

INFLUENCE OF PRODUCTIVITY AND DISTURBANCE ON PLANT SPECIES
DIVERSITY ACROSS THE GRASSLANDS OF THE GREAT PLAINS

A Thesis

by

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ABSTRACT

Plant species diversity is a critical element for the stability and functionality of all types of ecosystems. The drivers of plant species diversity remain up for debate with varying views of how a high level is achieved and maintained across all ecosystems. Literature states that intermediate levels of productivity and disturbance are essential for these high levels to be present. This logic has been disputed through empirical tests; however, other claims hold that these intermediate levels have not been appropriately examined. Here, I investigate the influence of productivity and disturbance (i.e., fire) on plant species diversity.

I set up experimental plots across the grassland prairies of Kansas where diversity, productivity, and fire patterns vary considerably. I conducted this study in the wetter, tallgrass prairies of eastern Kansas at Konza Prairie Biological Station and in the drier, mid- to short-grass prairies of western Kansas at Smoky Valley Ranch. Based on these locations, I positioned plots under different fire frequencies across moisture gradients topographically and regionally. I assessed productivity by clipping standing vegetation, drying it, and then weighing it. I controlled for the fire variable by examining areas under prescribed burn treatments based on time since most recently burned. I found that plant species diversity does not significantly differ across topography in tallgrass prairies though it did differ significantly across the climatic regional gradient of Kansas. From my results, I have concluded that productivity and disturbance influence plant species diversity of the Great Plains though other variables

likely drive plant species diversity as well such as annual versus perennial dominance, season of burn, and grazing.

DEDICATION

To my parents for their love, support, and understanding. I would not be where I am today without their unwavering love and encouragement throughout my life. To my siblings, Alex, Spencer, and Megan, for their advice and perspective on life. To my two young nieces, Arianna and Kyra, that they may always value the importance of education and seek further knowledge. And finally, to Helena for her constant belief in me. I cannot express adequately how grateful I am for her support.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW*

Introduction

The distributions of different species across the globe have puzzled researchers since the era of exploration. We can readily discern patterns in vegetation across a landscape, but why do these patterns occur? One of the most astounding vegetation patterns is the variation between places in the number of plant species (Griffin 2011). Species diversity has fascinated biogeographers and explorers for centuries. It continues to attract attention because it is a fundamental aspect of plant communities that also has important conservation implications.

What contributes to varying degrees of species diversity is a contested and unresolved issue (Griffin 2011). Some researchers have proposed that plant diversity patterns are linked to gradients of productivity and/or to disturbances such as fire and grazing (Grime 1973; Connell 1978). Productivity is the rate at which biomass accumulates over time. It is regulated by several factors such as nutrients, soils, and moisture (Grime 1973). Productivity varies over different scales; from fine scales such as topographic gradients to broader scales such as regional or global precipitation

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gradients. A disturbance is any discrete event in time that disrupts an ecosystem, community, or population (Sousa 1984). Disturbance are commonly defined as events that kill plants or remove part of their biomass. In this project, I investigate the influences of productivity and disturbance on plant species diversity in central North American grasslands.

Grime (1973) proposed the Intermediate Productivity Hypothesis, a model that predicts a unimodal pattern of plant species diversity along a productivity gradient. Species diversity is predicted to be low at high productivity due to the ability of species that require more moisture and/or nutrients to outcompete those that can persist under lesser moisture and/or nutrients. It also predicts low species diversity at low productivity due to only the resource-poor species being able to establish. Species diversity is predicted to be greatest under intermediate productivity because these conditions are suitable for the resource-poor species to persist and not be outcompeted by the ones that need more moisture and/or nutrients.

The Intermediate Disturbance Hypothesis is another predictive model of plant species diversity proposed by Connell (1978). It predicts a unimodal trend in plant species diversity along a gradient of varying disturbance levels. These disturbance levels can take several forms: disturbance frequency, time since previous disturbance, or the magnitude of the disturbance. The Intermediate Disturbance Hypothesis predicts low species diversity at sites recently disturbed since there is insufficient time for many species to recover; therefore, only the quickly establishing species exist. It also suggests low species diversity at sites with a long period since previously disturbed because

competitive species limit resource availability for the quickly establishing species since a disturbance has not reduced those competitive species. Whenever disturbance rates are intermediate, it is predicted that species diversity is high as this signifies a transition in persistence between quickly establishing plants and competitive plants.

A number of empirical studies have been conducted to evaluate the Intermediate Productivity Hypothesis and the Intermediate Disturbance Hypothesis, with varying results (Al-Mufti *et al.* 1977; Rosenzweig 1992; Rosenzweig & Abramsky 1993; Tilman & Pacala 1993; Huston & DeAngelis 1994; Abrams 1995; Aronson & Precht 1995; Collins *et al.* 1995; Rusch & Oesterheld 1997; Schwilk *et al.* 1997; Townsend *et al.* 1997; Collins & Steinauer 1998; Flöder & Sommer 1999; Beckage & Stout 2000; Molino & Sabatier 2001; Svensson *et al.* 2007; Sasaki *et al.* 2009; Adler *et al.* 2011; Fox 2013). Al-Mufti *et al.* (1977), Rosenzweig (1992), Rosenzweig & Abramsky (1993), Tilman & Pacala (1993), and Huston & DeAngelis (1994) concluded that greatest species diversity is supported at intermediate levels of productivity. Abrams (1995), Rusch & Oesterheld (1997), Svensson *et al.* (2007), and Adler *et al.* (2011) concluded that species diversity does not fit the predicted unimodal trend of the Intermediate Productivity Hypothesis. Aronson & Precht (1995), Moen & Collins (1996), Townsend *et al.* (1997), Flöder & Sommer (1999), Molino & Sabatier (2001), and Svensson *et al.* (2007) concluded that species diversity was maximized under intermediate disturbance levels. Schwilk *et al.* (1997), Collins & Steinauer (1998), Beckage & Stout (2000), and Fox (2013) concluded no support for maximal species diversity at intermediate disturbance levels. Collins *et al.* (1995) and Sasaki *et al.* (2009) could not support nor

oppose the Intermediate Disturbance Hypothesis, as the predicted unimodal trend was found in some empirical tests but not in others. Due to this mixed support for both predictive hypotheses, further explanation for what limits plant species diversity is still needed.

Huston (2014) combined the principles of both the Intermediate Productivity Hypothesis and the Intermediate Disturbance Hypothesis by proposing the Dynamic Equilibrium Model in hopes to better explain/predict plant species diversity. This model proposes species diversity as a product of the dynamic combination between productivity and disturbance. It suggests that species diversity will vary along a productivity gradient at a fixed point in succession as well as across a successional gradient at a fixed point in productivity. Therefore, this predictive model suggests a link between productivity and disturbance that provides explanation for how a variety of species coexist on these productivity and successional gradients. This model predicts maximum species diversity achieved when productivity and disturbance equilibrate one another. Species diversity is suggested to lessen as the two variables further fall from equilibrium across their gradient ranges. Though this research must examine the Intermediate Productivity Hypothesis and the Intermediate Disturbance Hypothesis because they are the foundation of the Dynamic Equilibrium Model, the overall focus of this research is to evaluate the predictive capabilities of the Dynamic Equilibrium Model.

Alongside the topographic moisture gradients restricted to the eastern Great Plains and the vast precipitation gradient from east to west across the Great Plains of the

United States, grasslands are a dynamic biome that are exposed to distinct pressures such as overgrazing, invasive encroachment, agricultural conversion, and burning (O'Mara 2012); thus, a prime location to study the interactions of productivity and disturbance on plant species diversity. The topographic variability in the tallgrass prairies of the eastern Great Plains permits the fine scale component of this research to be examined. In addition, the precipitation gradient across the Great Plains supports the evaluation of the regional component of this research. This research focuses on the relationship between plant species diversity and productivity/disturbance gradients across the grasslands of the Great Plains. Grasslands were chosen as the ecosystem upon which plant species diversity would be examined due to two observable productivity scales (topographic and climatic), the historic presence of multiple disturbance types in grasslands, and the ability for easier field manipulations of grasslands compared to other ecosystems such as forests that have longer-lived biota. The objectives of this research are to: 1) quantify diversity in grasslands of present species; 2) evaluate plant species diversity based on productivity and disturbance across a topographic gradient (fine scale); 3) evaluate plant species diversity based on productivity and disturbance across a regional gradient (broad scale); and 4) examine species compositions in relation to positions along the topographic and regional gradients.

Research Questions

1. How is species diversity of grassland plants affected by productivity and disturbance (fire) along a topographic gradient?

2. How is plant species diversity in grasslands influenced by productivity and disturbance (fire) along a regional, climatic gradient?
3. How do the abundances of *Andropogon gerardii*, *Bouteloua curtipendula*, *Panicum virgatum*, *Schizachyrium scoparium*, and *Sorghastrum nutans* vary across a topographic gradient?
4. How does the abundance of *B. curtipendula* vary across a regional gradient?

Hypotheses

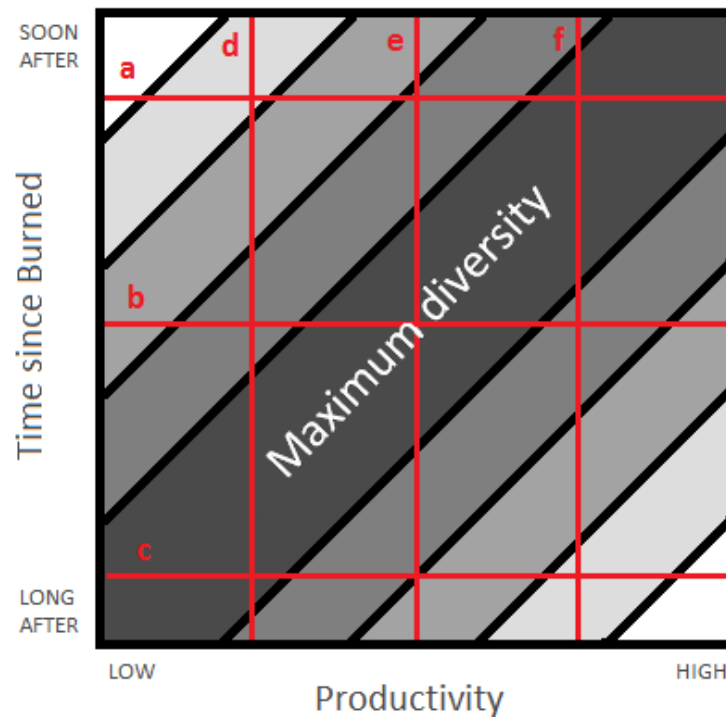


Figure 1.1. Dynamic Equilibrium Model. Predictions of plant species diversity shown along gradients of productivity and disturbance. Adapted from Huston (2014).

To address my first research question, I evaluate how trends in plant species diversity shift throughout succession topographically. In recently burned tallgrass communities (early-stage succession), diversity would be lowest on the ridge and increase toward the valley. This corresponds roughly to line *a* (Fig. 1.1). In tallgrass communities under moderate time since burned (mid-stage succession), diversity would be lowest at the ridge and valley and greatest at the midslope. This corresponds roughly to line *b* (Fig. 1.1). In tallgrass communities that have not experienced burning for a long period of time (late-stage succession), diversity would be lowest in the valley and increase toward the ridge. This corresponds roughly to line *c* (Fig. 1.1). Also for my first research question, I evaluate how trends in plant species diversity shift across productivity. On ridges in tallgrass communities (low productivity sites), diversity would be lowest soon after a fire event and increase through succession. This corresponds roughly to line *d* (Fig. 1.1). On midslopes in tallgrass communities (moderate productivity sites), diversity would be lowest soon after and long after a fire event and greatest at intermediate time since a fire event. This corresponds roughly to line *e* (Fig. 1.1). In valleys in tallgrass communities (high productivity sites), diversity would be highest soon after a fire event and decrease through succession. This corresponds roughly to line *f* (Fig. 1.1).

To address my second research question, I evaluate how trends in plant species diversity shift throughout succession regionally. In communities long since previously burned, diversity is low in the productive tallgrass prairies of the east and increases

toward the dry, less productive mixed-grass prairies to the west. This pattern corresponds to *line c* (Fig. 1.1). In grassland communities under moderate time since burned (mid-stage succession), diversity is still low in the eastern, productive tallgrass prairies and increases toward the dry, western mixed-grass prairies of lesser productivity. This pattern corresponds to *line b* (Fig. 1.1). Also for my second research question, I evaluate how trends in plant species diversity shift across productivity. In grassland communities of low productivity, diversity would be lower at mid-stage succession and increase as time since the previous fire event increases. This corresponds roughly to *line d* (Fig. 1.1).

To address my third research question, I evaluate how trends in five grass species shift throughout succession topographically. After a recent fire event (early-stage succession), the more xeric mid-grasses (*B. curtipendula* and *S. scoparium*) should be able to compete with the more mesic tallgrasses (*A. gerardii*, *P. virgatum*, and *S. nutans*) in the valley due to high resource and light availability. As time since the previous fire event increases (toward later-stage succession), it is expected that the xeric mid-grasses will retreat up the hillslope and the mesic tallgrasses should dominate as they outcompete the more xeric species for resource and light availability.

To address my fourth research question, I evaluate how trends in one grass species shift throughout succession regionally. It is anticipated that the xeric mid-grass species, *B. curtipendula*, will dominate in the drier, western grasslands than in the wetter, eastern tallgrass prairies through succession after a fire event.

Literature Review

Biodiversity can take several forms and be expressed across many gradients. Biodiversity relates to three scales at which the diversity of life can be viewed: ecosystem diversity, species diversity, and genetic diversity. Ecosystem diversity is the broadest scale because it considers the variation in ecosystems on Earth. Species diversity comprises the variation in species within ecosystems, which is the medial scale of biodiversity. Genetic diversity encompasses the variation of genes within species and it the finest scale of biodiversity (Griffin 2011). This research will focus on the medial scale, species diversity.

The spatial and temporal variation in species diversity has intrigued humans for centuries (Griffin 2011). Species diversity has important meaning for ecological purposes as well as society. Without a diversity of species, ecosystem processes are altered and ecosystem resilience is changed, which is important because humans rely on these innate ecosystem functions (Chapin III *et al.* 2000). Conservation is a key component in elevating levels of species diversity. High levels promote more dynamic, stable ecosystems with a wider range of habitats and supports a vast food web. Some consequences to society by changes in biodiversity are reductions in sources of food, fuel, structural materials, medicinal, or genetic resources (Chapin III *et al.* 2000). Placing a higher emphasis on species diversity is critical to the future of all species, and it starts at determining the conditions at which it is most highly obtained. It has been proposed that species diversity varies on global, regional, landscape, and local scales by

means of several gradients such as latitude (Gaston 2002), productivity (Grime 1973), and disturbance (Connell 1978).

Species diversity on a latitudinal gradient

The latitudinal species diversity gradient is one of the most intriguing patterns in nature (Eo *et al.* 2008). Viewing species diversity for a wide spectrum of taxonomic groups along a latitudinal gradient shows that the tropical zones possess higher numbers of plant and animal species, mid-latitudes are characteristic of lesser species diversity than the tropics, and polar regions are areas that have the lowest numbers of species compared to anywhere else on Earth (Stevens 1989; Gaston 1996; Gaston 2000). Many different mechanisms have been proposed to help explain this general pattern (Gaston 1996) such as competition, mutualism, predation, patchiness, environmental stability, environmental predictability, productivity, area, number of habitats, ecological time, evolutionary time, and solar energy (Rohde 1992).

Nearly a hundred hypotheses exist that attempt to explain the latitudinal pattern of species diversity (Griffin 2011). These hypotheses resemble either historical or ecological biogeographical thought (Wiens & Donoghue 2004). Historical biogeography considers the diversification of species among regions and lacks focus on the ecological interactions of species (Wiens & Donoghue 2004). Ecological biogeography often ignores this historical component and focuses more on the diversification of species based on their interactions with the environment (Wiens & Donoghue 2004). Pianka (1966) recognizes just a few of the more distinctive

hypotheses such as the time theory and the productivity hypothesis. The time theory resides in the historical biogeography classification. It assumes that as time increases, the species present in a community diversify (Pianka 1966). On the other hand, the productivity hypothesis sits within ecological biogeography. This hypothesis states that greater productivity produces greater diversity of species (Connell & Orias 1964; Pianka 1966).

Gaston (1996) outlines several other attempts at explaining the diversity of life from the equator to the poles. Colwell & Hurtt (1994) suggests, at least in part, that species diversity is a product of random latitudinal association between the size and placement of the geographic ranges of species. It is proposed that hard boundaries limit the geographical distribution of species and therefore species richness declines as latitude increases (Colwell & Hurtt 1994).

Another mechanism that attempts to convey an explanation of latitudinal species diversity considers origination, immigration, extinction, and emigration with particular emphasis on origination and extinction at larger scales (Cracraft 1992; Rosenzweig 1992; Rosenzweig 1995). It is suggested that origination and extinction of species produce spatial variation in species diversity in the lower latitudes as it is argued that the tropics represent high origination and extinction rates (Cracraft 1992; Rosenzweig 1992; Rosenzweig 1995).

Rosenzweig (1992; 1995) proposes that the larger area of the tropics conduces to speciation. The larger area produces larger geographic range sizes and population sizes for species, which buffer them from extinction and create a greater likelihood of a refuge

remaining following an environmental perturbation (Rosenzweig 1992; Rosenzweig 1995).

Blackburn & Gaston (1996) argues that species richness of a region will be dependent on the mean body size and the mean abundance of the species because these variables rely on the division of the same basic raw materials that can be supported by the region (Blackburn & Gaston 1996). Therefore, species richness is greatest in the tropics and decreases toward the poles. Though many other hypotheses exist, whether based in historical or ecological foundations, there is yet to be a resolution found to solve this acutely-examined latitudinal gradient in species diversity.

Species diversity on a productivity gradient

Productivity is the rate at which plant biomass accumulates over time. It can vary topographically with moisture increasing from the ridge to the valley (Fig. 1.2). Woody species occupy the riparian areas next to the valley bottoms because their moisture requirements are higher than that of the grasses and forb species that persist on the ridges.



Figure 1.2. Landscape at Konza Prairie. Higher woody presence in the valley and lesser on the ridge, indicating a moisture gradient across topography.

Productivity can also vary regionally such as the precipitation gradient from the eastern U.S. forests to the shortgrass prairies and steppes of eastern Colorado and western Kansas that are bounded by the leeward side of the Rocky Mountains. This regional moisture gradient is displayed in Figure 1.3. The left image demonstrates tallgrass species at Konza Prairie Biological Station in eastern Kansas that require greater moisture, whereas the right image shows mid- to short-grass species at Smoky Valley Ranch in western Kansas that can persist under the lower moisture availability that is present there.



Figure 1.3. Comparison of study sites. The left image show an individual of *Andropogon gerardii* (big bluestem). This individual remains rooted in the ground and stands taller than me. The right image depicts an individual of *Bouteloua curtipendula* (sideoats grama). Still rooted in the ground as well, this individual stands shorter than my knee.

The Intermediate Productivity Hypothesis suggests that plant species diversity conforms to a unimodal trend across a productivity gradient (Grime 1973). This model predicts that where plant productivity is low due to low availability of moisture and/or nutrients, plant species diversity will be low because few species are adapted to these threshold conditions. This is indicated by the brown circle (Fig. 1.4). Low moisture and/or nutrients provide insufficient resources for establishment of high diversity of plants. Only plants that are well-adapted for low resource availability are able to occupy these low productivity sites. Therefore, plant species diversity is suggested to be low.

This model also proposes that high productivity results in low plant species diversity due to high amounts of moisture and/or nutrients. This is depicted by the dark green circle (Fig. 1.4). High abundance of moisture and/or nutrients allow species that readily obtain these resources to dominate these highly productive sites. These dominant species exclude other species through competition. The stress-tolerant species are unable to compete because they are adapted for survival under limited resource availability, so when resources are abundant, they are outcompeted. Therefore, plant species diversity is predicted to be low. Finally, this model put forth that plant species diversity is high at intermediate rates of productivity due to intermediate availability of moisture and/or nutrients. This is shown as the light green circle (Fig. 1.4). Intermediate levels of moisture and/or nutrients allow for the coexistence of stress-tolerant and competitive species. Here, resources are not too low to preclude the survival of competitive species that require high resource availability, nor are they too high for competitive species to outcompete the stress-tolerant species. Therefore, intermediate productivity permits these different types of species to coexist.

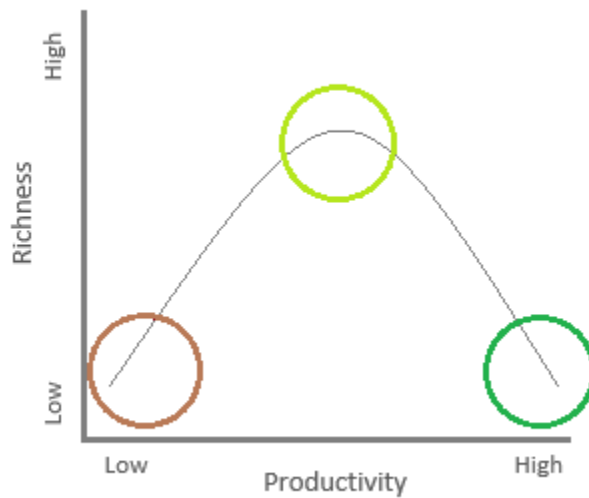


Figure 1.4. Intermediate Productivity Hypothesis. Predictions of plant species richness shown across a gradient of productivity. Adapted from Grime (1973).

The Intermediate Productivity Hypothesis has received much scrutiny over the past several decades since Grime (1973) proposed it. The validity of this hypothesis remains up for debate with research in support of it (Al-Mufti *et al.* 1977; Rosenzweig 1992; Rosenzweig & Abramsky 1993; Tilman & Pacala 1993; Huston & DeAngelis 1994) and research opposing it (Abrams 1995; Rusch & Oosterheld 1997; Svensson *et al.* 2007; Adler *et al.* 2011). Al-Mufti *et al.* (1977) found that the greatest number of species were achieved at intermediate rates of productivity for tall herb, woodland floor, and grassland communities. Rosenzweig (1992) concluded that the unimodal pattern is the true productivity pattern. Rosenzweig & Abramsky (1993) attributed high productivity to low plant species diversity due to competitive exclusion. Tilman & Pacala (1993) compiled several studies that all support a unimodal trend for plant species diversity under intermediate levels of a certain proxy for productivity: biomass for

Mediterranean grasslands (Puerto *et al.* 1990), British herbs (Al-Mufti *et al.* 1977), and the South African Fynbos (Bond 1983); water drainage for a North American prairie (Dix & Smeins 1967); moisture index for a Californian climatic gradient (Westman & Whittaker 1975); and soil nutrients for Australian vegetation (Beadle 1966), a Malaysian rainforest (Ashton 1977), and Costa Rican forests (Holdridge *et al.* 1971). Huston & DeAngelis (1994) concluded that a unimodal trend for plant species diversity is supported along productivity gradients. Huston & DeAngelis (1994) also concluded that high productivity results in lessened spatial heterogeneity and limiting resources due to competition.

Abrams (1995) argues that the competition-related theories that predict unimodal trends in plant species diversity are either theoretically flawed, only applicable to a narrow scope of conditions, or lacking sufficient empirical support. Therefore, Abrams (1995) suggests that competitive exclusion may not be a mechanism by which trends in plant species diversity are produced. Rusch and Oesterheld (1997) observed plant species diversity in a Pampas grassland and concluded that productivity-diversity relationships are insufficient and that predictive models of these relationships should consider the impact of disturbances. Rusch and Oesterheld (1997) determined that plant species richness increased when disturbed by grazing with an increase in exotic forbs and no change in presence of native flora. Grazing shifted the the species composition to cool-season dominance as grazing reduces warm-season grasses.

Svennson *et al.* (2007) tested the significance of productivity to species diversity of disturbed marine hard-substratum assemblages and found no significant difference in

species diversity between just disturbed sites and disturbed sites observed over a productivity gradient. Therefore, it was concluded that productivity has no significant influence on the diversity of marine hard-stratum assemblages (Svensson *et al.* 2007). Adler *et al.* (2011) argues that the foundations set forth by the Intermediate Productivity Hypothesis are too general to predict plant species diversity adequately. Moreover, it was found that there was no support for a unimodal trend in plant species diversity as predicted by the Intermediate Productivity Hypothesis in herbaceous-dominated plant communities at local scales, regional scales, or global scales (Adler *et al.* 2011).

Species diversity on a disturbance gradient

A disturbance is any discrete event in time that disrupts an ecosystem, community, or population (Sousa 1984). Moreover, a disturbance is an event that kills plants or destroys at least some of their biomass. Therefore, these definitions characterize fire as a disturbance, which is the focal disturbance of this research. A disturbance gradient varies spatially across a landscape. Time since previously burned is an example of a disturbance gradient (Connell 1978; Huston 2014) and is the one used for this research. A spring burn at Konza Prairie Biological Station in 2014 is depicted in Figure 1.5. The foreground depicts a charred landscape with burned vegetation that had been disturbed by a fire. A fire burns in the background.



Figure 1.5. Fire burning across Konza Prairie.

The amount of time since a fire event changes the landscape composition of species types. Sites that were recently disturbed are characterized typically of herbaceous species such as grasses and forbs, whereas woody species have a higher propensity to establish at sites long after a disturbance and reduce the presence of the herbaceous plants. Two positions on the time-since-burned disturbance gradient are illustrated in Figure 1.6. The image on the left burns annually and was burned in the spring of 2015 or three months prior to the capture of the image. The right image burns every four years and was previously burned in the spring of 2013 or two years and three months prior to this image being taken.



Figure 1.6. Comparison between different burn treatments. The image on the left illustrates a landscape that comprises herbaceous species predominantly such as *A. gerardii* and *Schizachyrium scoparium* (little bluestem). More woody species dominance composes the image on the right such as *Cornus drummondii* (rough-leaf dogwood) and *Rhus glabra* (smooth sumac) across that landscape.

The Intermediate Disturbance Hypothesis predicts that plant species diversity fits a unimodal trend across a disturbance gradient such as time since previously burned (Connell 1978). This model suggests that plant species diversity is low soon after a disturbance. This is demonstrated as the yellow circle (Fig. 1.7). It is due to insufficient amount of time for species to recover. Only the few species that are quick to establish persist. Therefore, low plant species diversity is predicted. Plant species diversity is predicted to be low as well at sites long after a disturbance. This is shown as the red circle (Fig. 1.7). At sites long after a disturbance, competitive species reduce the

abundance of the quickly establishing plants by consuming available resources and limiting the intake of resources to other species. Finally, this model proposes that intermediate time since previously disturbed achieves high plant species diversity. This is indicated as the orange circle (Fig. 1.7). Intermediate levels of time since disturbance permit the quickly establishing and competitive species to coexist. Here, time since disturbed is not too much for the quickly establishing species to die out or to be competitively excluded, nor is it too little time for the competitive species to be present. Therefore, a prediction of high plant species diversity results because multiple plant types can coexist.

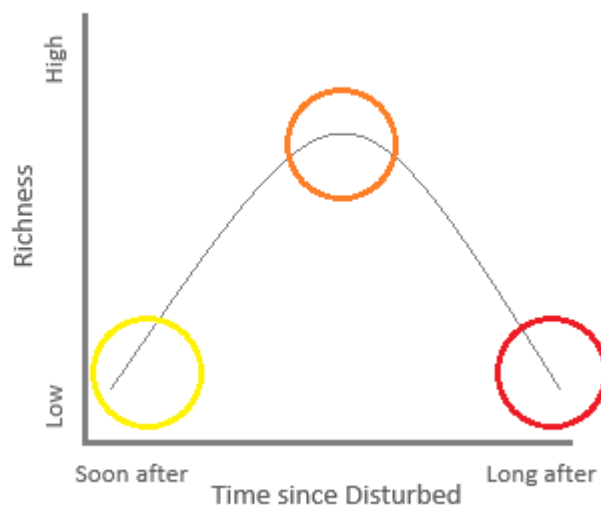


Figure 1.7. Intermediate Disturbance Hypothesis. Predictions of plant species richness shown across a gradient of disturbance. Adapted from Connell (1978).

The Intermediate Disturbance Hypothesis, proposed by Connell (1978), has been debated over the past several decades since its inception in the 1970s. Its predictive

capabilities have been scrutinized with support (Aronson & Precht 1995; Moen & Collins 1996; Townsend *et al.* 1997; Flöder & Sommer 1999; Molino & Sabatier 2001; Svensson *et al.* 2007), opposition (Schwilk *et al.* 1997; Collins & Steinauer 1998; Beckage & Stout 2000; Fox 2013), and contradictory findings (Collins *et al.* 1995; Sasaki *et al.* 2009). Aronson & Precht (1995) suggest that the Intermediate Disturbance Hypothesis should be examined on a large-scale basis (greater than 1 hectare) to assess its capabilities adequately. On this landscape-sized scale in coral reef ecosystems, Aronson & Precht (1995) found that coral species diversity in these Belizean reefs was maximized at intermediate levels of disturbance. Moen & Collins (1996) analyzed the Intermediate Disturbance Hypothesis in conjunction with differing trophic levels. Two-trophic-level systems yielded a maximal diversity predictive response at intermediate levels of disturbance, indicating support for the hypothesis, whereas three-trophic-level systems produced a bimodal trend prediction in diversity (Moen & Collins 1996). Therefore, Moen & Collins (1996) suggest that different number of trophic levels are important determinant to consider for plant species diversity. Townsend *et al.* (1997) found that greatest diversity of macroinvertebrate taxa in streams was achieved at intermediate levels of disturbance, which supports the unimodal trend predicted by the Intermediate Disturbance Hypothesis. Flöder & Sommer (1999) show support for the Intermediate Disturbance Hypothesis in natural plankton communities. The highest number of plankton species responded at intermediate levels of experimental mixing and grazing by zooplankton (Flöder & Sommer 1999). Molino & Sabatier (2001) found that Guianan tropical forest communities produced greatest species diversity at intermediate

disturbance levels by examining the response in number of species to natural treefall gaps. Though Svensson *et al.* (2007) found no support for productivity-diversity relationships, diversity in marine hard-substratum assemblages was greatest at intermediate levels of biomass removal from scraping, therefore supporting the predictions of the Intermediate Disturbance Hypothesis.

Schwilk *et al.* (1997) claim that plant species diversity in the South African fynbos does not support the predictions of the Intermediate Disturbance Hypothesis. Sites that were infrequently burned achieved highest plant species diversity, whereas diversity was lowest at sites of moderate and high fire frequency (Schwilk *et al.* 1997). Collins & Steinauer (1998) argue that plant species diversity of tallgrass prairies related to number of fires does not conform to the unimodal trend of the Intermediate Disturbance Hypothesis but instead, plant species diversity fits negatively to an increase in fires. Beckage & Stout (2000) found no support for the Intermediate Disturbance Hypothesis for a Floridian pine savanna over a fire frequency gradient. Fox (2013) argues that the Intermediate Disturbance Hypothesis is invalid and should not be a method by which species diversity is explained. Based on empirical invalidations of the model, Fox (2013) suggests that the disturbance mechanisms on which it is founded are flawed due to its theoretical foundations.

Collins *et al.* (1995) suggest varying results for the Intermediate Disturbance Hypothesis by means of two different disturbance gradients. First, plant species diversity was greatest at sites of infrequent fires and lessened as fire frequency increased, indicating a monotonic decline instead of a unimodal trend as predicted by the

Intermediate Disturbance Hypothesis. Second, greatest plant species diversity was achieved at intermediate levels of time since previously burned, which supports the Intermediate Disturbance Hypothesis. These findings furthered Collins *et al.* (1995) to conclude no support for the initial floristic composition model of succession. Since neither frequent fire nor immediately following a fire event optimized plant species diversity, no support was found for the initial floristic composition model of succession. Proposed by Egler (1954), the initial floristic composition model of succession is another predictive model of plant species diversity that states that nearly all species are present immediately following a disturbance at the start of succession. Wilson (2014) displays the controversy of initial floristic composition model of succession and suggests that its validity remains unknown. Sasaki *et al.* (2009) found mixed results for the Intermediate Disturbance Hypothesis. Plant species diversity was not maximized at intermediate levels of grazing in harsh environmental conditions in the Mongolian rangelands, therefore opposing the Intermediate Disturbance Hypothesis. These harsh conditions did not indicate support for high plant species diversity for any one area along the grazing disturbance gradient (Sasaki *et al.* 2009). Under benign environmental conditions, support for the hypothesis resulted with greatest species diversity at intermediate levels of grazing (Sasaki *et al.* 2009).

Species diversity over gradients of productivity and disturbance

Since a general consensus regarding how plant species diversity is achieved could not be met considering both the Intermediate Productivity Hypothesis and the Intermediate Disturbance Hypothesis, other ways by which plant species diversity can be explained is necessary. Huston (1979; 2014) proposed another predictive model of plant species diversity that links the principles of the Intermediate Productivity Hypothesis and the Intermediate Disturbance Hypothesis to form the Dynamic Equilibrium Model (Fig 1.8).

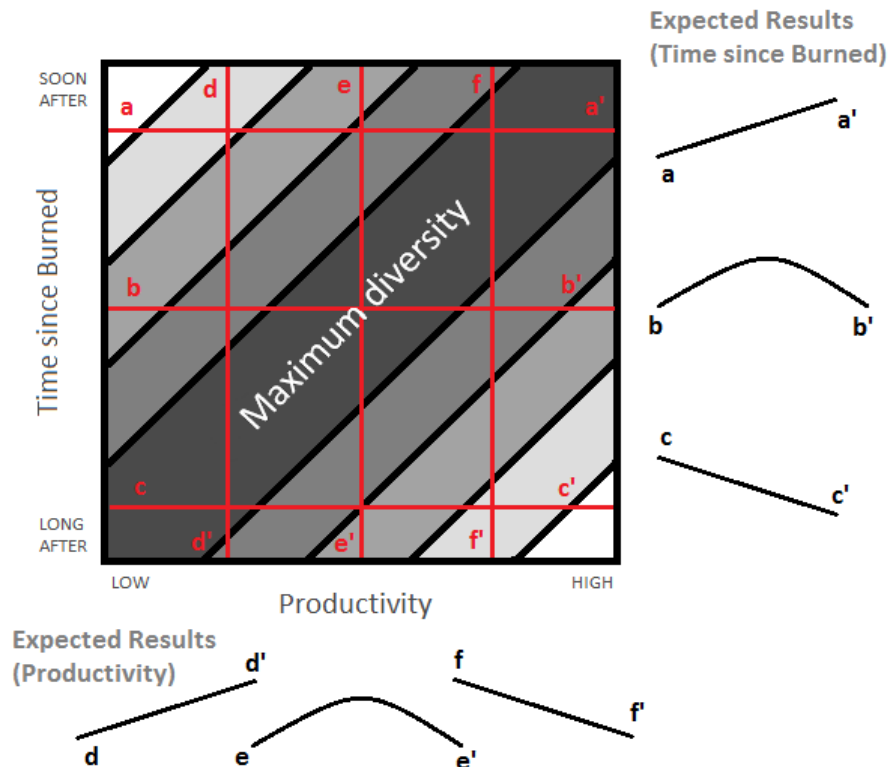


Figure 1.8. Dynamic Equilibrium Model predictions. Expected results in plant species diversity along these gradients are indicated. Adapted from Huston (2014).

The Dynamic Equilibrium Model suggests that maximum species diversity is achieved whenever productivity equilibrates to the disturbance gradient (Huston 2014). The x-axis demonstrates a gradient of increasing productivity (e.g., greater moisture and/or nutrients) (Fig. 1.8). The y-axis indicates a successional gradient of increasing time since a fire event. The following three scenarios are to explain certain instances under specific conditions that characterized predictions for species diversity maxima.

First, under low productivity and long after a fire event (intersection of lines *c* and *d* in Fig. 1.8), species diversity is predicted to be high because the lack of a disturbance is not able to reduce species establishment. Therefore, species that are capable of persisting under low productivity and late-successional species are present, indicating higher species diversity to be predicted.

Second, it is predicted that high species diversity under intermediate productivity and intermediate time since a fire event as represented at the junction of lines *b* and *e* (Fig. 1.8). Intermediate productivity is too low for competitive exclusion to occur quickly, meaning species that are optimized at low and high productivities coexist at intermediate productivity. In addition, though early-successional and late-successional species are optimized under soon after and long after a fire event, respectively, intermediate time since a fire event suggests that these species types coexist, meaning high species diversity.

Third, species diversity is predicted to be higher under high productivity and soon after a fire event. The above model suggests this prediction because a recent fire event will regulate the competitive species that dominate under high productivity,

allowing for the establishment of early-successional species that would otherwise be outcompeted. Therefore, competitive species that require high productivity and early-successional species persist under these conditions, maximizing the species diversity. This can be observed where lines *a* and *f* (Fig. 1.8).

The Dynamic Equilibrium Model also predicts under what conditions species diversity is minimized. The following six scenarios refer to how low and moderate species diversity are characterized (Fig. 1.8).

First, at the intersection of lines *a* and *d* (Fig. 1.8), productivity is too low and the fire event is too recent for the establishment of many species. Only the few early-successional species that can persist under low productivity are predicted to exist.

Second, where lines *a* and *e* join (Fig. 1.8), species diversity is still not predicted to be maximized because the fire event is too recent for species that are optimized at high productivities to occur under an intermediate productivity. Therefore, only the several early-successional species that persist under an intermediate productivity are suggested to exist. Moderate levels of species diversity are predicted compared to low predictions at the (*a*, *d*) intersection.

Third, at the convergence of lines *b* and *d* (Fig. 1.8), the time since the previous fire event is not long enough under low productivity for species diversity to be maximal. Low productivity sites need more time since a fire to establish high species diversity. Only the several mid-successional species that can persist under low productivity are suggested to exist. Moderate levels of species diversity are predicted compared to low predictions at the (*a*, *d*) intersection.

Fourth, where lines *b* and *f* intersect (Fig. 1.8), too much time since the previous fire event has passed under high productivity for maximized species diversity. This is due to the competitive species that require high productivity having sufficient time to establish and outcompete other species since fire has not been present as recently as needed to reduce their dominance. Therefore, only the several mid-successional species that require high productivity are predicted to exist. Moderate levels of species diversity are predicted compared to low predictions at the (*c*, *f*) intersection.

Fifth, where lines *c* and *e* join (Fig. 1.8), species diversity is still not predicted to be maximized because productivity is too high under long after the previous fire event. Too much time since the previous fire event has passed to regulate species that can outcompete late-successional species under intermediate productivity. Therefore, only the several late-successional species that can persist under intermediate productivity are suggested to exist. Moderate levels of species diversity are predicted compared to low predictions at the (*c*, *f*)

Sixth, where lines *c* and *f* converge (Fig. 1.8), productivity is too high and the previous fire event is too far removed temporally that only the few late-successional species that can occupy highly productive sites are suggested to exist. This is due to the high rate of competitive exclusion.

Huston (1979; 2014) proposed this model to suggest that species diversity is produced by a dynamic combination of productivity and disturbance gradients where diversity changes along a productivity gradient at a fixed point in succession as well as along a successional gradient at a fixed point of productivity. Therefore, the Dynamic

Equilibrium Model links the principles of the Intermediate Productivity Hypothesis and the Intermediate Disturbance Hypothesis by considering the degree at which species that range on productivity and successional gradients coexist.

The model (Fig. 1.8) indicates expected trends in species diversity for particular conditions of productivity and disturbance dynamics. At a fixed point in early succession and along the productivity gradient (line *a-a'*), a positive relationship is predicted. A unimodal relationship is suggested as time since a fire event transitions to mid-succession (line *b-b'*) across this productivity gradient. As the fixed point along the time since burned axis changes to late succession (line *c-c'*), a negative relationship is predicted along the productivity gradient. Another positive relationship in species diversity is predicted as the productivity axis becomes fixed at low levels (line *d-d'*) and time-since-disturbance increases. The model suggests a unimodal trend (line *e-e'*) across the disturbance gradient once the productivity becomes fixed at intermediate levels. When the fixed point transitions to high productivity (line *f-f'*), the model predicts a negative trend as time-since-disturbance increases. For my research, these expected trends in species diversity will be tested to assess the predictive capabilities of the Dynamic Equilibrium Model along a fine-scale, topographic gradient of a tallgrass prairie and a broad-scale, climatic gradient of a temperate grassland.

Grassland species

Grasslands comprise many different species of grasses and forbs as well as several shrubs and trees, depending on whether the land is managed with fire and/or

grazing or not at all (Anderson *et al.* 1970). Five warm-season grass species compose between 60 and 80% of the plant cover of tallgrass prairie grasslands: *Andropogon gerardii*, *Bouteloua curtipendula*, *Panicum virgatum*, *Schizachyrium scoparium*, and *Sorghastrum nutans* (Weaver 1954; Anderson *et al.* 1970).

The dominant lowland species consist of *A. gerardii*, *P. virgatum*, and *S. nutans* (Weaver 1954). These grasses are considered mesic tallgrass species due to their competitive abilities in the valley lowlands, where resources and moisture are greatest. *A. gerardii* is one of the most widely spread species in tallgrass prairies and can reach upward of 2.1 to 3.7 meters in height (Weaver 1954). *P. virgatum* occurs in moist areas typical of valley lowlands as well as on upland disturbed sites (Weaver 1954; Knapp 1984). It reaches heights of 1.2 to 2.1 meters (Weaver 1954). *S. nutans* grows very similarly to *A. gerardii* in terms of moisture requirements being high and grows to heights of approximately 1.8 meters (Weaver 1954).

The dominant upland species consist of *B. curtipendula* and *S. scoparium* (Weaver 1954). These grasses are considered xeric mid-grass species due to their abilities to persist under lower moisture availability in the ridge uplands, where resources and moisture is lesser. *B. curtipendula* is a drought-resistant grass that constitutes a lower percentage of the plant cover in a tallgrass prairie due to the greater water availability (Weaver 1954). It ranges in height of 0.9 to 1.1 meters (Weaver 1954). *S. scoparium* is one of the more widely spread species in tallgrass prairies and reaches heights of 0.3 to 1.1 meters (Weaver 1954).

CHAPTER II
STUDY AREA

Study Sites

I sampled at two locations across a regional climate gradient in Kansas: Konza Prairie Biological Station and Smoky Valley Ranch. These two locations are illustrated in Figure 2.1.

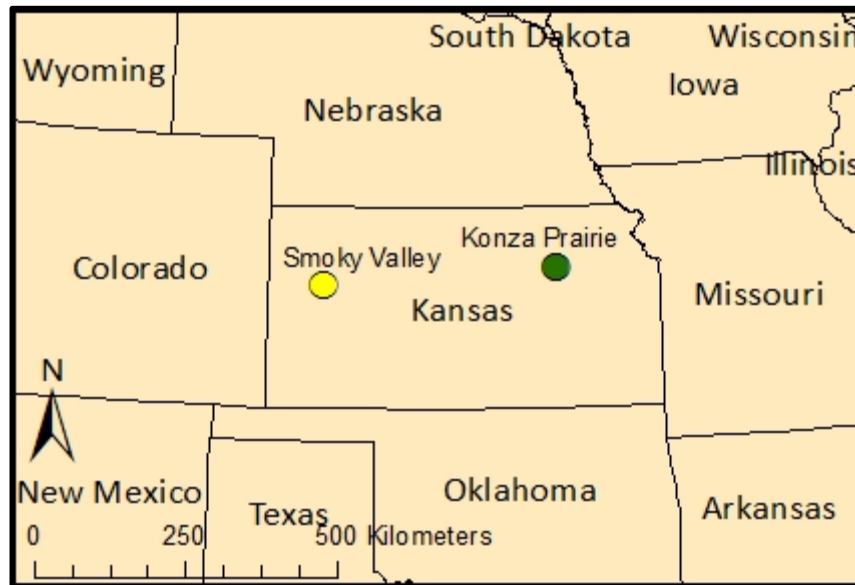


Figure 2.1. Map of the regional study area.

Konza Prairie Biological Station

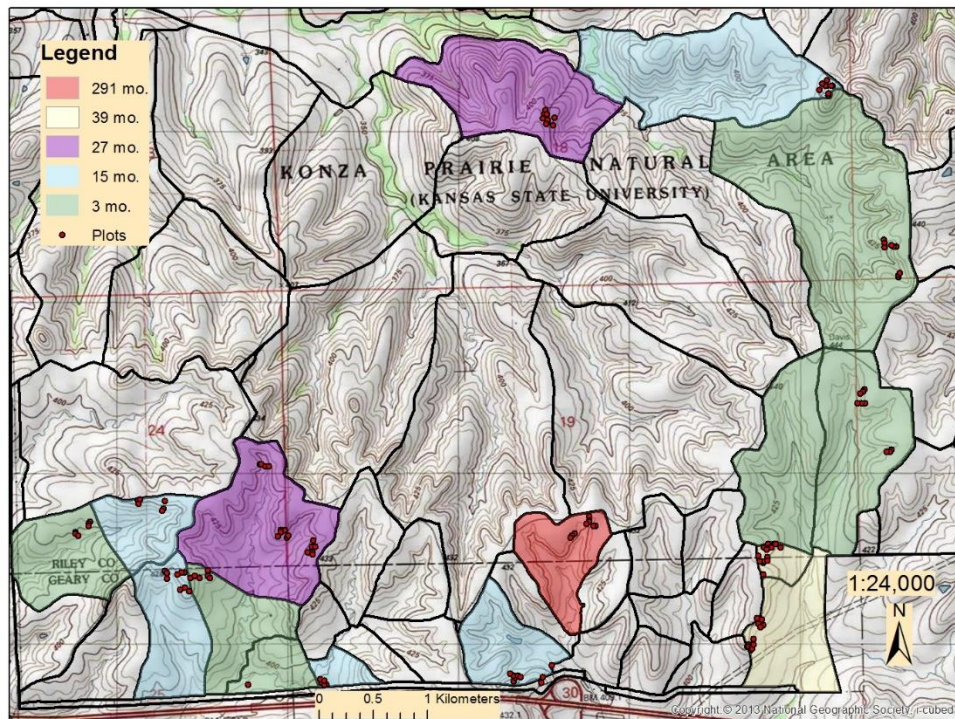


Figure 2.2. Map of Konza Prairie Biological Station. Red points indicate sampled plots.

Site Description

Konza Prairie (39.09° N, 96.56° W) is a 3487-ha native tallgrass prairie preserve situated in northeastern Kansas, USA (Knapp *et al.* 1998) (Fig. 2.2). This area receives approximately 904 mm of annual precipitation (U.S. Climate Data). This places it on the wet end of North America's temperate grassland, which occupies a zone with approximately 500-900 mm of annual precipitation (NASA). The average July temperature is 33.1 °C and the average January temperature is 4.8 °C (U.S. Climate

Data). The growing season is a six month period that spans April to September with precipitation and temperature peaking in June and July, respectively (Craine *et al.* 2012) (Fig. 2.3).

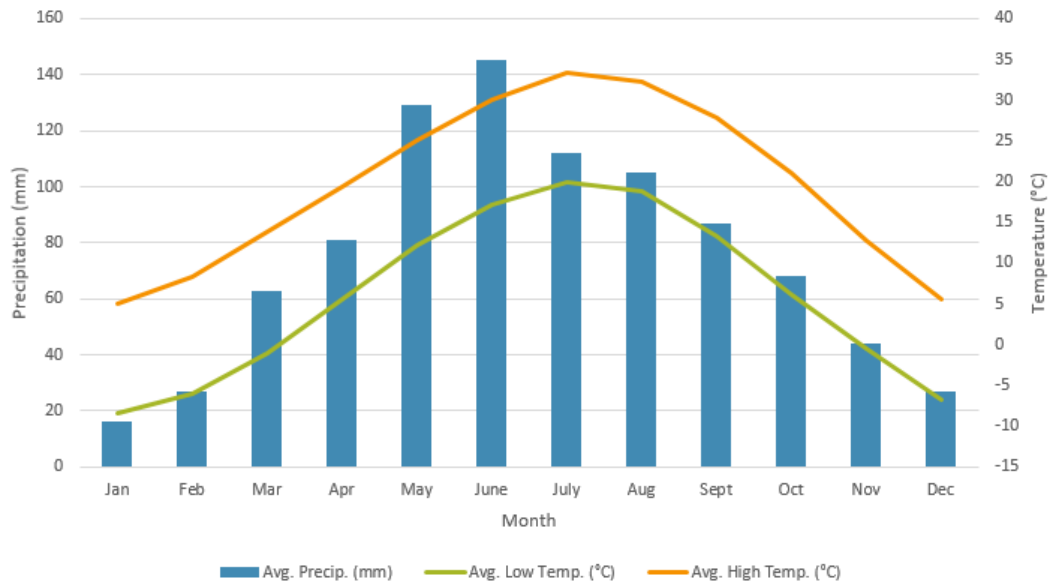


Figure 2.3. Climograph for Konza Prairie Biological Station.

Konza Prairie is located within the Flint Hills, an ecoregion known for its hilly terrain and exposed bedrock that deterred conversion to row-crop agriculture that is commonplace within the Great Plains. This has allowed for the Flint Hills to remain in their tallgrass prairie natural state. Typical tall- and mid-grass species of the Flint Hills are *Andropogon gerardii* (Big bluestem), *Panicum virgatum* (Switchgrass), *Schizachyrium scoparium* (Little bluestem), and *Sorghastrum nutans* (Indiangrass). There are also a wide range of associated forbs and several woody species as well. Konza Prairie is a Long-Term Ecological Research (LTER) site that is funded by the

National Science Foundation and owned in partnership by the Nature Conservancy and Kansas State University (KSU) and managed by the Division of Biology at KSU.

Konza Prairie is divided into units under which different management treatments are applied: grazing by native herbivores (bison), grazing by introduced herbivores (cattle), and prescribed fire. Grazing is either present or absent, whereas prescribed burns are conducted on one, two, four, or twenty year cycles that are unique to each unit. Ecological research sits at the forefront of Konza Prairie management, where the treatments are planned to elucidate the processes that drive this ecosystem for the purpose of management and restoration advancements to the tallgrass prairies.

Geology

The geology of the area is an important influence because of how diversity is predicted to differ across topography. Konza Prairie comprises a landscape of terraced hills due to surficial processes (Oviatt 1998). Limestone and mudstone (shale) form these terraces that date back to the Permian age (Jewett 1941; Miller and West 1993; Oviatt 1998). The limestone layers resist erosion, whereas the mudstone layers that alternate between the limestone layers are less-resistant (Oviatt 1998). Therefore, the hills at Konza Prairie resemble terraces with the limestone forming benches and the mudstone forming slopes (Oviatt 1998). The Florence Limestone makes up the ridge and is the youngest limestone layer at Konza Prairie, whereas the Neva Limestone is the oldest limestone layer and is situated near the valley bottom (Smith 1991; Oviatt 1998).

The Shroyer, Threemile, Crouse, and Cottonwood Limestone layers date between the Florence and Neva layers and make up the midslopes (Smith 1991; Oviatt 1998).

Glaciation of Kansas occurred only in the northeastern portion of the state, which had significant impacts on the drainage and waterways of the region (Aber 1991). This glaciation that occurred during the Pleistocene comprised the advancement of the Minnesota lobe followed by the Dakota lobe that dates back between 0.7 and 0.6 million year ago BP (Aber 1991).

As a result of these surficial processes, the landscape at Konza Prairie is topographically diverse. The elevation reaches 406 m (Blecker *et al.* 2006) with a 122 m topographic relief (USGS).

Soils

The predominant soil order on Konza Prairie is the Mollisol. These soils are rich in organic material and are typical of mid-latitude grasslands worldwide. The parent material of these Mollisols is largely loess. A black or very dark brown hue characterize these Mollisols at Konza Prairie (Ransom *et al.* 1998).

Although these Mollisols span the breadth of Konza Prairie, they differ in their silt, clay, loam, and sand contents. This variation mainly occurs topographically due to the geology and surficial processes such as erosion and deposition. The soils on the ridges and benches are made up of silt loam or silty clay loam with the clay content ranging from 26 to 34 percent (Ransom *et al.* 1998). The sideslope soils contain silty clay loam, gravelly silty clay loam, and gravelly silty clay with a range of 35 to 55

percent clay content (Ransom *et al.* 1998). The rock fragment content of the sideslopes range 15 to 35 percent (Ransom *et al.* 1998). The soils on the footslopes are fine and a silty clay loam with a clay content ranging 35 to 40 percent (Ransom *et al.* 1998). Rock fragments can be common in the surface layers of the footslopes but rarely comprise more than 15 percent of the total soil volume (Ransom *et al.* 1998). Finally, the floodplain soils are characterized as deep, moderately well-drained, and moderately permeable (Ransom *et al.* 1998). These soils are typically silty clay loam and range 35 to 40 percent in their clay content (Ransom *et al.* 1998). Rock fragments make up less than 15 percent of the total soil volume (Ransom *et al.* 1998).

Land Use History

The Flint Hills ecoregion of northeastern Kansas resembled the present-day grasslands during the presettlement era, largely dominated by tallgrass species (Hickey & Webb 1987). The Kansa, Osage, Pawnee, and Wichita tribes inhabited this region during presettlement (Marchand 1993). Fire was a significant land management approach that these American Indian people utilized (Williams 2003). As settlement advanced into the Great Plains in the mid 1800s, debate ensued about whether the Flint Hills would be farmed or ranched (Hickey & Webb 1987). Farming and ranching competed alongside each other with row-crop agriculture predominantly situated in the uplands due to the steep topographic relief of the area and grazing largely by cattle on the nutritious tallgrass species. The 1870s were pivotal in agriculture in the Flint Hills. Flint nodules resting in the topsoil broke the plows of many farmers and drought and soil

erosion ruined their crops (Hickey & Webb 1987). The 1880s saw a livestock boom and officially determined the Flint Hills to be dominated by ranching, ceasing any large farming efforts (Hickey & Webb 1987). Still to present day, ranching remains a vital economic anchor to this region with the area dominated by swaths of tallgrass prairie.

Smoky Valley Ranch

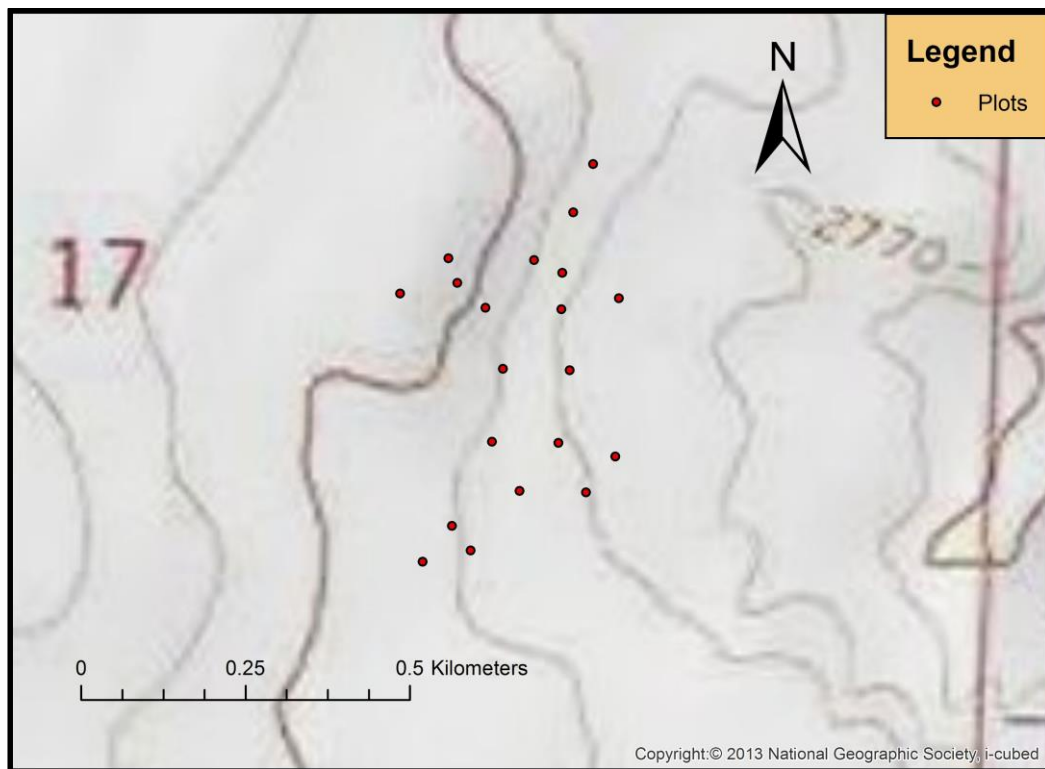


Figure 2.4. Map of Smoky Valley Ranch. Red points indicate sampled plots.

Site Description

Smoky Valley (38.86° N, 100.98° W) is a 6799-ha conservation prairie operated by The Nature Conservancy situated in western Kansas (The Nature Conservancy). The

landscape at Smoky Valley is illustrated in Figure 2.4 with the red dots indicating the sampled plots. This site is composed predominantly of mid-grass and shortgrass prairies. This location receives about 510 mm of precipitation annually (U.S. Climate Data). This positions it at the lower end of North America's temperate grassland, a zone that ranges approximately 500-900 mm of precipitation annually (NASA). The average July temperature is 32.7 °C and the average January temperature is 5.7 °C (U.S. Climate Data). The growing season occurs during the summer months where precipitation and temperature are at their maxima (Fig. 2.5).

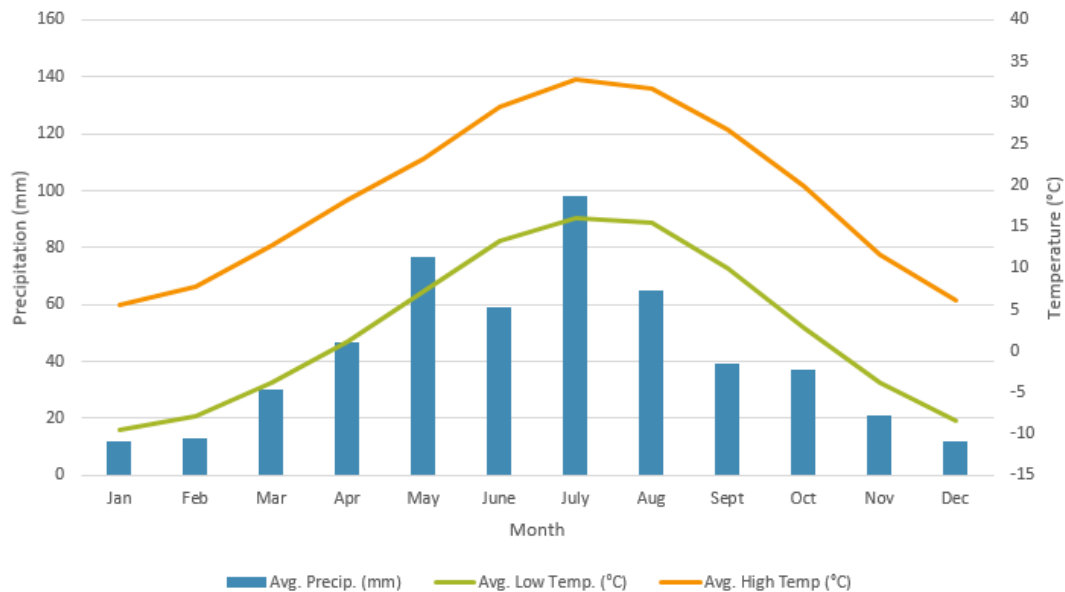


Figure 2.5. Climograph for Smoky Valley Ranch.

Compared to Konza Prairie, Smoky Valley has much less topographic variability across the site though there are rocky outcrops scattered throughout the landscape. Typical mid- and shortgrass species of western Kansas are *Bouteloua curtipendula*

(Sideoats grama), *B. gracilis* (Blue grama), and *B. dactyloides* (Buffalo grass). Forbs and some woody species are also present alongside these dominant grasses. Smoky Valley Ranch is a research-driven operation that focuses on land management and conservation strategies of mid- and shortgrass prairies.

Similar to Konza Prairie, Smoky Valley is split into divisions based on particular management treatments such as grazing by bison and cattle as well as prescribed fire. These units are grazed and/or burned at varying annual or seasonal intervals. These management approaches help address key ecological concepts that are useful to the land management of land owners.

Geology

Chalk and shale comprise the types of rocks present at Smoky Valley in western Kansas (Bell *et al.* 1964). The Smoky Hill chalk is the oldest rock formation at Smoky Valley (Bell *et al.* 1964). It resulted from the accumulation of tiny microscopic marine organisms on the seafloor of the massive inland sea that occupied western Kansas throughout the Cretaceous Period (Bell *et al.* 1964). Though the topography is relatively flat at Smoky Valley, rocky outcrops composed of these chinks are scattered throughout the landscape. The Pierre shale resides on top of the Smoky Hill chalk as a product of sedimentation of the Cretaceous Sea (Bell *et al.* 1964). The uplifting of the Rocky Mountain chain drained the water from the Cretaceous Sea, which caused erosion and deposition of these chinks and shales (Bell *et al.* 1964). These surficial processes

are what caused these chalk outcroppings. The silty, Peorian loess was deposited across the region via aeolian processes (Bell *et al.* 1964).

Though Smoky Valley lacks the topographic relief of Konza Prairie, its elevation is higher due to the gradual climb across the Great Plains toward the Rocky Mountains. The elevation at Smoky Valley rises to 879 m (Blecker *et al.* 2006) with a topographic relief of 34 m (USGS).

Soils

Mollisols are the predominant soil order at Smoky Valley as well. Though these soils support the tallgrass species at Konza Prairie, they also create a suitable environment for the presence of the mixed-grass prairies at Smoky Valley. Windblown, Peorian loess makes up the parent material for these Mollisols (Bell *et al.* 1964).

With the Smoky Hill River running through the area, the soil types range from loamy fine sand to clay loam particularly in the floodplains (Bell *et al.* 1964). The windblown silts are less significant in these alluvial areas (Bell *et al.* 1964).

Land Use History

The presettlement era in this part of western Kansas was home to several American Indian tribes such as the Arapaho and Cheyenne people (The Nature Conservancy). Fire was an important land management strategy employed by American Indian people (Williams 2003). Settlement of the central United States initialized many cattle trails across the state and brought ranching to western Kansas (The Nature

Conservancy). Due to the low topographic relief of this region, conversion from short- and mid-grass prairies to row-crop agriculture occurred. Farming and ranching efforts remain as a significant part of the economy in western Kansas. This site is preserved by the Nature Conservancy as the upper reaches of the Smoky Hill River that flows through the area marks the important ecological transition between short- and mid-grass prairies.

CHAPTER III

METHODS

This study focused its local scale component at Konza Prairie Biological Station, whereas the regional scale context was assessed between Konza Prairie and Smoky Valley Ranch. The prescribed burning conducted at Konza Prairie represents the disturbance variable with differing times-since-disturbance existing across that landscape. These different times-since-disturbance allow for plant species diversity to be observed along the successional trajectory for grassland ecosystems. With these different levels of disturbance coupled with a range in productivity (being either local or regional), a comprehensive assessment of plant species diversity can be achieved (Huston 1979; Huston 2014).

Fieldwork

I conducted fieldwork at Konza Prairie in June and August of 2015. Konza Prairie is broken up into watershed units that constitute a specific time-since-disturbance. I collected samples based on these specific times-since-disturbance to ensure that multiple levels of disturbance were met. At the time of sampling (summer 2015), these watershed units had been burned in either March or April of 2015, 2014, 2013, 2012, and 1991. These five separate years-since-fire yielded five distinct levels of disturbance and therefore follows the recommendations that at least three levels are

needed to appropriately assess plant species diversity along a disturbance gradient (Huston 2014).

A range in productivity exists both locally and regionally. There is a regional productivity gradient across the grasslands of the Great Plains; however, productivity also varies locally among different topographic positions because of differences in soil moisture, depth, and fertility (Tomanek & Albertson 1957). Moisture content based on topography is a good metric to determine productivity (Coblentz and Riitters 2004; Moeslund *et al.* 2013). I evaluated productivity by examining aboveground net primary productivity as it signifies a relationship with plant species diversity (Hector *et al.* 1999). Productivity assessed topographically is expected to be greatest in the valley bottoms and to decrease toward the ridges. As with disturbance, a minimum of three levels of productivity are required to properly assess how plant species diversity varies along a productivity gradient (Huston 2014). Plots were set up within each of the five separate years-since-fire, which ensured the cross-sampling of productivity and disturbance gradients.

Plots were 0.5 m by 0.5 m in size and were set up by the use of a sampling frame constructed of polyvinyl chloride (PVC) pipe (Komac *et al.* 2014). These plots were placed under all five years-since-fire and situated on the ridge, the midslope, and the valley bottom of each appropriate hillslope. I determined the placement of each plot through the use of a random numbers sheet. This sheet enabled me to randomly select appropriate hillslopes and to generate a random step count to determine the appropriate placement of each plot at the ridge, midslope, and valley. I sampled ten to thirteen

replicate plots at each hillslope position for watershed units burned in the springs 2015, 2014, 2013, and 2012. Three replicate plots were sampled at each hillslope position for the one watershed unit burned in 1991. I only sampled three replicate plots due to the relatively small size of the watershed unit as well as the extensive amount of research already being conducted in this unit, which limits the available space to comfortably sample this area. I determined species richness in the field by tallying the total number of species within each 0.25 sq. m plot (Adler *et al.* 2011; Komac *et al.* 2014). Following the tallying of species, I clipped a quarter of the standing biomass of each plot to take back for laboratory analysis. Standing biomass considers both live and dead plant organisms. The procedure I used to sample at Konza Prairie along a topographic gradient is displayed in Figure 2.7.

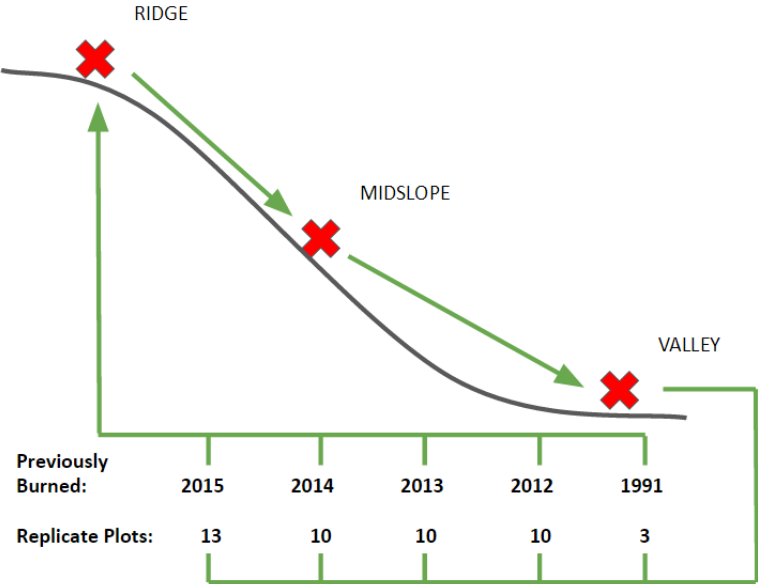


Figure 3.1. Field sampling procedure.

A plot delineated by the PVC pipe sampling frame as well as plant identification of a clipped individual are illustrated in Figure 2.8.

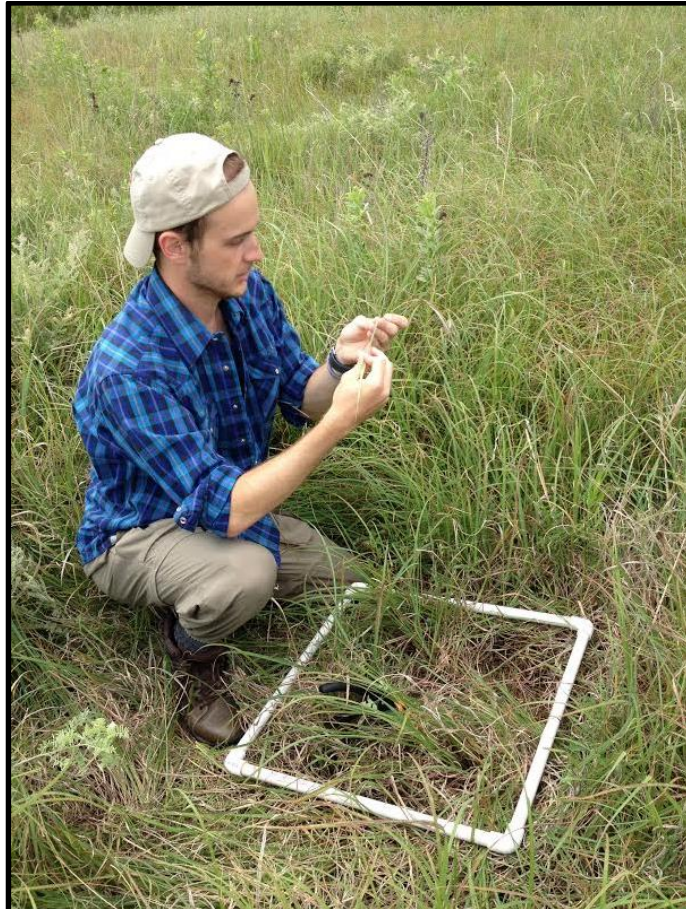


Figure 3.2. An individual of grass being identified.

Laboratory Analysis

In addition to species richness, this study takes into account species abundances to fully assess species diversity of plants in this grassland environment. To quantify species composition, I examined the biomass of each species that was clipped for each plot. The biomass of each sample was measured by drying the clipped matter in the

oven at 60 °C for 48 hours and weighed to the nearest hundredth of a gram (Hoover *et al.* 2014). This permitted me to quantify the standing biomass by obtaining a value for dried biomass of each plot. After the drying period was completed, I separated the sample by species and weighed them to quantify species composition (Magurran 2004). A sample separated by its species in the drying oven is depicted in Figure 2.9.



Figure 3.3. Samples drying in the oven.

Data Analyses

Two characterizations for plant species diversity were used in this study: species richness and a diversity index acquired from the Shannon Information Index (H')

(Shannon 1948). Species richness was easily determined in the field by tallying the total number of species, whereas the Shannon Information Index requires laboratory analyses to be completed before it can be calculated because it is based on the proportional abundance of each species. The equation to calculate this index is $-\sum p_i \ln p_i$, where p_i represents the proportion of plot biomass represented by each species. To attain the values for p_i , the biomass for each species is divided into the total biomass for a given plot.

I used two methods to assess plant species diversity in relation to productivity. First, I examined it over three different topographic positions (ridge, midslope, and valley) and two positions over the climatic region (Konza Prairie Biological Station and Smoky Valley Ranch). This topographic gradient generally corresponds to an increase in productivity from ridge to valley (Schimel *et al.* 1991; Blair 1997) and the regional climatic gradient results in a decrease in productivity from east to west (McCulley & Burke 2004). Second, I examined productivity based on the vegetation I had clipped in the field. To do so, I had to develop a method for examining productivity that was sampled at different years-since-fire. Comparing productivity calculated for samples with the same time-since-fire within a year is more straightforward than comparing areas that had been burned during different years. To standardize productivity that had been burned in different years, I first determined the maximum biomass value for each year-since-fire. Then, I calculated the percentage of each plot relative to the maximum biomass value for its respective year-since-fire. Therefore, the maximal value in percent productivity for each year-since-fire was 100%, with values diminishing as biomass for

individual plots decreased. Moreover, this arranged the productivity data to be comparable among different years-since-fire.

Richness and diversity data, therefore, were either organized categorically or continuously. The categorical data comprise plant species diversity evaluated at positions across the topographic gradient, across the regional climatic gradient, and along the year-since-fire successional trajectory. Conversely, plant species diversity examined across percent productivity composes the continuous data. For the categorical data, I performed Analyses of Variance (ANOVA) to determine the significance among sample means (Zar 1999). I tested for significance at $P < 0.05$. For the continuous data, I conducted regression analyses to look for relationships between measures of species diversity and productivity, testing for significance at $P < 0.05$ (Zar 1999).

CHAPTER IV

RESULTS

Research Question 1

How is species diversity of grassland plants affected by productivity and disturbance such as fire on a fine, topographic scale?

Biomass increased across the topographic gradient from ridge to valley (Fig. 4.1) for plots that were burned 3 months before sampling (ANOVA: $F=5.56$, $P<0.01$); 15 months before sampling (ANOVA: $F=3.65$, $P<0.04$); and 27 months before sampling (ANOVA: $F=3.38$; $P<0.05$). For these three periods since fire, significance was determined between the ridge and valley but not between the ridge and midslope and the midslope and valley. A similar, but statistically insignificant, trend emerged for the plots that were burned less recently.

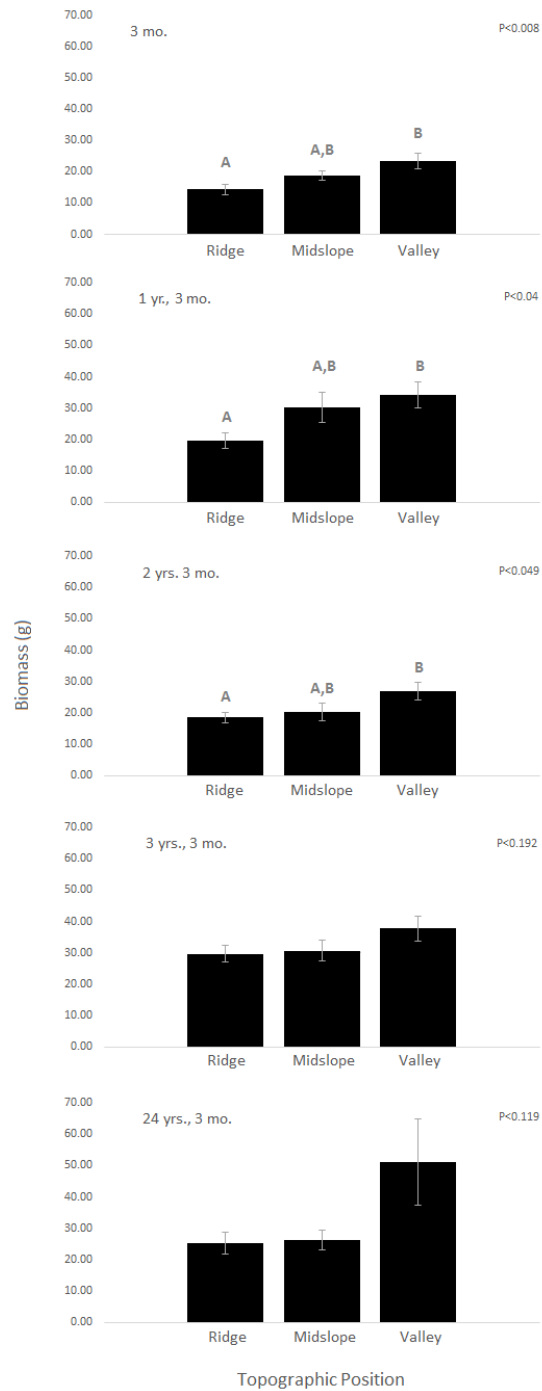


Figure 4.1. Biomass. Mean biomass by topographic position for 3 months; 15 months; 27 months; 39 months; and 291 months. Topographic positions labeled with different letters indicate significantly different means ($P < 0.05$).

Intermediate Productivity Hypothesis

Species richness revealed a relatively consistent value across all three topographic positions. The means between the ridge and midslope, the ridge and valley, and the midslope and valley were statistically insignificant (Fig. 4.2; ANOVA: $F=0.06$, $P<0.95$).

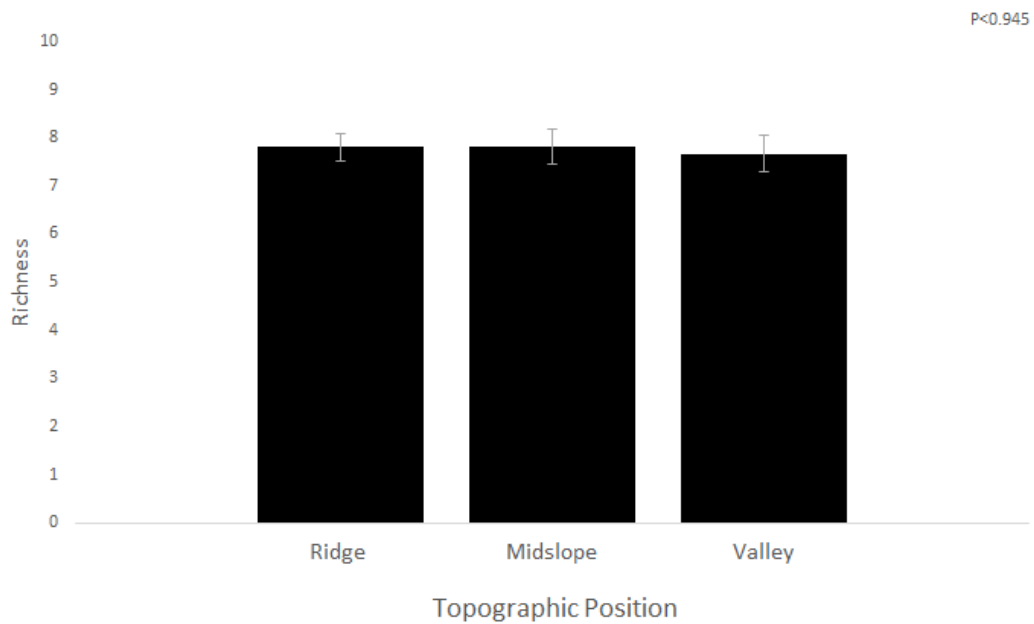


Figure 4.2. Mean plant species richness by topographic position for all years-since-fire.

The Shannon Information Index remains relatively consistent across all three topographic positions. The means between the ridge and midslope, the ridge and valley, and the midslope and valley were not statistically significant (Fig. 4.3; ANOVA: $F=0.72$; $P<0.49$).

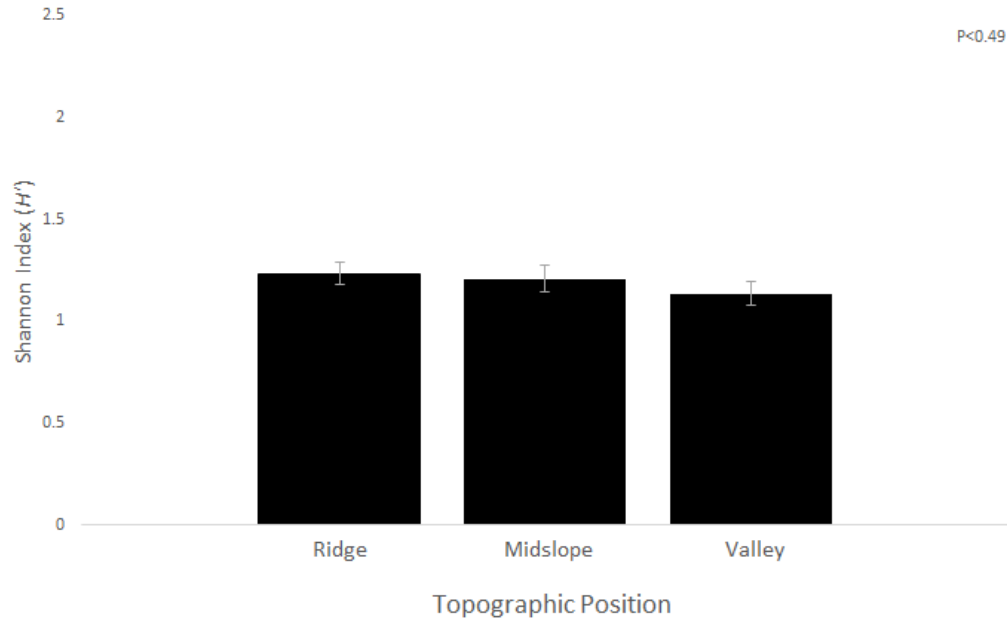


Figure 4.3. Mean indices for the Shannon Information Index by topographic position for all years-since-fire.

A weak negative trend emerged for plant species richness for the sampled plots across the estimated productivity gradient. However, the relationship was not statistically significant (Fig. 4.4; $R^2=0.01$, $F=1.22$, $P<0.27$).

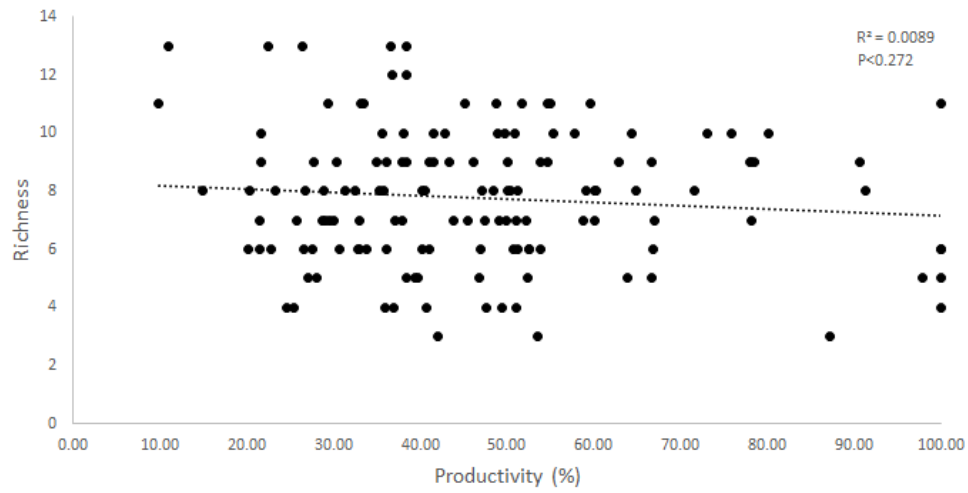


Figure 4.4. Plant species richness by percent productivity.

Indices for the Shannon Information Index from the sampled plots revealed a weak negative trend across the estimated productivity gradient. However, the relationship was statistically insignificant (Fig. 4.5; $R^2=0.01$, $F=1.58$, $P<0.21$).

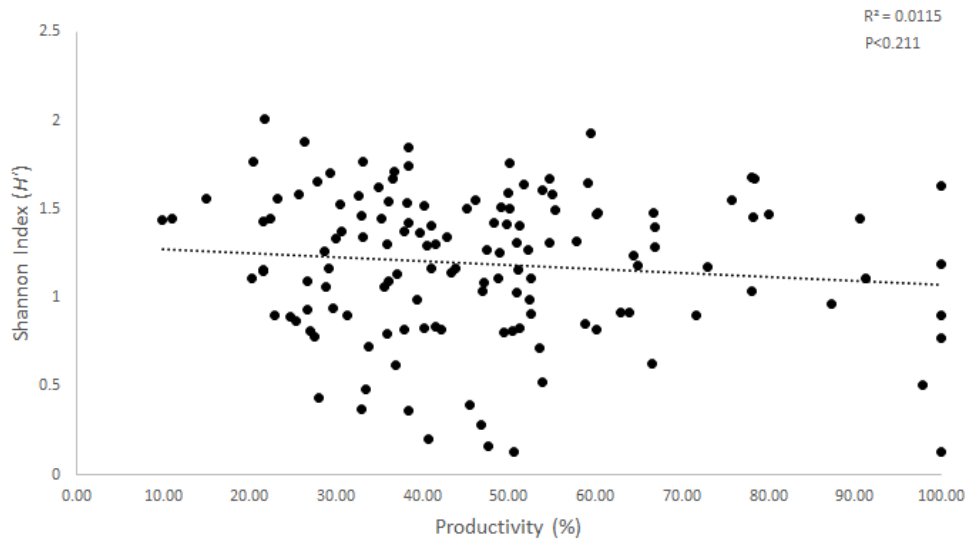


Figure 4.5. Indices for the Shannon Information Index by percent productivity.

Intermediate Disturbance Hypothesis

Plant species richness revealed a unimodal trend for the sampled plots across a successional gradient of time since fire. Two hundred ninety-one months tested significantly different from the four other periods that were sampled (Fig. 4.6; ANOVA: $F=2.73$, $P<0.03$).

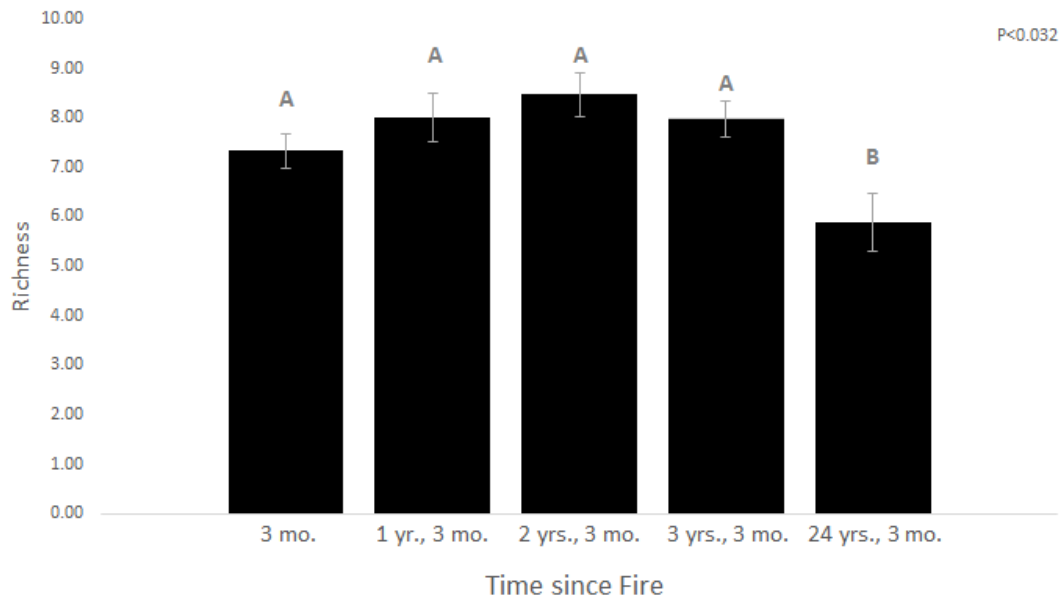


Figure 4.6. Mean plant species richness by time since fire. Times-since-fire labeled with different letters indicate significantly different means ($P<0.05$).

Indices for the Shannon Information Index did not vary significantly from 3 months to 39 months; however, 291 months was statistically significant from the other four times-since-fire that were sampled (Fig. 4.7; ANOVA: $F=4.93$, $P<0.01$).

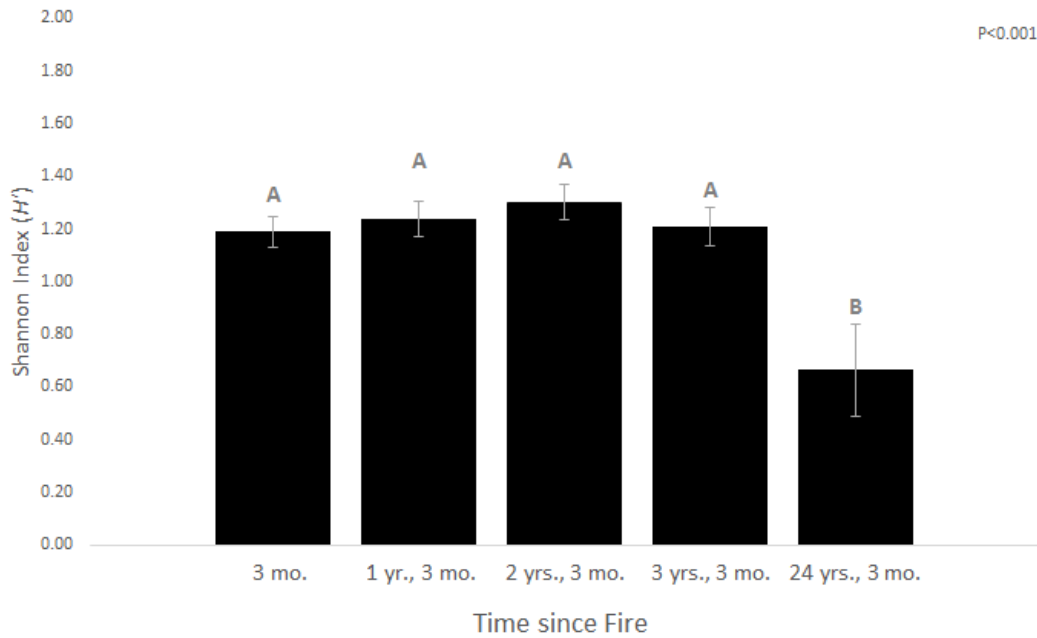


Figure 4.7. Mean indices for the Shannon Information Index by time since fire. Times-since-fire labeled with different letters indicate significantly different means ($P < 0.05$).

Dynamic Equilibrium Model

Weak negative trends in plant species richness from the sampled plots were found across the percent productivity gradient for all times-since-fire except at 39 month, where a weak positive trend emerged. However, all five times-since-fire tested statistically insignificant (Fig. 4.8; Table 4.1).

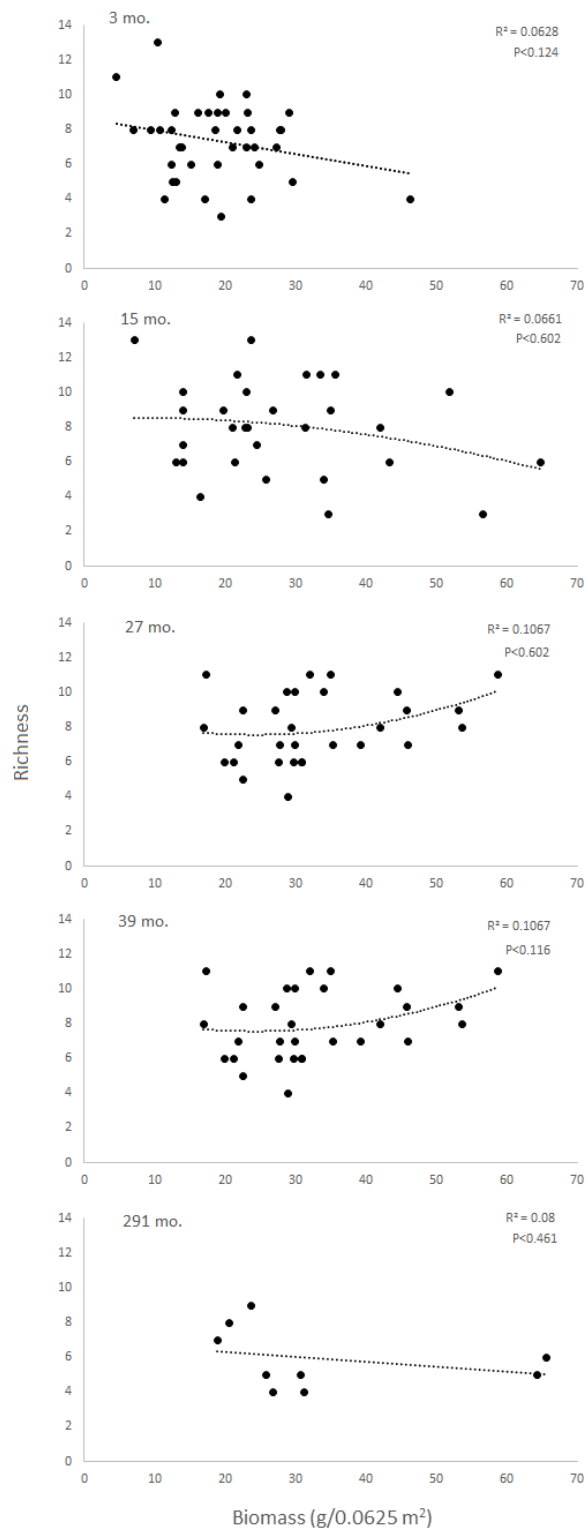


Figure 4.8. Plant species richness for each of the five times-since-fire by biomass.

Table 4.1. Regression analysis results for Figure 4.8.

Disturbance interval	R² value	F-value	P-value
3 mo.	0.06	2.48	0.12
15 mo.	0.06	1.79	0.19
27 mo.	0.07	0.28	0.6
39 mo.	0.11	2.64	0.12
291 mo.	0.08	0.61	0.46

Indices for the Shannon Information Index revealed weak negative trends from the sampled plots across the estimated productivity gradient for all times-since-fire except at 39 months, which revealed a weak positive trend. Moreover, all five times-since-fire tested statistically insignificant (Fig. 4.9; Table 4.2).

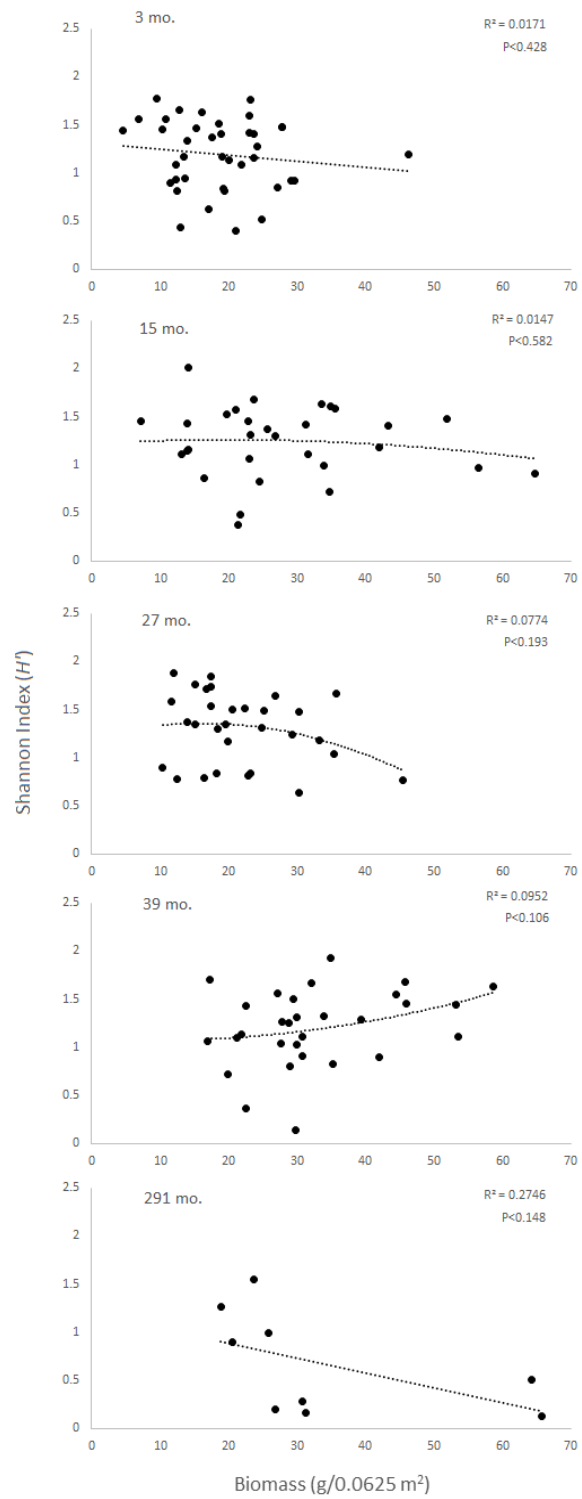


Figure 4.9. Indices for the Shannon Information Index for each of the five times-since-fire by biomass.

Table 4.2. Regression analysis results for Figure 4.9.

Disturbance interval	R² value	F-value	P-value
3 mo.	0.02	0.64	0.43
15 mo.	0.01	0.31	0.58
27 mo.	0.08	1.78	0.19
39 mo.	0.1	2.8	0.11
291 mo.	0.27	2.65	0.15

Plant species richness was maximized at 15 months; 27 months, and 39 months for the ridge, midslope, and valley, respectively. Plant species richness tapered off from those maximal values at each topographic position for the other times-since-fire creating a relatively unimodal shape for the sampled plots particularly at the midslope and valley positions. All these relationships tested not statistically significant (Fig. 4.10; Table 4.3).

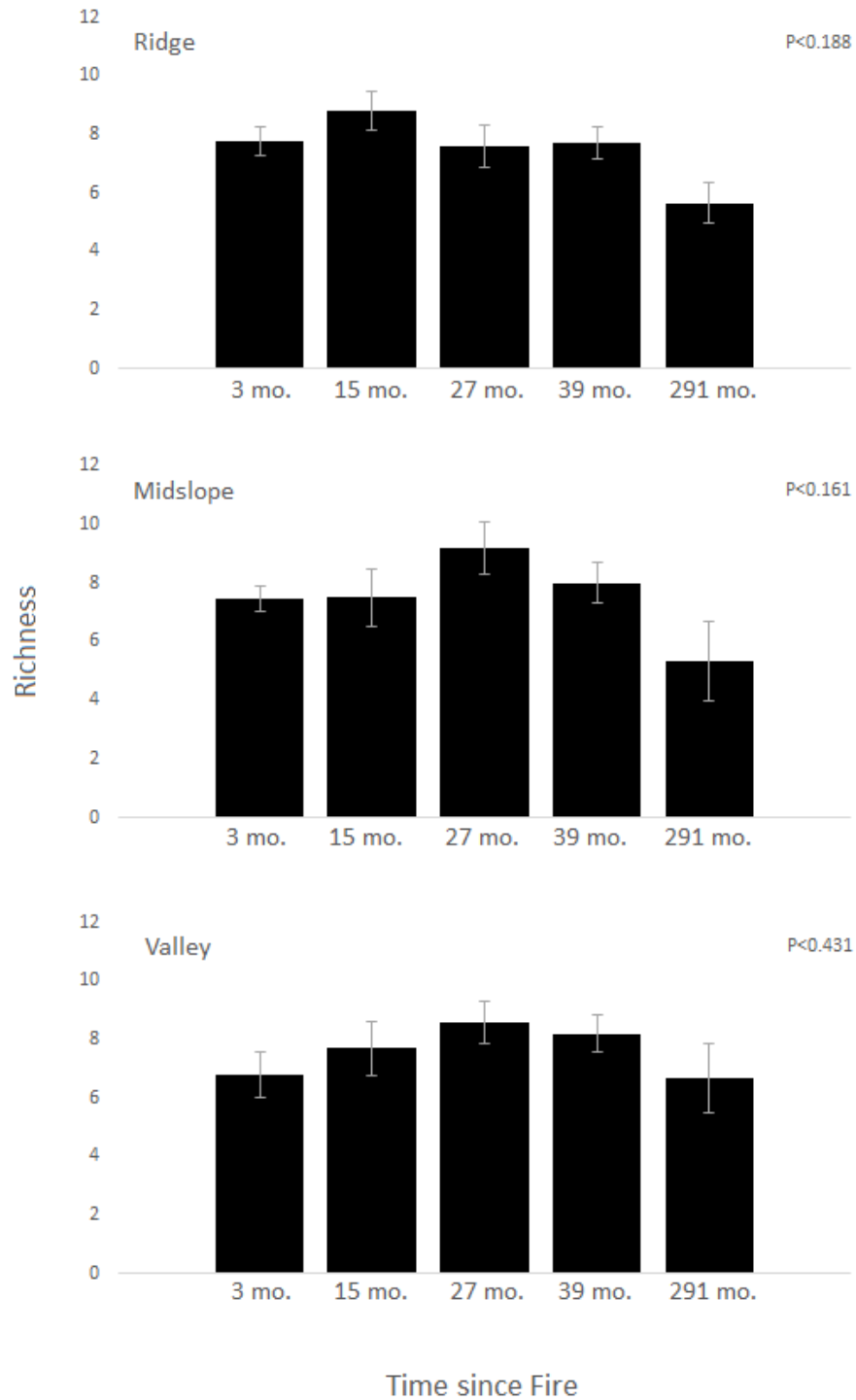


Figure 4.10. Mean plant species richness for each topographic position by time since fire.

Table 4.3. ANOVA results for Figure 4.10.

Topographic Position	F-value	P-value
Ridge	1.62	0.19
Midslope	1.73	0.16
Valley	0.98	0.43

Indices for the Shannon Information Index were maximized at 15 months; 27 months; and 39 months for ridge, midslope, and valley, respectively. The ridge and valley positions display a relative weak unimodal trend for the sampled plots. The midslope was the only position that tested significantly different (Fig. 4.11; ANOVA: Midslope: $F=4.54$, $P<0.01$).

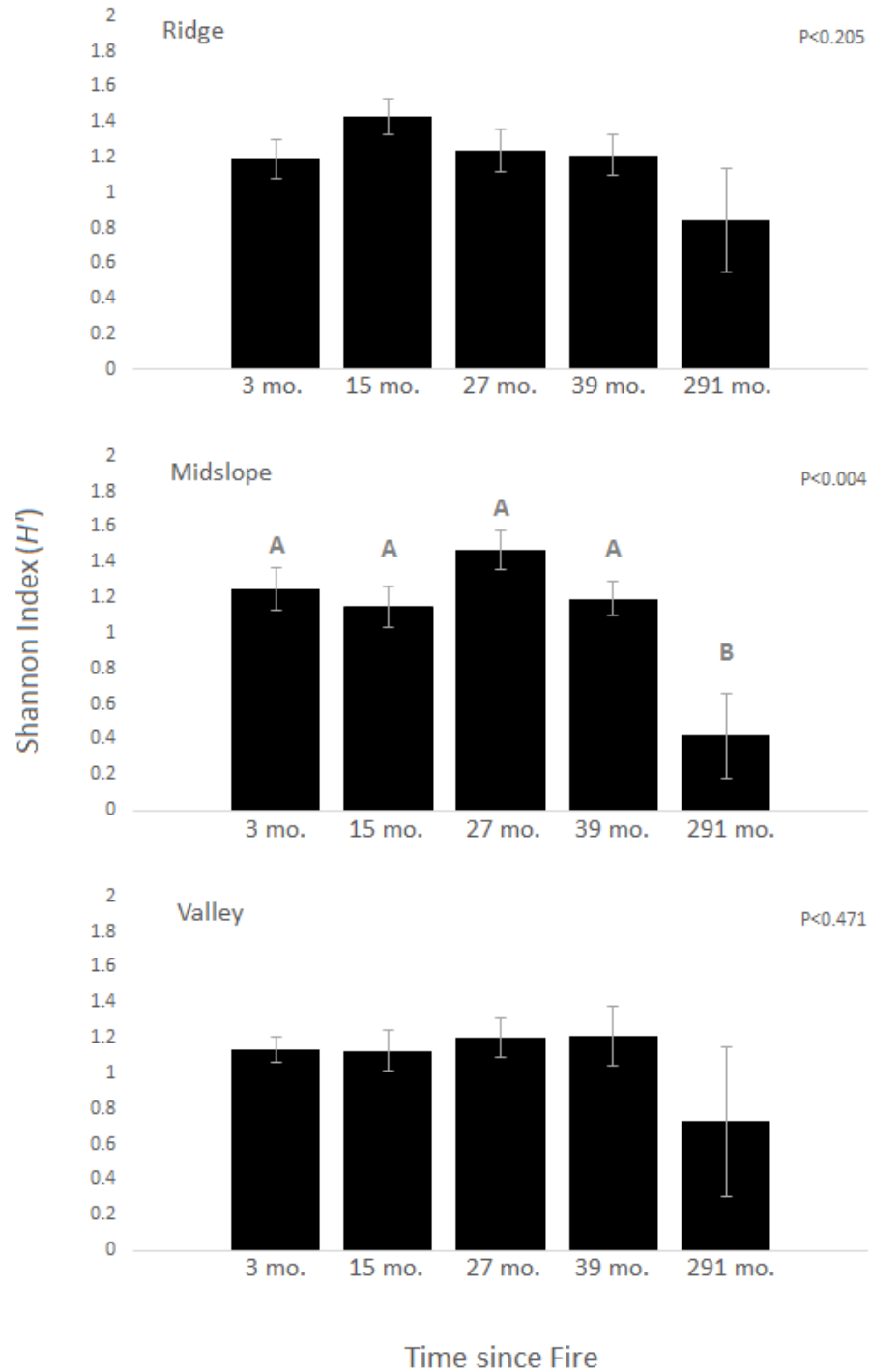


Figure 4.11. Mean indices for the Shannon Information Index for each topographic position by time since fire. Times-since-fire labeled with different letters indicate significantly different means ($P < 0.05$).

Research Question 2

How is plant species diversity in grasslands influenced by productivity and disturbance such as fire on a broad, regional scale?

Plant species richness for the sampled plots at a mid-successional stage revealed a positive relationship across the estimated productivity gradient, whereas sampled plots at a late-successional stage indicated no real relationship. The mid-succession relationship tested statistically significant (Fig. 4.12; $R^2=0.21$, $F=4.79$, $P<0.04$).

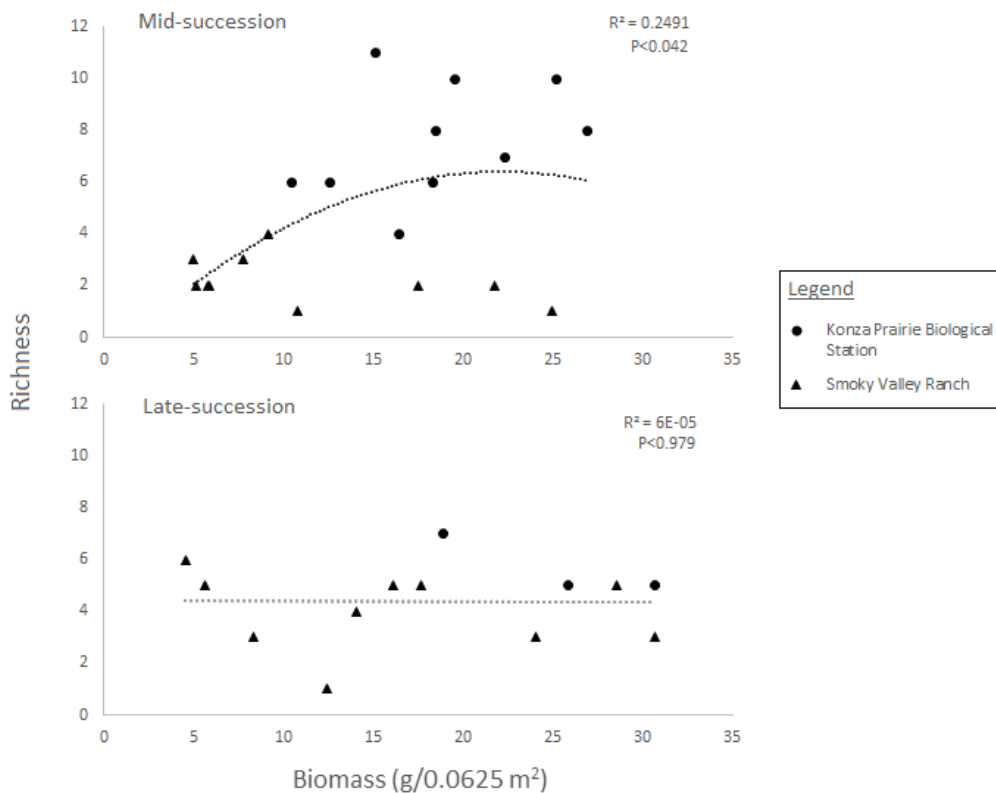


Figure 4.12. Plant species richness at mid- and late-succession by biomass.

A positive trend of indices for the Shannon Information Index for the sampled plots at a mid-successional stage emerged. This trend tested statistically significant (Fig. 4.13; $R^2=0.28$, $F=7.15$, $P<0.02$). The indices under late succession for the sampled plots revealed a negative relationship though it tested statistically insignificant.

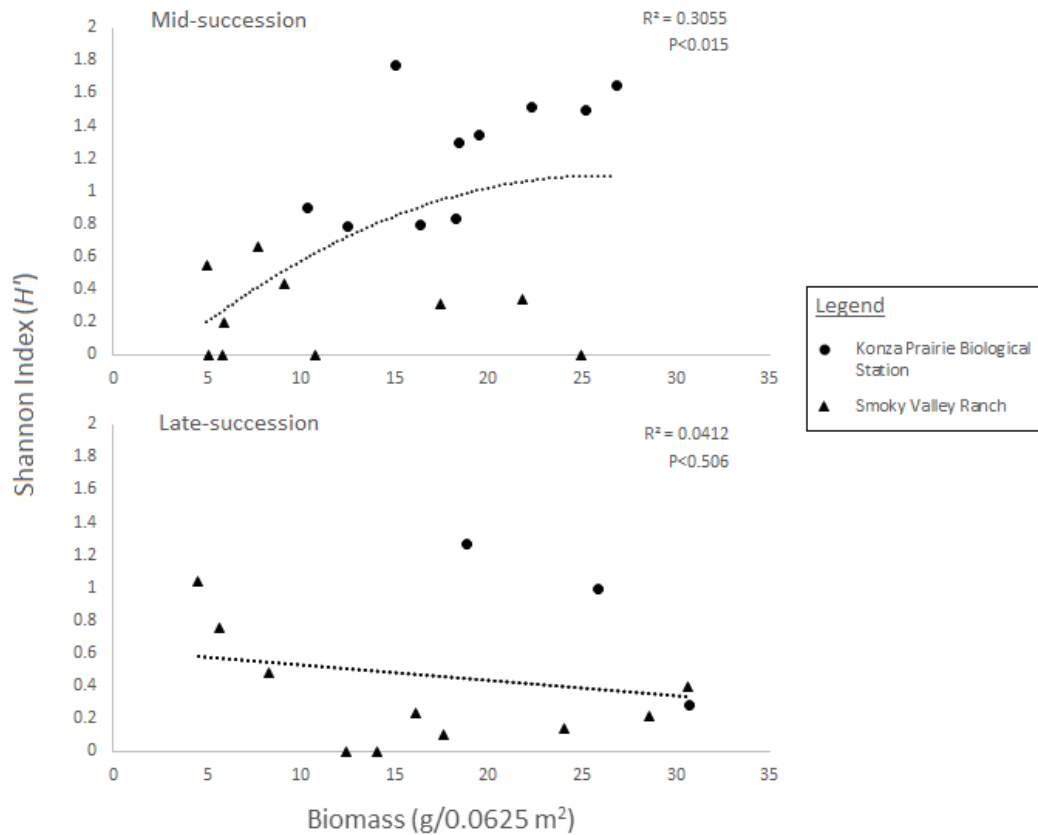


Figure 4.13. Indices for the Shannon Information Index for mid- and late-succession by biomass.

Plant species richness increased from mid- to late-succession for the sampled plots at the drier, Smoky Valley site. These two stages in succession after fire tested significantly different (Fig. 4.14; ANOVA: Smoky Valley: $F=10.57$, $P<0.01$). Plant

species richness for the sampled plots at the wetter, Konza Prairie site decreased from mid- to late-succession though this relationship tested statistically insignificant.

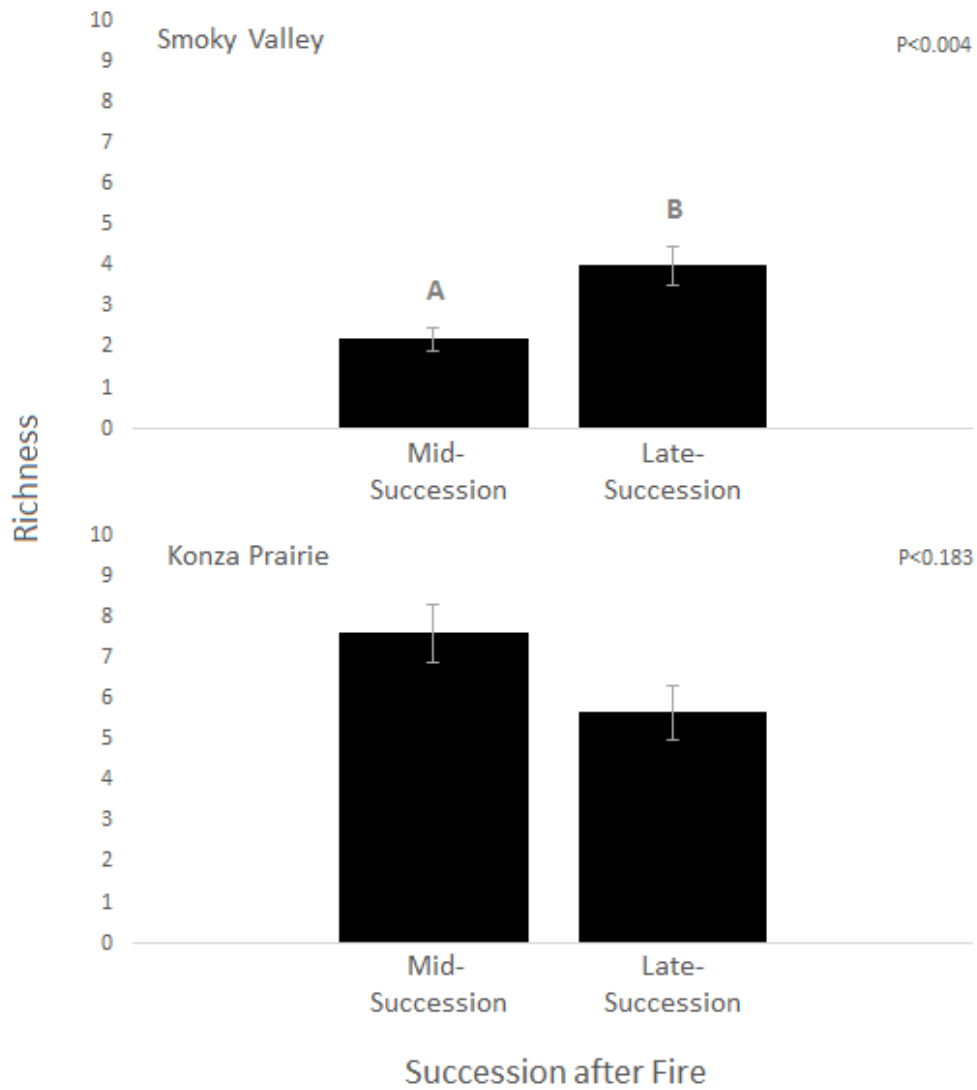


Figure 4.14. Mean plant species richness for both regional sites by succession after fire. Stages in succession labeled with different letters indicate significantly different means ($P < 0.05$).

Indices for the Shannon Information Index increased from mid- to late-succession for the plots sampled at the drier, Smoky Valley site, whereas the indices decreased from mid- to late-succession for the sampled plots at the wetter, Konza Prairie site. Moreover, both of these relationships tested not statistically significant (Fig. 4.15; Table 4.4).

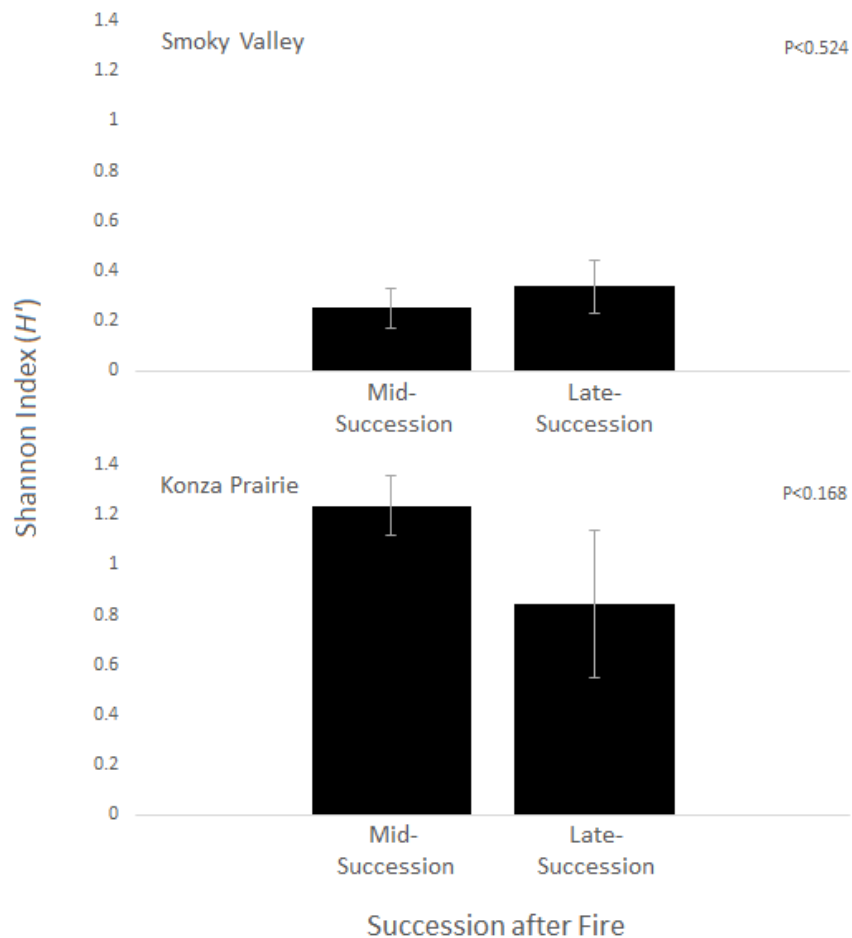


Figure 4.15. Mean indices for the Shannon Information Index for both regional sites by succession after fire.

Table 4.4. ANOVA results for Figure 4.15.

Site	F-value	P-value
Smoky Valley	0.42	0.52
Konza Prairie	2.18	0.17

Research Question 3

*How do the abundances of *Andropogon gerardii*, *Bouteloua curtipendula*, *Panicum virgatum*, *Schizachyrium scoparium*, and *Sorghastrum nutans* vary across a topographic gradient?*

On the ridge at Konza Prairie, percent biomass for *A. gerardii* was lower at 15 months than at 3 months after the previous fire event. Percent biomass increased significantly among sampled plots along an early- to late-successional gradient. At the midslope, percent biomass significantly differed at 291 months following a fire event compared to the other four times sampled across succession for *A. gerardii*. The valley revealed an inverted unimodal trend for the sampled plots for *A. gerardii* though the means of each time sampled across succession were not statistically significant (Fig. 4.16; Table 4.5).

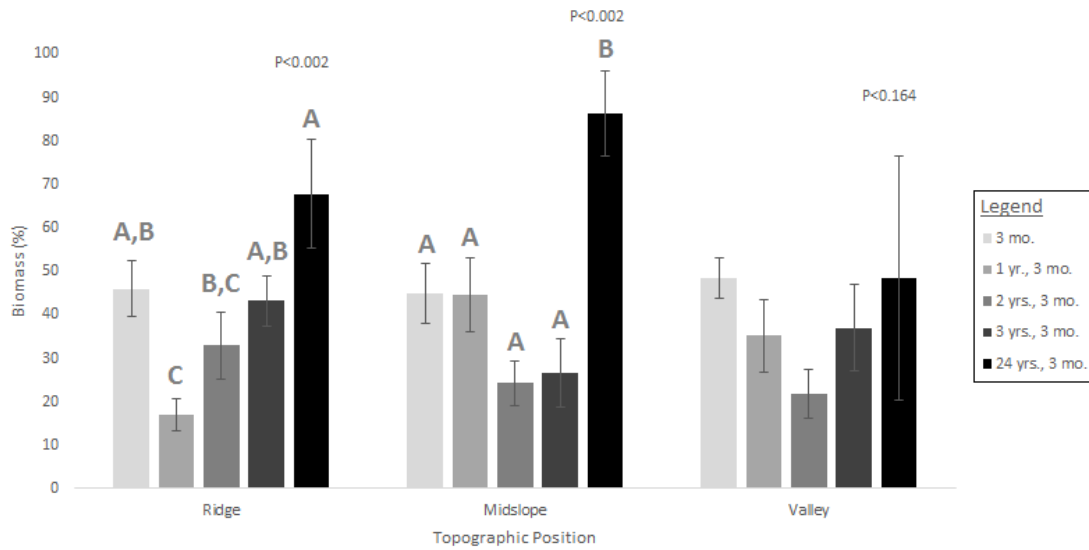


Figure 4.16. Mean percent biomass across succession at each topographic position for *A. gerardii* at Konza Prairie. Stages in succession labeled with different letters indicate significantly different means ($P < 0.05$).

Table 4.5. ANOVA results for Figure 4.16.

Topographic Position	F-value	P-value
Ridge	5.09	0.002
Midslope	5.11	0.002
Valley	1.72	0.164

Three months; 27 months; 39 months; and 291 months following a fire event revealed no significant trend across the topographic positions for *A. gerardii*. However, it did significantly increase from the ridge to the midslope for 15 months after a fire event (Fig. 4.17: Table 4.6).

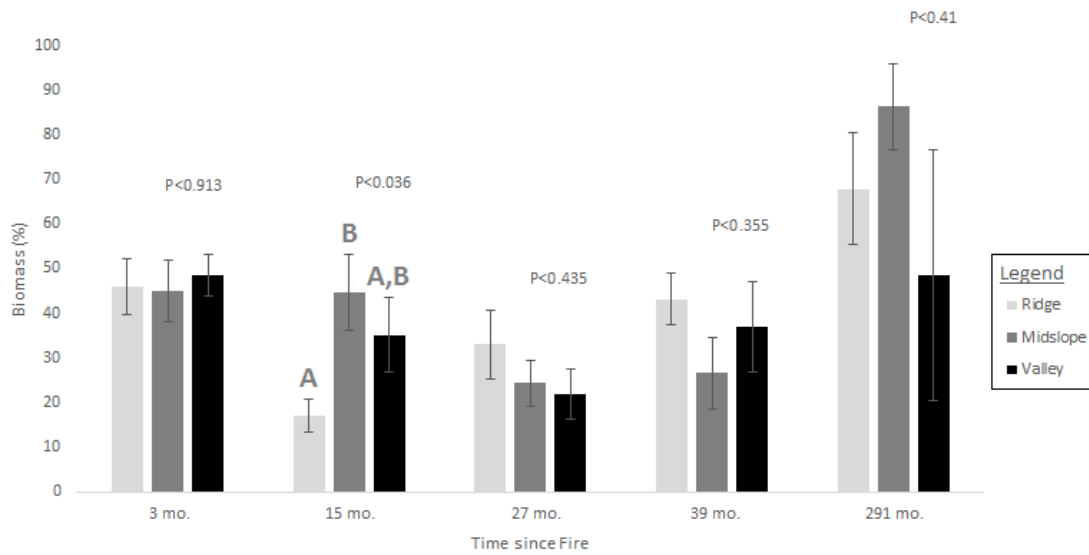


Figure 4.17. Mean percent biomass across topography at different stages in succession for *A. gerardii* at Konza Prairie. Topographic positions labeled with different letters indicate significantly different means ($P < 0.05$).

Table 4.6. ANOVA results for Figure 4.17.

Disturbance interval	F-value	P-value
3 mo.	0.09	0.91
15 mo.	3.78	0.04
27 mo.	0.86	0.44
39 mo.	1.07	0.36
291 mo.	1.04	0.41

Percent biomass did not significantly differ for *B. curtipendula* across succession after fire at the ridge, midslope, or valley at Konza Prairie (Fig. 4.18; Table 4.7).

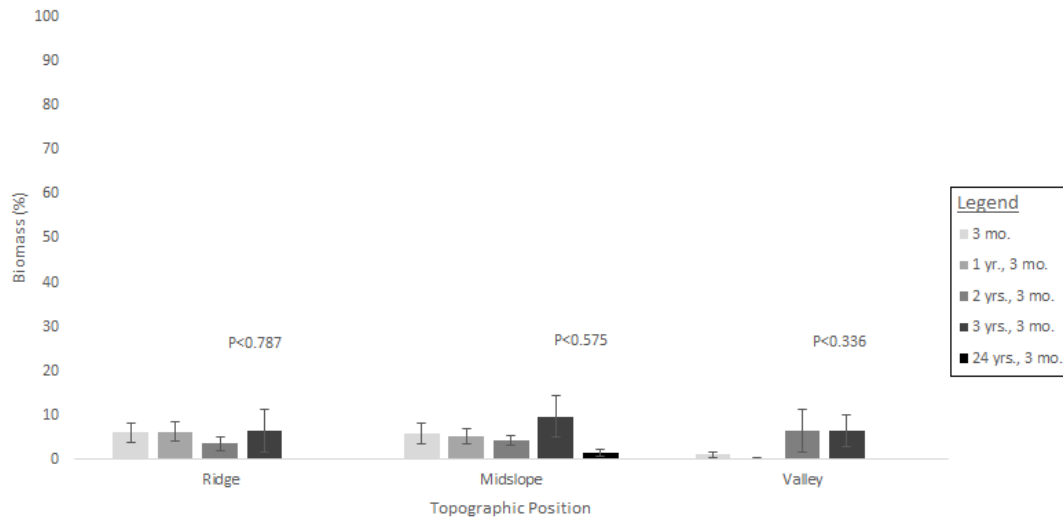


Figure 4.18. Mean percent biomass across succession at each topographic position for *B. curtipendula* at Konza Prairie.

Table 4.7. ANOVA results for Figure 4.18.

Topographic Position	F-value	P-value
Ridge	0.43	0.79
Midslope	0.73	0.56
Valley	1.17	0.34

Fifteen months since a fire event revealed a significant difference between mean percent biomass of the midslope and valley for *B. curtipendula*. The other four times sampled across succession after fire tested statistically insignificant across topography (Fig. 4.19: Table 4.8).

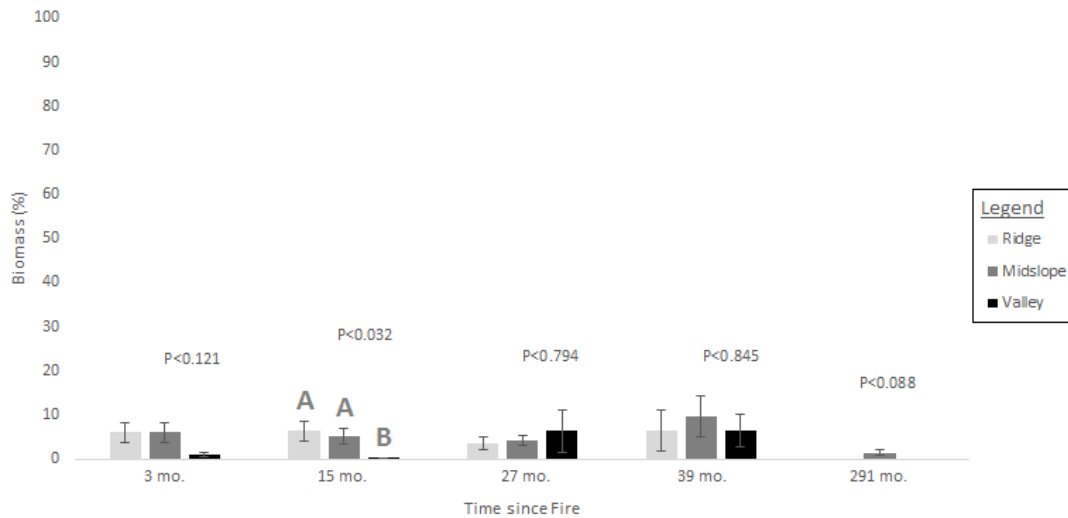


Figure 4.19. Mean percent biomass across topography at different stages in succession for *B. curtipendula* at Konza Prairie. Topographic positions labeled with different letters indicate significantly different means ($P<0.05$).

Table 4.8. ANOVA results for Figure 4.19.

Disturbance interval	F-value	P-value
3 mo.	2.24	0.12
15 mo.	3.94	0.03
27 mo.	0.23	0.79
39 mo.	0.17	0.85
291 mo.	3.74	0.09

The percent biomass for times in succession after fire on the ridge and midslope positions were not significantly different for *P. virgatum* at Konza Prairie. Conversely, the valley revealed a significant decrease in percent biomass as succession increased to 27 months following a fire event after which percent biomass of *P. virgatum* significantly increased as succession ensued (Fig. 4.20; Table 4.9).

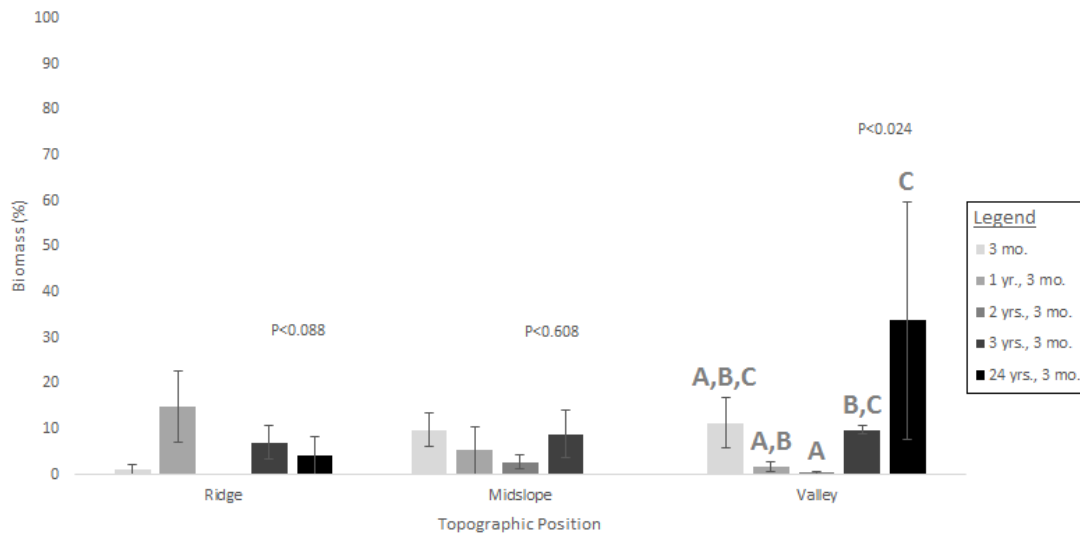


Figure 4.20. Mean percent biomass across succession at each topographic position for *P. virgatum* at Konza Prairie. Stages in succession labeled with different letters indicate significantly different means ($P < 0.05$).

Table 4.9. ANOVA results for Figure 4.20.

Topographic Position	F-value	P-value
Ridge	2.18	0.09
Midslope	0.68	0.61
Valley	3.14	0.02

The percent biomass for all five times-since-fire tested statistically insignificant across topographic position for *P. virgatum* (Fig. 4.21: Table 4.10).

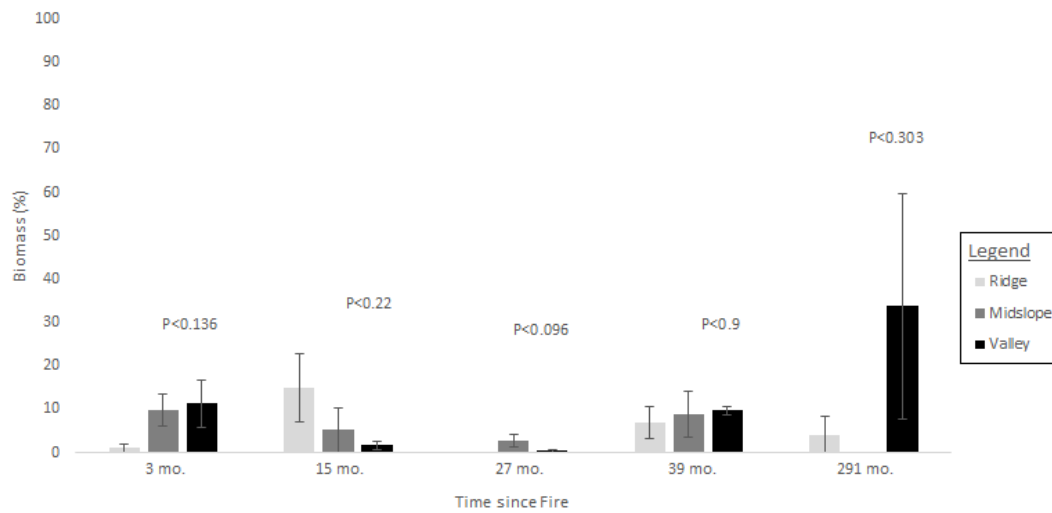


Figure 4.21. Mean percent biomass across topography at different stages in succession for *P. virgatum* at Konza Prairie.

Table 4.10. ANOVA results for Figure 4.21.

Disturbance interval	F-value	P-value
3 mo.	2.11	0.14
15 mo.	1.6	0.22
27 mo.	2.56	0.1
39 mo.	0.11	0.9
291 mo.	1.47	0.3

The percent biomass across succession after fire for *S. scoparium* at Konza Prairie tested statistically insignificant for at the ridge, midslope, and valley (Fig. 4.22; Table 4.11).

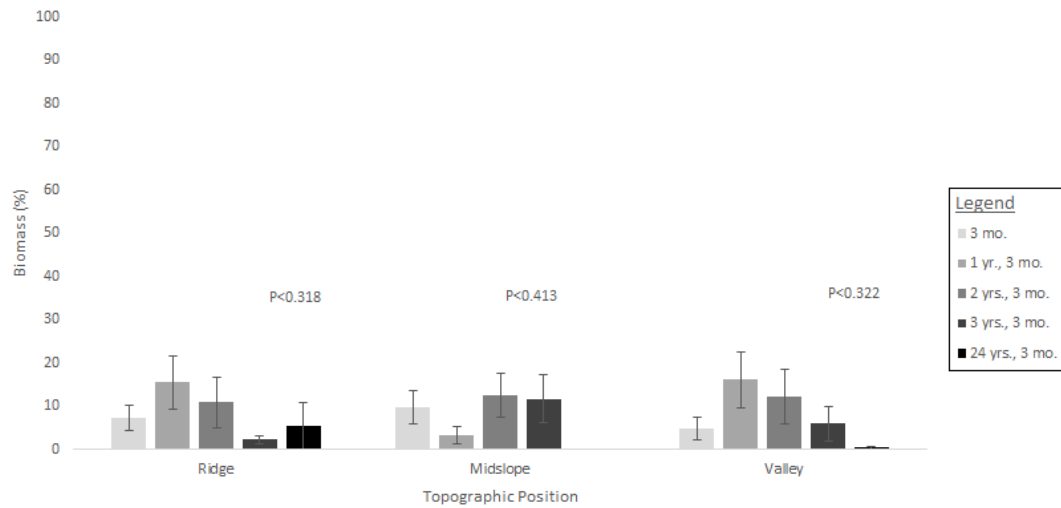


Figure 4.22. Mean percent biomass across succession at each topographic position for *S. scoparium* at Konza Prairie.

Table 4.11. ANOVA results for Figure 4.22.

Topographic Position	F-value	P-value
Ridge	1.22	0.32
Midslope	1.01	0.41
Valley	1.21	0.32

The percent biomass across topographic position for *S. scoparium* was not statistically significant for all five times-since-fire (Fig. 4.23: Table 4.12).

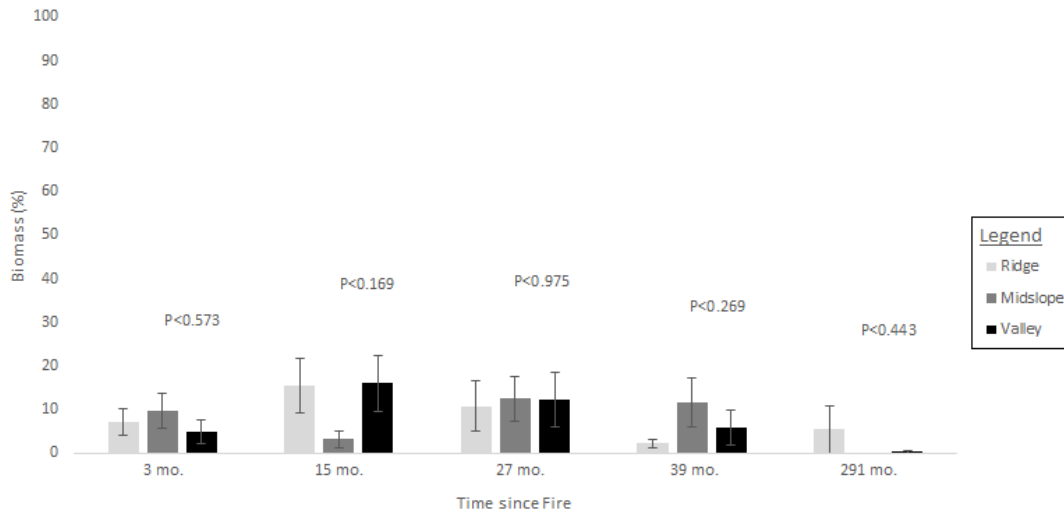


Figure 4.23. Mean percent biomass across topography at different stages in succession for *S. scoparium* at Konza Prairie.

Table 4.12. ANOVA results for Figure 4.23.

Disturbance interval	F-value	P-value
3 mo.	0.57	0.57
15 mo.	1.9	0.17
27 mo.	0.03	0.98
39 mo.	1.38	0.27
291 mo.	0.94	0.44

On the ridge at Konza Prairie, the percent biomass across succession after fire for *S. nutans* tested statistically insignificant. However, percent biomass significantly increased from 27 months to 39 months on the midslope. Furthermore, percent biomass significantly decreased from 15 months to 27 months in the valley (Fig. 4.24; Table 4.13).

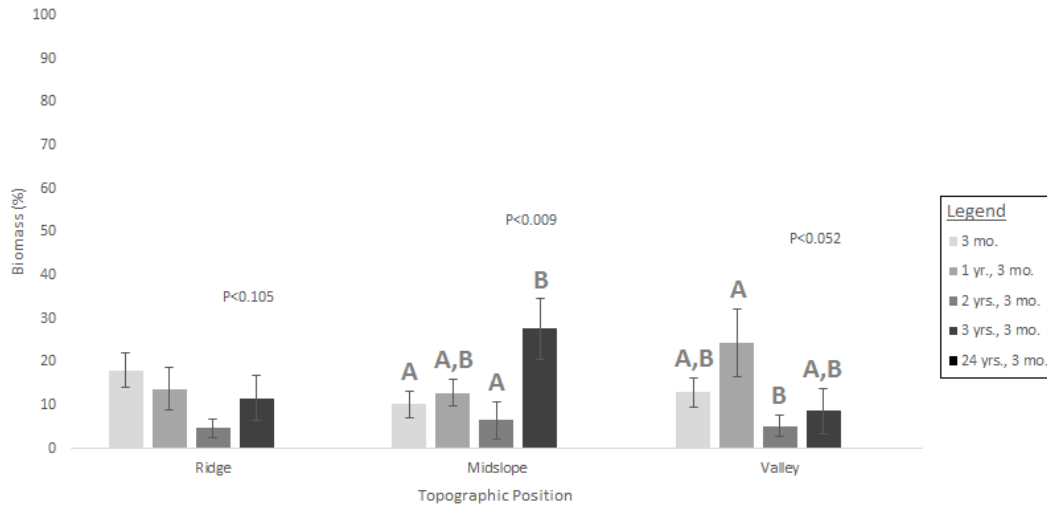


Figure 4.24. Mean percent biomass across succession at each topographic position for *S. nutans* at Konza Prairie. Stages in succession labeled with different letters indicate significantly different means ($P < 0.05$).

Table 4.13. ANOVA results for Figure 4.24.

Topographic Position	F-value	P-value
Ridge	2.05	0.11
Midslope	3.9	0.01
Valley	2.58	0.05

The percent biomass for all five times-since-fire tested statistically insignificant across topographic position for *S. nutans* (Fig. 4.25: Table 4.14).

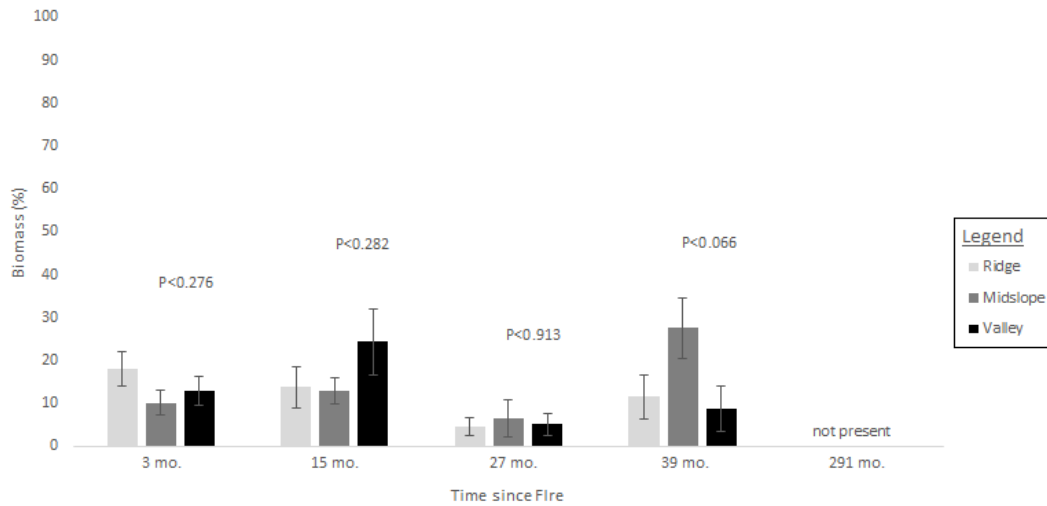


Figure 4.25. Mean percent biomass across topography at different stages in succession for *S. nutans* at Konza Prairie.

Table 4.14. ANOVA results for Figure 4.25.

Disturbance interval	F-value	P-value
3 mo.	1.33	0.28
15 mo.	1.33	0.28
27 mo.	0.09	0.91
39 mo.	3.01	0.07
291 mo.	no species	no species

Research Question 4

*How does the abundance of *B. curtispindula* vary across a regional gradient?*

The percent biomass of *B. curtispindula* tested statistically insignificant between mid- and late-successional stages following a fire event at the drier, Smoky Valley site and the wetter, Konza Prairie site (Fig. 4.26; Table 4.15).

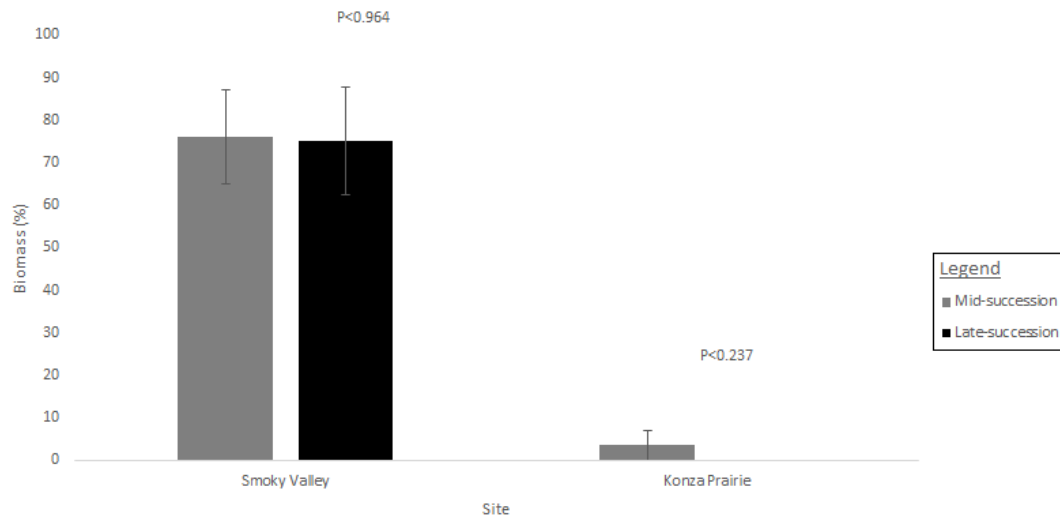


Figure 4.26. Mean percent biomass at mid- and late-successional stages at both sites for *B. curtipendula*.

Table 4.15. ANOVA results for Figure 4.26.

Site	F-value	P-value
Smoky Valley	0.00	0.96
Konza Prairie	1.56	0.24

Conversely, the percent biomass of *B. curtipendula* significantly decreased from Smoky Valley to Konza Prairie at mid- and late-successional stages (Fig. 4.27; Table 4.16).

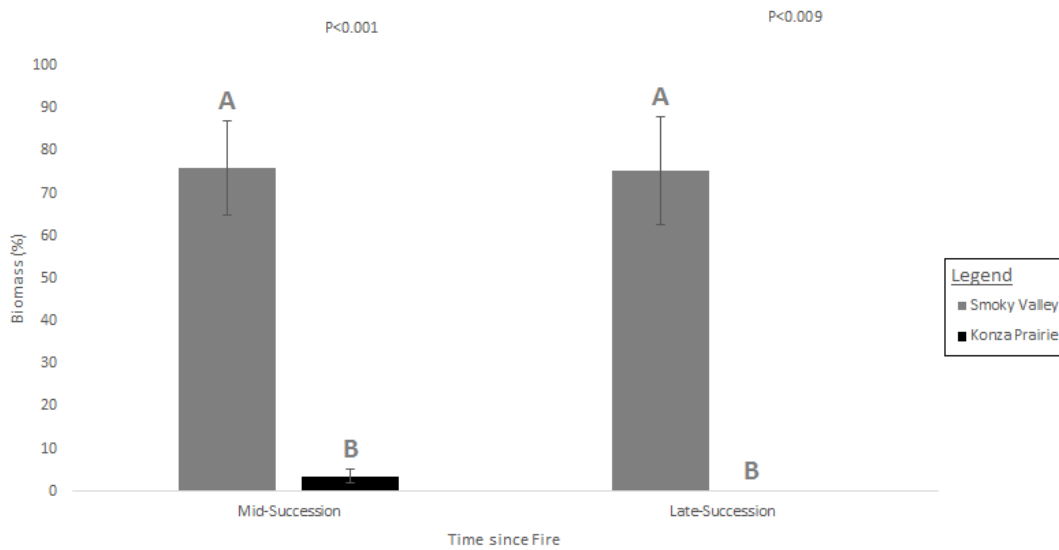


Figure 4.27. Mean percent biomass at both sites at mid- and late-successional stages for *B. curtipendula*. Sites labeled with different letters indicate significantly different means ($P < 0.05$).

Table 4.16. ANOVA results for Figure 4.27.

Site	F-value	P-value
Mid-Succession	42.42	0.01
Late-Succession	9.94	0.01

CHAPTER V

DISCUSSION AND CONCLUSION*

Discussion

How is species diversity of grassland plants affected by productivity and disturbance such as fire on a fine, topographic scale?

Plant species diversity varying across a topographic, productivity gradient can be based on how biomass collects over time. Biomass accumulates more in the valley than on the ridge. This increase in biomass over topography indicates a fine-scale productivity gradient. This pattern is attributed to an increase in moisture and the increase depth in soil from ridge to valley. Therefore, this topographic gradient serves as an appropriate way to gauge a gradient in productivity and evaluate models in which predictions of plant species diversity are attempted. However, there was no significant difference in plant species richness nor the Shannon indices along this topographic, productivity gradient to support the unimodal trend predicted by the Intermediate Productivity Hypothesis (Grime 1973). Similarly, percent productivity did not reveal a unimodal trend in plant species richness nor the Shannon indices as suggested by the Intermediate Productivity Hypothesis.

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Plant species diversity varying across a disturbance gradient tests the capabilities of the Intermediate Disturbance Hypothesis. Connell (1978) proposes this hypothesis that relates how diversity levels differ along a time continuum since the previous disturbance event. Only the plots sampled in an old-growth prairie (burned 291 months prior to sampling) significantly differed from all the other plots burned much more recently. Therefore, I find no comprehensive support for the Intermediate Disturbance Hypothesis.

Since the findings for the Intermediate Productivity Hypothesis and the Intermediate Disturbance Hypothesis oppose their predictions, other predictive models of diversity are needed to be assessed such as the Dynamic Equilibrium Model proposed by Huston (1979; 2014). Huston (1979; 2014) proposed that productivity and disturbance should not be considered independently, but rather where they interact with one another to produce varying levels of diversity.

Although the Dynamic Equilibrium Model suggests that plant species diversity will vary across productivity at different stages in succession, none of the observed trends for either plant species richness or the Shannon indices significantly support these predictions. In addition, neither plant species richness nor the Shannon indices supported the expected trends in plant species diversity as predicted by the Dynamic Equilibrium Model across succession at different levels of productivity. Although the predicted unimodal trend emerged at the midslope across succession after fire, only the plots sampled in an old-growth prairie (burned 291 months prior to sampling) significantly differed from those plots burned much more recently. Therefore, no

comprehensive support was found to support the predictive capabilities of the Dynamic Equilibrium Model.

Overall, no significant trends can be concluded in plant species diversity across productivity and disturbance gradients. Several factors likely have influence on the findings. The antecedent conditions to time of sampling, particularly the precipitation received in the month of May, likely increased the sampled productivity values to exist at the upper bounds or exceed what is commonly associated as a productivity range for a tallgrass prairie. The high amount of precipitation likely telescoped the diversity across the topographic gradient to be similar. May received 272.6 mm of rainfall in 2015, which greatly exceeds its average rainfall of 129 mm (Fig. 5.1).

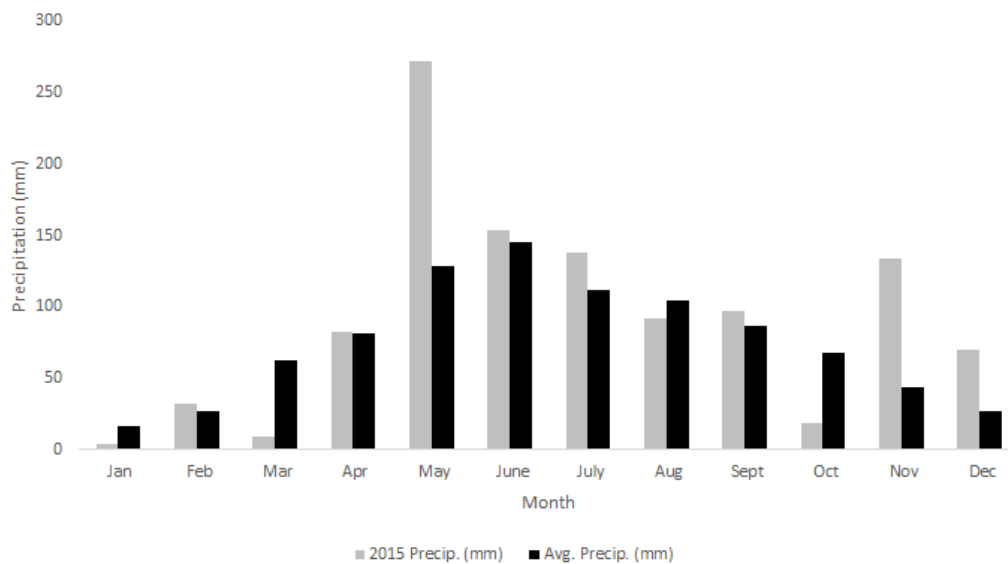


Figure 5.1. Precipitation (mm) for 2015 and the average at Konza Prairie by month.

Biomass clipped in June of 2015 after previously burned in March of 2015 (i.e., 3 months after previous fire event) produced an average of 301.46 g/m² and a maximum of 740.16 g/m². These values only represent the first half of the growing season (Craine *et al.* 2012). While during an entire growing season, tallgrass prairies in northeastern Kansas typically produce 180-473 g/m² (Risser *et al.* 1981). Hulbert (1969) found that a tallgrass prairie produced 180 g/m² and Anderson *et al.* (1970) found that a tallgrass prairie produced 325-473 g/m². Anderson *et al.* (1970) examined an area that burned annually from 1950 to 1966. The values I observed at Konza Prairie would likely be situated at the upper extent of this range in productivity for a tallgrass prairie or even exceed it due to sampling time conducted halfway through the growing season with peak biomass occurring toward the end of the growing season (McCulley 2002). These high productivity values would only confine to the upper restricted portion of the productivity gradient (Fig. 5.2). Therefore, the predictive capabilities of the Dynamic Equilibrium Model for this study can only be assessed at the upper portion of the productivity gradient. Plant species diversity would not differ greatly under high productivity at different points across a disturbance gradient (Huston 2014). Since the plant species diversity for all five times-since-fire did not significantly differ across the sampled productivity, support is found for the small, upper portion that was sampled along a productivity gradient because the Dynamic Equilibrium Model does not predict significant variation in diversity at high productivity. However, this does not mean that full support was concluded for the predictive capabilities of the Dynamic Equilibrium Model. This is simply because the entire productivity gradient for a tallgrass prairie was

unable to be examined. It would be interesting to see how diversity would vary if the productivity variable were controlled. This could be accomplished with a gradient of regimented water amounts and nutrients such as nitrogen.

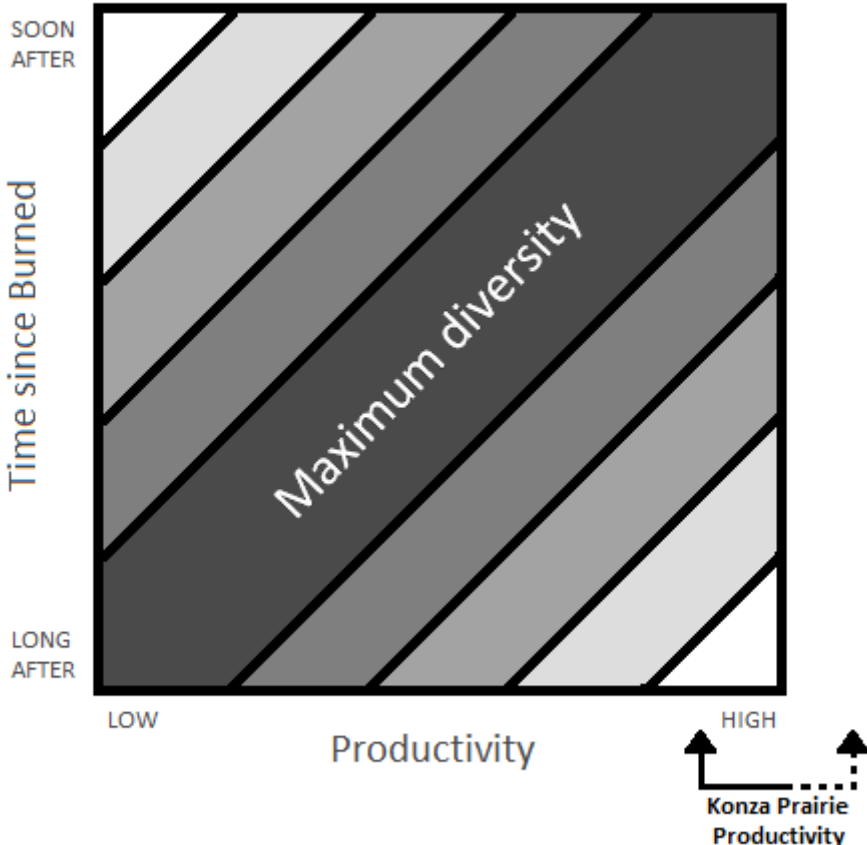


Figure 5.2. Productivity values at Konza Prairie shown at the upper end of the productivity gradient. Adapted from Huston (2014).

Productivity and fire can favor dominance of plant types such as with perennial plants, which alters the diversity of plant species. Perennial plant species dominate at Konza Prairie. Most sampled plots contained either zero or one annual plant species with the annual plant species count never exceeding two for any plot. This was even the case under recently burned conditions (i.e., 3 months since fire event), where annual plants would be expected to dominate at early-stage succession. The dominating perennial grass species have deep-extending roots up to six meters long and belowground rhizomes that are protected from the effects of fire (Weaver 1954). These belowground structures allow for resilience of perennial grasses following a fire event and other disturbances (Weaver 1954). Therefore, this precludes the establishment of many annual plants and therefore, reducing the plant species diversity.

There are certain conditions that maximize the dominance of perennial species such as season of burn and influence of grazing by herbivores. Season of burn regulates the dominance of C₃ and C₄ species, which differ in the way they fix CO₂ (Betts 2015). C₃ species are cool-season plants that are optimized at 18-24°C, whereas C₄ species are warm-season plants that are optimized at 32-35°C (Betts 2015). C₄ species are better adapted to higher temperatures due to their leaf anatomy that allows them to efficiently conduct photosynthesis with little fixed CO₂ being lost (Betts 2015). Though C₄ species can be either annual or perennial, the majority of the native C₄ tall- and mid-grass species that occur at Konza Prairie are perennials such as *Andropogon gerardii*, *Sorghastrum nutans*, *Panicum virgatum*, *Schizachyrium scoparium*, and *Bouteloua curtipendula* (Betts 2015). Konza Prairie predominantly conducts its prescribed burns in

the spring. Spring burning reduces C₃ species, which dominate during the spring as they are cool-season plants (Anderson *et al.* 1970). Therefore, C₄ species are permitted to prosper in the absence of the C₃ species (Anderson *et al.* 1970). Moreover, since the sampled plots were burned in the springs at Konza Prairie, this is conducive to the establishment of only several dominant C₄ species, driving plant species diversity to be low. Conversely, C₃ species gain dominance if grasslands burn in the summer or early fall by reducing C₄ perennial grasses that dominate the warm season (Anderson *et al.* 1970). C₃ dominance allows for the establishment of many forbs alongside cool-season grasses. Therefore, higher plant species diversity would be predicted under summer to early fall burns, where the fewer, dominant perennial grasses would be reduced. Since all the plots were sampled in areas burned in the spring, C₄ dominance was observed, which reduced the variability of plant species diversity across the gradients of productivity and disturbance.

Though fire influences plant species diversity, other disturbances such as grazing regulate it as well. Large herbivores, such as bison and cattle, have been found to increase plant species diversity (Olf & Ritchie 1998). Fire-grazing interactions, known as pyric herbivory, also influence plant species diversity (Fuhlendorf *et al.* 2009). Pyric herbivory suggests that herbivores are more likely to graze areas that burn under fire frequencies most conducive for reestablishment of preferentially grazed species. Tallgrass prairies in the southern Great Plains support pyric herbivory claims, where bison and random fire events promoted heterogeneity, species diversity, and ecosystem functions (Fuhlendorf *et al.* 2009). Fuhlendorf *et al.* (2009) proposes that landscapes

disturbed under high and low intensities from pyric herbivory create a shifting-mosaic landscape and therefore, greater heterogeneity and higher gamma species diversity. Furthermore, high and low intensities from pyric herbivory disturbance produces greater animal species diversity such as with grassland birds, resulting in greater ecosystem functionality (Fuhlendorf *et al.* 2009). The C₄, warm-season grasses are preferred by grazers because weight gain on these animals is greatest when grazed in areas burned during the spring, which promotes the establishment of these C₄ grasses (Anderson *et al.* 1970). Also, grazers prefer warm-season grasses because the protein contents from them are more efficiently used (Betts 2015). Collins *et al.* (1998) found high C₄ grass dominance and low C₃ species richness in tallgrass prairies that were burned and ungrazed, whereas C₃ forbs significantly increased with the addition of grazing. Moreover, C₄ species richness increased under a burned and grazed treatment (Collins *et al.* 1998). Therefore, Collins *et al.* (1998) concluded that plant species diversity increased when grazing by native herbivores was present. Collins and Calabrese (2012) concluded similarly to Collins *et al.* (1998) and Fuhlendorf *et al.* (2009), finding species diversity maximized under infrequent burning and grazed condition and finding species diversity minimized under frequent burning and ungrazed conditions. In general, due to warm-season grasses being favored by herbivores, grazing regulates the abundance of these C₄ species without removal of them, allowing space for the presence of C₃ species in addition. Since all plots were only sampled under a fire disturbance without any presence of grazing, plant species diversity was reduced, creating a more homogenous landscape.

How is plant species diversity in grasslands influenced by productivity and disturbance such as fire on a broad, regional scale?

Plant species diversity significantly increased at mid-succession across productivity, which disagrees with the unimodal predictions of the Dynamic Equilibrium Model. Late-succession of plant species diversity revealed no significant trend.

Plant species diversity increased from mid- to late-succession at Smoky Valley, aligning with the predictions of the Dynamic Equilibrium Model. Konza Prairie demonstrated a decrease from mid- to late-succession in plant species diversity, providing support for the predictions of the Dynamic Equilibrium Model though both were insignificant.

Scaling the succession after fire gradient causes difficulties because expected trends are attempted to be compared to observed trends. Therefore, these points in succession were classified under early-, mid-, or late-succession. Data sampling reflects a discontinuous gradient, in contrast to the continuous gradient demonstrated by the theoretical model from the literature. This is a limitation for fitting observed data to theoretical models.

Interesting trends emerged from this regional, climatic gradient though only some light was shed on the predictive capabilities of the Dynamic Equilibrium Model. This resulted from some of the necessary data being absent that would have been useful in gaining a fuller understanding of how productivity and disturbance influence grassland plant species diversity at a regional scope. Huston (2014) states that a

minimum of three levels of productivity and disturbance are needed to evaluate the full gradient of both variables. Since only two levels of productivity and disturbance were assessed, only portions of these gradients were able to be examined. Presence and absence data to assess the regional component of this study adequately are outlined in Figure 5.3.

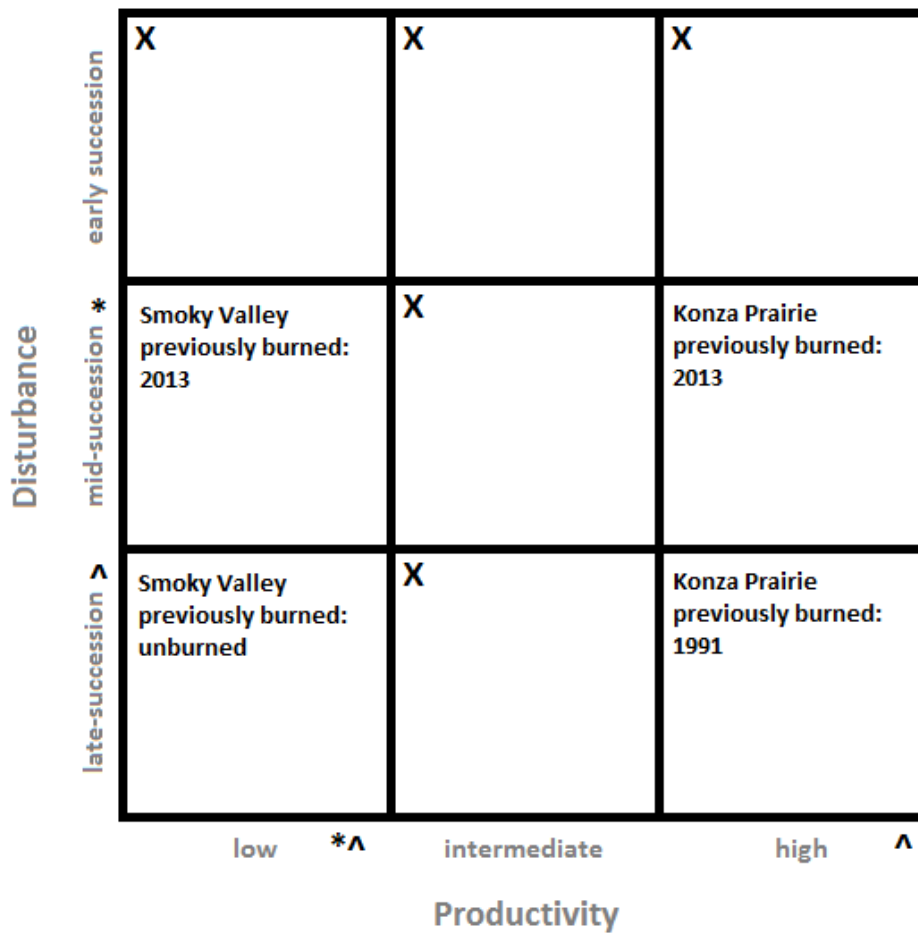


Figure 5.3. Presence and absence of data at fixed points in succession across productivity and at fixed points in productivity across succession.

* indicates significance

^ indicates support for predictions of the Dynamic Equilibrium Model

X indicates absence of data

Furthermore, it would be interesting to evaluate the predictive capabilities of the Dynamic Equilibrium Model in other biome types. Huston (1979; 2014) suggests that the Dynamic Equilibrium Model can be applied to all types of ecosystems as long as a minimum of three levels of both productivity and disturbance are examined. For example, in marine sub-stratum assemblages, Svensson *et al.* (2007) did not find support for the Dynamic Equilibrium Model. So, the Dynamic Equilibrium Model has been tested in other biome types; however, to know whether the diversity of particular biomes would fit its predictions, extensive studies would be needed in many different types of biomes.

How do the abundances of Andropogon gerardii, Bouteloua curtipendula, Panicum virgatum, Schizachyrium scoparium, and Sorghastrum nutans vary across a topographic gradient?

The tallgrass species, *A. gerardii*, *P. virgatum*, and *S. nutans*, require higher moisture content. Therefore, these species are most likely to establish dominance in the valley lowlands (Weaver 1954). Smith & Huston (1989) suggest that species are restricted to certain zones through space and time such as along a topographic productivity gradient or through succession after fire. Therefore, these tallgrass species should be most prominent where productivity is highest and increase in their dominance as time since fire increases. None of these species were significantly greater in the valley or increase in dominance after time since a fire event elapsed. This is likely a result of the high productivity experienced at Konza Prairie at the time of sampling.

This created a range in high productivity that did not allow for these species abundances to vary spatially or temporally as predicted.

The mid-grass species, *B. curtipendula* and *S. scoparium*, require less moisture compared to the tallgrass species. Therefore, these species are more likely to occur in the xeric uplands (Weaver 1954). Smith & Huston (1989) suggest that mid-grass species would be more prominent under low productivity and recently following a fire. Overall, neither of these species were most prominent where productivity was low or where fire recently disturbed an area. The only instance that supported these predictions was for *B. curtipendula*, where its abundance significantly decreased from ridge to valley at 15 months following a fire event. However, the other non-supportive findings for these two species are also likely a result of the high productivity sampled at Konza Prairie. The higher productivity allowed for the tallgrass species to be more prominent and reduce the presence of the mid-grass species. Therefore, the abundance of the mid-grasses did not comprehensively vary spatially or temporally as predicted.

How does the abundance of B. curtipendula vary across a regional gradient?

With decreasing moisture from east to west across the grasslands of North America, the establishment of drought-tolerant species is favored. Smith & Huston (1989) propose that species are restricted to distinct zones in space and time such as along a regional productivity gradient or through succession after fire. Under these assumptions, the drought-tolerant, *B. curtipendula*, would increase dominance as moisture decreases across the productivity gradient, particularly when fire has been

absent for longer stretches of time. This prediction was supported as there was a significant increase in the percent biomass of *B. curtipendula* from Konza Prairie to Smoky Valley. However, there was no significant difference of percent biomass between mid- and late-stage succession for either site though only two points along succession were able to be sampled, which does not allow for adequate assessment. *B. curtipendula* is able to dominate in the drier landscapes due to its drought tolerance and conditions unfavorable for establishment of competitive species.

Conclusion

I expected to find dramatic variation in plant species diversity across productivity and disturbance. Diversity was expected to be greatest where productivity and disturbance equilibrated one another and diminish as those gradients fell out of equilibrium. However, I found no significant variation in diversity across these gradients, which is likely a result of several factors. The productivity at the time of sampling was likely confined to the upper extent of the productivity range for a tallgrass prairie. Therefore, the minimal variation in diversity that was observed would be expected as only a small portion of the productivity gradient could be assessed. However, the predictive capabilities of the remainder of the Dynamic Equilibrium Model remain unknown as the full range in tallgrass prairie productivity was not observed. Spring burning likely also influenced a lessened diversity as it promotes competitive, warm-season grasses. Finally, lack of grazing likely lessened diversity as

herbivores preferentially consume those competitive, warm-season species, which regulates their dominance and allows for other species to establish alongside of them.

Patterns in plant species diversity show that productivity and disturbance likely play a role in their distributions though several other factors are also influential. The sampled productivity of the tallgrass prairie site for this research does not likely encapsulate a wide enough range to assess plant species diversity adequately. However, a regional gradient in productivity does span widely. Disturbance is a key element in grassland dynamics with type, time of year, and intensity vastly producing wide ranges in plant species diversity. These grasslands evolved out of fire. Particular species are well-suited to dominate under conditions of frequent fire, resulting in diminished plant species diversity. When other disturbances, such as grazing, are present, these fire-evolved grasses are regulated by the herbivores, allowing many other species to flourish and maximize plant species diversity. The time of year fire is present in these grasslands determines species types and therefore, how plant species diversity varies.

This study shows that productivity and disturbance have influences on plant species diversity. However, particular characteristics of those variables such as a full range in productivity, the type of disturbance, and when a disturbance is present are likely important factors to consider regarding diversity. Therefore, more studies are needed to control productivity by applying different levels of water and nutrients to the plants to encapsulate the entire gradient so that diversity under different disturbance types and when they are present can be evaluated to fully assess the predictive capabilities of the Dynamic Equilibrium Model.

REFERENCES

- Aber, J.S. 1991. The glaciation of northeast Kansas. *Boreas* 20:297-314.
- Abrams, P.A. 1995. Monotonic or unimodal diversity-productivity gradients: what does competition theory predict? *Ecology* 76 (7):2019-2027.
- Adler, P. B., E. W. Seabloom, E. T. Borer, H. Hillebrand, Y. Hautier, A. Hector, W. S. Harpole, L. R. O'Halloran, J. B. Grace, T. M. Anderson, J. D. Bakker, L. A. Biederman, C. S. Brown, Y. M. Buckley, L. B. Calabrese, C. J. Chu, E. E. Cleland, S. L. Collins, K. L. Cottingham, M. J. Crawley, E. I. Damschen, K. F. Davies, N. M. DeCrappeo, P. A. Fay, J. Firn, P. Frater, E. I. Gasarch, D. S. Gruner, N. Hagenah, J. H. R. Lambers, H. Humphries, V. L. Jin, A. D. Kay, K. P. Kirkman, J. A. Klein, J. M. H. Knops, K. J. La Pierre, J. G. Lambrinos, W. Li, A. S. MacDougall, R. L. McCulley, B. A. Melbourne, C. E. Mitchell, J. L. Moore, J. W. Morgan, B. Mortensen, J. L. Orrock, S. M. Prober, D. A. Pyke, A. C. Risch, M. Schuetz, M. D. Smith, C. J. Stevens, L. L. Sullivan, G. Wang, P. D. Wragg, J. P. Wright, and L. H. Yang. 2011. Productivity Is a Poor Predictor of Plant Species Richness. *Science* 333 (6050):1750-1753.
- Al-Mufti, M.M., C.L. Sydes, S.B. Burness, J.P. Grime, and S.R. Band. 1977. A quantitative analysis of shoot phenology and dominance in herbaceous vegetation. *Journal of Ecology* 65 (3):759-791.
- Anderson, K.L., E.F. Smith, and C.E. Owensby. 1970. Burning bluestem range. *Journal of Range Management* 23 (2):81-92.
- Aronson, R.B. and W.F. Precht. 1995. Landscape patterns of reef coral diversity: A test of the intermediate disturbance hypothesis. *Journal of Experimental Marine Biology and Ecology* 192:1-14.
- Ashton, P.S. 1977. A contribution of rain forest research to evolutionary theory. *Annals of the Missouri Botanical Garden* 64 (4):694-705.
- Beadle, N.C.W. 1966. Soil phosphate and its role in molding segments of the Australian flora and vegetation, with special reference to xeromorphy and sclerophylly. *Ecology* 47 (6):992-1007.
- Beckage, B. and J.I. Stout. 2000. Effects of repeated burning on species richness in a Florida pine savanna: A test of the intermediate disturbance hypothesis. *Journal of Vegetation Science* 11:113-122.

- Bell, E.L., C.M. Call, J.S. Hagihara, L.D. Linnell. 1964. Soil Survey of Logan County, Kansas. *United States Department of Agriculture (Soil Conservation Service) and Kansas Agricultural Experiment Station Series 1959*, No. 35.
- Betts, D.L. 2015. What is the difference between C₃ plants and C₄ plants? *Kansas State University Research and Extension*.
- Blackburn, T.M. and K.J. Gaston. 1996. A sideways look at patterns in species richness, or why there are so few species outside the tropics. *Biodiversity Letters* 3 (2):44-53.
- Blair, J.M. 1997. Fire, N availability, and plant responses in grasslands: a test of the transient maxima hypothesis. *Ecology* 78 (8):2359-2368.
- Blecker, S.W., R.L. McCulley, O.A. Chadwick, E.F. Kelly. 2006. Biological cycling of silica across a grassland bioclimate sequence. *Global Biogeochemical Cycles* Vol. 20, GB3023.
- Bond, W. 1983. On alpha diversity and the richness of the Cape Flora: a study in Southern Cape Fynbos. Chapter 19 in *Mediterranean-Type Ecosystems* F.J. Kruger *et al.* (eds.) pp 337-356.
- Chapin III, F. S., E. S. Zavaleta, V. T. Eviner, R. L. Naylor, P. M. Vitousek, H. L. Reynolds, D. U. Hooper, S. Lavorel, O. E. Sala, S. E. Hobbie, M. C. Mack, and S. Diaz. 2000. Consequences of changing biodiversity. *Nature* 405 (6783):234-242.
- Coblentz, D. D., and K. H. Riitters. 2004. Topographic controls on the regional-scale biodiversity of the south-western USA. *Journal of Biogeography* 31 (7):1125-1138.
- Colwell, R.K. and G.C. Hurtt. 1994. Nonbiological gradients in species richness and a spurious Rapoport effect. *American Naturalist* 144:570-595.
- Collins, S.L. 1990. Introduction: fire as a natural disturbance in tallgrass prairie ecosystems. In *Fire in North American Tallgrass Prairies*, edited by S.L. Collins and L.L. Wallace. University of Oklahoma Press, Norman, OK. p 3-7.
- Collins, S.L., S.M. Glenn, and D.J. Gibson. 1995. Experimental Analysis of Intermediate Disturbance Hypothesis and Initial Floristic Composition: Decoupling Cause and Effect. *Ecology* 76 (2):486-492.
- Collins, S.L. and E.M. Steinauer. 1998. Geomorphology of Konza Prairie--Chapter 9 of *Grassland dynamics*. -- Oxford Univ. Press. 140-156.

- Collins, S.L., A.K. Knapp, J.M. Briggs, J.M. Blair, and E.M. Steinauer. 1998. Modulation of diversity by grazing and mowing in native tallgrass prairie. *Science* 280 (745):745-747.
- Collins, S.L. and L.B. Calabrese. 2012. Effects of fire, grazing and topographic variation on vegetation structure in tallgrass prairie. *Journal of Vegetation Science* 23:563-575.
- Connell, J.H. and E. Orias. 1964. The ecological regulation of species diversity. *The American Naturalist* 98 (903):399-414.
- Connell, J.H. 1978. Diversity in Tropical Rain Forests and Coral Reefs. *Science* 199 (4335):1302-1310.
- Cracraft, J. 1992. Explaining the patterns of biological diversity: integrating causation at different spatial and temporal scales. In Eldredge, N., editors, *Systematics ecology, and the biodiversity crisis*, New York: Columbia University Press, 59-76.
- Craine, J.M., E.M. Wolkovich, E.G. Towne. 2012. The role of shifting and filtering in generating community-level flowering phenology. *Ecography* 35:1033-1038.
- Dix, R.L. and F.E. Smeins. 1967. The prairie, meadow, and marsh vegetation of Nelson County, North Dakota. *Canadian Journal of Botany* 45:21-58.
- Egler, F.E. 1954. Vegetation science concepts I. Initial floristic composition, a factor in old-field vegetation development. *Vegetatio* 4:412-417.
- Eo, S. H., J. P. Wares, and J. P. Carroll. 2008. Population divergence in plant species reflects latitudinal biodiversity gradients. *Biology Letters* 4 (4):382-384.
- Flöder, S. and U. Sommer. 1999. Diversity in planktonic communities: An experimental test of the intermediate disturbance hypothesis. *Limnology Oceanography* 44 (4):1114-1119.
- Fox, J. W. 2013. The intermediate disturbance hypothesis should be abandoned. *Trends in Ecology & Evolution* 28 (2):86-92.
- Fuhlendorf, S.D., D.M. Engle, J. Kerby, and R. Hamilton. 2009. Pyric herbivory: rewilding landscapes through the recoupling of fire and grazing. *Conservation Biology* 23 (3):588-598.

- Gaston, K.J. 1996. Biodiversity--latitudinal gradients. *Progress in Physical Geography* 20:466-476.
- Gaston, K.J. 2000. Global patterns in biodiversity. *Nature* 405:220-227.
- Grassland: Mission: Biomes. *Grassland: Mission: Biomes*. NASA: Earth Observatory, 05 Apr. 2015.
- Grime, J.P. 1973. Competitive exclusion in herbaceous vegetation. *Nature* 242:344-347.
- Griffin, D.A. 2011. Diversity Theories. In *The SAGE Handbook of Biogeography* 43-56. SAGE Publications Ltd.
- Hector, A., B. Schmid, C. Beierkuhnlein, M. C. Caldeira, M. Diemer, P. G. Dimitrakopoulos, J. A. Finn, H. Freitas, P. S. Giller, J. Good, R. Harris, P. Hogberg, K. Huss-Danell, J. Joshi, A. Jumpponen, C. Korner, P. W. Leadley, M. Loreau, A. Minns, C. P. H. Mulder, G. O'Donovan, S. J. Otway, J. S. Pereira, A. Prinz, D. J. Read, M. Scherer-Lorenzen, E. D. Schulze, A. S. D. Siamantziouras, E. M. Spehn, A. C. Terry, A. Y. Troumbis, F. I. Woodward, S. Yachi, and J. H. Lawton. 1999. Plant diversity and productivity experiments in European grasslands. *Science* 286 (5442):1123-1127.
- Hickey, J.V. and C.E. Webb. 1987. The transition from farming to ranching in the Kansas Flint Hills. *Great Plains Quarterly*. Paper 351.
- Holdridge, L.R., W.C. Grenke, W.H. Hatheway, T. Liang, and J.A. Tosi. 1971. Forest environments in tropical life zones: a pilot study. Pergamon Press, New York.
- Hoover, D.L., A.K. Knapp, and M.D. Smith. 2014. Resistance and resilience of a grassland ecosystem to climate extremes. *Ecology* 95 (9):2646-2656.
- Hulbert, L.C. 1969. Fire and litter effects in undisturbed bluestem prairie in Kansas. *Ecology* 50 (5):874-877.
- Huston, M.A. 1979. A General Hypothesis of Species Diversity. *The American Naturalist* 113(1):81-101.
- Huston, M.A. and D.L. DeAngelis. 1994. Competition and Coexistence: the effects of resource transport and supply rates. *The American Naturalist* 144 (6):954-977.
- Huston, M. A. 2014. Disturbance, productivity, and species diversity: empiricism vs. logic in ecological theory. *Ecology* 95 (9):2382-2396.

- Jewett, J.M. 1941. The geology of Riley and Geary Counties, Kansas. Kansas Geological Survey Bulletin 39. Lawrence, Kansas, USA.
- Knapp, A.K. 1984. Water relations and growth of three grasses during wet and drought years in a tallgrass prairie. *Oecologia* 65:35-43.
- Knapp, A.K., J.M. Briggs, D.C. Hartnett, S.L. Collins. 1998. Grassland dynamics. -- Oxford Univ. Press.
- Komac, B., M. Domenech, and R. Fanlo. 2014. Effects of grazing on plant species diversity and pasture quality in subalpine grassland in the eastern Pyrenees (Andorra): Implications for conservation. *Journal for Nature Conservation* 22:247-255.
- Magurran, A.E. 2004. Measuring biological diversity, 18-71. Blackwell Publishing Ltd.
- Marchand, M.J. TALES OUT OF SCHOOL. *The Historic Indians of Kansas*. Emporia State University.
- McCulley, R.L. 2002. Biogeochemical response of U.S. Great Plains grasslands to regional and interannual variability in precipitation. *Colorado State University* 1-151.
- McCulley, R.L. and I.C. Burke. 2004. Microbial community composition across the Great Plains: landscape versus regional variability. *Soil Biology & Biochemistry* 68:106-115.
- Miller, K.B. and R.R. West. 1993. Reevaluation of Wolfcampian cyclotherms in northeastern Kansas: significance of subaerial exposure and flooding surfaces. Pages 1-26 in Current research on Kansas geology. Kansas Geological Survey Bulletin 235. Lawrence, Kansas, USA.
- Moen, J. and S.L. Collins. 1996. Trophic Interactions and Plant Species Richness along a Productivity Gradient. *Oikos* 76 (3):603-607.
- Moeslund, J., L. Arge, P. Bøcher, T. Dalgaard, R. Ejrnæs, M. Odgaard, and J.-C. Svenning. 2013. Topographically controlled soil moisture drives plant diversity patterns within grasslands. *Biodiversity and Conservation* 22 (10):2151-2166.
- Molino, J.F. and D. Sabatier. 2001. Tree Diversity in Tropical Rain Forests: A Validation of the Intermediate Disturbance Hypothesis. *Science* 294:1702-1704.
- Olf, H. and M.E. Ritchie. 1998. Effects of herbivores on grasslands plant diversity. *TREE* 13 (7):261-265.

- O'Mara, F.P. 2012. The role of grasslands in food security and climate change. *Annals of Botany* 110 (6):1263-1270.
- Oviatt, C.G. 1998. Geomorphology of Konza Prairie--Chapter 3 of Grassland dynamics. -- Oxford Univ. Press. 35-47.
- Pianka, E.R. 1966. Latitudinal gradients in species diversity: a review of concepts. *The American Naturalist* 100 (910):33-46.
- Puerto, A., M. Rico, M.D. Matías, and J.A. García. 1990. Variation in structure and diversity in Mediterranean grasslands related to trophic status and grazing intensity. *Journal of Vegetation Science* 1 (4):445-452.
- Ransom, M.D., C.W. Rice, T.C. Todd, W.A. Wehmueller. 1998. Geomorphology of Konza Prairie--Chapter 4 of Grassland dynamics. -- Oxford Univ. Press. 48-66.
- Risser, P.G., E.C. Birney, H.D. Blocker, S.W. May, W.J. Parton, and J.A. Wiens. 1981. Producers--Chapter 6 of The true prairie ecosystem. *Hutchinson Ross Publishing Company* 155-184.
- Rohde, K. 1978. Latitudinal gradients in species diversity and their causes. II. Marine parasitological evidence for a time hypothesis. *Biologisches Zentralblatt* 97:405-418.
- Rosenzweig, M.L. 1992. Species diversity gradients: we know more and less than we thought. *Journal of Mammalogy* 73:715-730.
- Rosenzweig, M.L. and Z. Abramsky. 1993. How are diversity and productivity related? Pages 52-65 in R.E. Ricklefs and D. Schluter, editors. *Species diversity in ecological communities: historical and geographical perspectives*. University of Chicago Press, Chicago, Illinois, USA.
- Rosenzweig, M.L. 1995. *Species diversity in space and time*: Cambridge: Cambridge University Press.
- Rusch, G.M. and M. Oesterheld. 1997. Relationship between Productivity, and Species and Functional Group Diversity in Grazed and Non-Grazed Pampas Grasslands. *Oikos* 78 (3):519-526.
- Sasaki, T., S. Okubo, T. Okayasu, U. Jamsran, T. Ohkuro, and K. Takeuchi. 2009. Management applicability of the intermediate disturbance hypothesis across Mongolian rangeland ecosystems. *Ecological Applications* 19 (2):423-432.

- Schimel, D.S., T.G.F. Kittel, A.K. Knapp, T.R. Seastedt, W.J. Parton, and V.B. Brown. Physiological interactions along resource gradients in a tallgrass prairie. *Ecology* 72 (2):672-684.
- Schwilk, D.W., J.E. Keeley, and W.J. Bond. 1997. The intermediate disturbance hypothesis does not explain fire and diversity pattern in fynbos. *Plant Ecology* 132:77-84.
- Shannon, C.E. 1964. The mathematical theory of communication. In C.E. Shannon and W. Weaver, The mathematical theory of communication. University of Illinois Press, Urbana.
- Smith, T. and M. Huston. 1989. A theory of the spatial and temporal dynamics of plant communities. *Vegetatio* 83:49-69.
- Smith, G.N. 1991. Geomorphology and geomorphic history of the Konza Prairie Research Natural Area, Riley and Geary Counties, Kansas. M.S. thesis. Kansas State University, Manhattan, Kansas, USA.
- Smoky Valley Ranch, The Nature Conservancy. *Smoky Valley Ranch, The Nature Conservancy*. Web.
- Sousa, W.P. 1984. The Role of Disturbance in Natural Communities. *Annual Review of Ecology and Systematics* 15:353-391.
- Stevens, G.C. 1989. The latitudinal gradient in geographical range: how so many species co-exist in the tropics. *American Naturalist* 133:240-256.
- Svensson, J.R., M. Lindegarth, M. Siocha, M. Lenza, M. Molis, M. Wahl, and H. Pavia. 2007. Maximum species richness at intermediate frequencies of disturbance: consistency among levels of productivity. *Ecology* 88 (4):830-838.
- Temperature - Precipitation - Sunshine - Snowfall. *Climate United States*. Web. 05 Apr. 2015.
- Tilman, D. and S. Pacala. 1993. The maintenance of species richness in plant communities. Pages 13-25 in R.E. Ricklefs and D. Schluter, editors. Species diversity in ecological communities: historical and geographical perspectives. University of Chicago Press, Chicago, Illinois, USA.
- Tomanek, G.W. and F.W. Albertson. 1957. Variation in cover, composition, production, and roots of vegetation on two prairies in western Kansas. *Ecological Monographs* 27 (3):267-281.

- Townsend, C.R., M.R. Scarsbrook, and S. Dolédec. 1997. The intermediate disturbance hypothesis, refugia, and biodiversity in streams. *Limnology Oceanography* 42 (5):938-949.
- USGS TNM 2.0 Viewer. *USGS TNM 2.0 Viewer*. Web. 15 Feb. 2016.
- Weaver, J.E. 1954. Grasses and communities of lowland (Chapter 2) and Grasses and communities of upland (Chapter 4)--North American prairie. Johnsen Publishing Company 23-38, 53-67.
- Westman, W.E. and R.H. Whittaker. 1975. The Pygmy Forest region of northern California: studies on biomass and primary productivity. *Journal of Ecology* 63 (2):493-520.
- Wiens, J.J. and M.J. Donoghue. 2004. Historical biogeography, ecology, and species richness. *Trends in Ecology and Evolution* 19:639-644.
- Williams, G.W. 2003. References on the American Indian use of fire in ecosystems. *USDA Forest Service*.
- Wilson, J.B. 2014. Does the Initial Floristic Composition model of succession really work? *Journal of Vegetation Science* 25:4-5.
- Zar, J.H. 1999. Multisample hypotheses: the analysis of variance (Chapter 10) and Simple linear regression (Chapter 17)--Biostatistical Analysis, Fourth Edition. Pearson Education, Inc. 177-207, 324-359.

APPENDIX A

Appendix A consists of presence and absence data for all 158 plots from Konza Prairie Biological Station and Smoky Valley Ranch collected in the summer of 2015. The 1s indicate that the species occurred and the 0s indicate that the species did not occur within the 0.25 m². The species were tallied from an area of 0.5 m by 0.5 m.

Table A.1. Presence/Absence data by species at Konza Prairie (3 months, ridge).

Site		Konza Prairie Biological Station												
Time since fire		3 months												
Topographic position		Ridge												
Species	Plots	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	0	1	1	0	1	0	0	1	0
<i>Amorpha canescens</i>		0	0	0	1	1	0	0	1	0	1	1	1	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	1	0	1	0	0	0
<i>Baptisia australis</i>		0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	1	0	1	1	1	1	0	1	1	1	1	1
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Carex brevior</i>		0	1	1	1	0	0	1	1	0	0	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	1	1	0	0	0	0	0	0	0	1
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Eupatorium altissimum</i>		0	0	1	1	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Liatris punctata</i>		0	1	0	0	0	0	1	0	0	0	1	1	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		1	0	0	0	0	0	0	0	0	1	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	1	1	0	0	0	0	0
<i>Physalis heterophylla</i>		1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		1	0	0	1	1	1	0	1	0	1	1	1	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Sorghastrum nutans</i>		1	1	1	1	1	1	1	1	1	1	1	0	0
<i>Sporobolus compositus</i>		1	0	1	0	0	0	0	0	0	1	0	0	1
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	0	1	0	1	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	1	1	0	1	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	1	0	0	0	0	0	0	0	0	0	0

Table A.2. Presence/Absence data by species at Konza Prairie (3 months, midslope).

Site		Konza Prairie Biological Station													
Time since fire		3 months													
Topographic position		Midslope													
Species	Plots	14	15	16	17	18	19	20	21	22	23	24	25	26	
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Ambrosia artemisiifolia</i>		0	0	1	0	0	0	0	0	0	1	0	0	0	
<i>Amorpha canescens</i>		0	0	1	0	1	0	0	0	0	0	1	0	0	
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1	1	1	1	
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	1	0	0	0	0	
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Artemisia ludoviciana</i>		0	0	0	0	0	1	0	0	0	0	0	0	0	
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Asclepias verticillata</i>		1	0	0	0	0	0	0	1	1	1	0	0	0	
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Bouteloua curtipendula</i>		1	1	0	1	1	1	1	0	1	1	1	1	0	
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Carex brevior</i>		0	1	1	1	1	1	0	0	0	0	1	1	1	
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	1	0	0	0	
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0	0	1	0	
<i>Dichanthelium oligosanthes</i>		0	0	0	0	1	1	0	0	0	0	1	0	1	
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Eupatorium altissimum</i>		1	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0	0	0	1	
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Lespedeza violacea</i>		0	0	1	0	0	0	0	0	0	1	1	1	0	
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0	0	1	0	
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	1	0	0	0	0	
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	1	
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Panicum virgatum</i>		0	1	1	1	0	1	0	1	0	1	1	0	0	
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	1	0	0	0	0	0	0	
<i>Physalis heterophylla</i>		1	0	0	0	0	0	1	0	1	0	0	0	0	
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Rhus glabra</i>		0	0	0	0	0	0	1	0	0	0	0	0	0	
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0	1	0	0	
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Schizachyrium scoparium</i>		1	1	0	1	1	1	0	0	1	0	1	1	0	
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Solidago canadensis</i>		0	1	0	0	0	0	0	0	0	0	0	0	0	
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Solidago speciosa</i>		0	0	0	1	0	0	0	1	0	1	0	0	0	
<i>Sorghastrum nutans</i>		1	1	1	1	1	1	0	0	1	1	0	1	0	
<i>Sporobolus compositus</i>		0	1	0	0	0	0	0	0	0	0	0	0	1	
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Symphotrichum oblongifolium</i>		1	0	0	0	0	0	0	0	0	0	0	1	0	
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Vernonia baldwinii</i>		0	0	0	0	1	0	0	0	0	0	0	0	0	
<i>Viola nephrophylla</i>		0	1	0	0	0	0	0	0	0	0	0	0	0	

Table A.3. Presence/Absence data by species at Konza Prairie (3 months, valley).

Site		Konza Prairie Biological Station												
Time since fire		3 months												
Topographic position		Valley												
Species	Plots	27	28	29	30	31	32	33	34	35	36	37	38	39
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	1	1	1	0	0	1	0	0	1
<i>Amorpha canescens</i>		1	0	0	0	0	0	1	0	1	1	1	0	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	1	0	1	1	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	1	0	1	1	0	1	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	0	0	0	1	0	1	0	1	1	0	0	1
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	1	1	1	1	0	0	0	0	1	1	1
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	1	0	0	0	0	0	0	1
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		1	0	0	0	0	0	0	0	0	0	1	1	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0	1	1	1
<i>Liatis punctata</i>		0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	1	1	1	0	1	1	1	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	0	1	0	1	0	1	0	1	1	1	0	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	1	0	0	1	0	0	0
<i>Sorghastrum nutans</i>		1	1	1	0	1	0	1	1	1	1	0	1	1
<i>Sporobolus compositus</i>		0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	1	0	0	0	0	0	0

Table A.4. Presence/Absence data by species at Konza Prairie (15 months, ridge).

Site		Konza Prairie Biological Station									
Time since fire		15 months									
Topographic position		Ridge									
Species	Plots	40	41	42	43	44	45	46	47	48	49
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	1	0	0
<i>Ambrosia artemisiifolia</i>		1	0	0	0	1	1	1	1	0	1
<i>Amorpha canescens</i>		0	1	1	1	0	0	0	0	1	1
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	1	1	1	1	1	1	1	1	0
<i>Bouteloua dactyoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0	0	0	0	0	1	1	1
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	1	0	0	0	1	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	1	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	1	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	1	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		1	1	0	0	0	0	0	0	1	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	1	0	0	0	0
<i>Liatris punctata</i>		1	1	0	1	0	1	0	1	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Mirabilis albidia</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		1	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	1	1	0	0	0	1	1
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	1	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	1	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	1	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		1	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	1	0	0	0	1	1	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		1	1	1	1	1	1	1	1	1	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	1	1
<i>Sorghastrum nutans</i>		1	1	1	1	1	1	0	1	1	1
<i>Sporobolus compositus</i>		0	1	0	0	0	0	0	1	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum oblongifolium</i>		0	1	0	0	0	1	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		1	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table A.5. Presence/Absence data by species at Konza Prairie (15 months, midslope).

Site		Konza Prairie Biological Station									
Time since fire		15 months									
Topographic position		Midslope									
Species	Plots	50	51	52	53	54	55	56	57	58	59
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	1	0	0	1	1	1	0	0
<i>Amorpha canescens</i>		0	0	0	1	0	0	0	1	0	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	1	1	0	1	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	1	0
<i>Bouteloua curtipendula</i>		1	1	1	1	1	1	1	1	1	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	1	0	0	0	1	1	1	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	1	0	0	0	0	1	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	1	0	0	0	1	0	1	0
<i>Geranium carolinianum</i>		0	0	1	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	1	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	1
<i>Liatris punctata</i>		1	0	0	0	0	1	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		1	0	0	0	0	0	1	0	0	0
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		1	0	1	0	0	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	1	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	1	0	1
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	1	1	1	0	1	0	0	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	1
<i>Solidago speciosa</i>		0	0	0	0	1	0	0	0	0	0
<i>Sorghastrum nutans</i>		1	1	1	1	1	1	1	1	1	1
<i>Sporobolus compositus</i>		0	0	0	0	0	0	1	1	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	1	0	0	1	0	1	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	1	1	1	0	0

Table A.6. Presence/Absence data by species at Konza Prairie (15 months, valley).

Site		Konza Prairie Biological Station									
Time since fire		15 months									
Topographic position		Valley									
Species	Plots	60	61	62	63	64	65	66	67	68	69
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	1	1	1	0	0	1	0	0
<i>Amorpha canescens</i>		1	0	0	0	1	0	0	1	0	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	1	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	0	1	0	0	0	0	0	0	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		1	0	1	1	1	1	0	1	1	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	1	1	1	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	1	1	0	0	1	0	1	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	1	1	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	1	0	0	0	0	0	1	1	0
<i>Liatis punctata</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	1	0	1	0	0	0	0
<i>Lythrum californicum</i>		1	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	1	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		1	1	1	1	0	1	0	1	0	0
<i>Pediemelum tenuiflorum</i>		0	0	0	0	0	0	0	1	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	1	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	1	0	0	0	1	0
<i>Ruellia strepens</i>		0	0	0	0	0	1	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		1	1	1	1	1	1	0	0	1	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		1	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	1	0	0	1	0	0	0	1	0
<i>Sorghastrum nutans</i>		1	1	1	1	1	1	0	1	1	1
<i>Sporobolus compositus</i>		0	0	0	1	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	1	0	1	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table A.7. Presence/Absence data by species at Konza Prairie (27 months, ridge).

Site		Konza Prairie Biological Station									
Time since fire		27 months									
Topographic position		Ridge									
Species	Plots	70	71	72	73	74	75	76	77	78	79
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		1	1	1	1	1	1	0	1	0	0
<i>Amorpha canescens</i>		1	0	0	0	0	0	0	1	1	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	0	0	1	1	1	0	0	1	1
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	1	1	0	0	0	0	1	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		1	0	0	1	0	0	1	1	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	1	0	1	0	0	0	1	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	1	0	1	0	1
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	1	0	0	0	1	1	1	1
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	1	0	0	0	0
<i>Mirabilis albida</i>		0	0	0	1	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	1	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	1	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	1
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	1	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	1	0	0	1	1	0	1	0	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	1	0	0
<i>Sorghastrum nutans</i>		1	1	1	1	0	0	0	0	1	1
<i>Sporobolus compositus</i>		1	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		1	1	1	1	1	0	0	0	0	0
<i>Verbesina alternifolia</i>		1	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		1	1	1	1	1	0	1	0	0	1
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table A.8. Presence/Absence data by species at Konza Prairie (27 months, midslope).

Site		Konza Prairie Biological Station									
Time since fire		27 months									
Topographic position		Midslope									
Species	Plots	80	81	82	83	84	85	86	87	88	89
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	1	1	0	1	1	0	1	1	1
<i>Amorpha canescens</i>		0	1	0	0	0	0	1	0	0	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	1	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	1	1	1	1	1	0	1	1	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	1	1	1	0	0	1	1	1	1
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	1	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	1
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	1	1	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	1	0	0	0	1	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	1	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	1	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	1	0	0	0	0	0
<i>Liatis punctata</i>		0	0	0	0	1	0	1	0	1	1
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	1	0	0	0	0	0	0	0
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	1	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	1	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	1	0	0	0	0	0	1	1	1
<i>Pediemelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	1	0	0	1	1
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	1	1	1	0	1	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	0	1	1	1	1	0	1	1	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	1	0	0	0	0	0	0	0	1
<i>Sorghastrum nutans</i>		1	1	0	1	0	1	1	1	1	0
<i>Sporobolus compositus</i>		0	0	0	0	0	0	0	1	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	1	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		1	1	1	1	1	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	1	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		1	1	0	0	0	0	0	1	1	0
<i>Viola nephrophylla</i>		1	0	0	0	0	0	0	0	0	0

Table A.9. Presence/Absence data by species at Konza Prairie (27 months, valley).

Site		Konza Prairie Biological Station									
Time since fire		27 months									
Topographic position		Valley									
Species	Plots	90	91	92	93	94	95	96	97	98	99
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	1	1	0	1	1	0	0	0	0
<i>Amorpha canescens</i>		1	1	0	0	1	0	1	1	1	1
<i>Andropogon gerardii</i>		1	0	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	1	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	1	0	0	1	0	0	0	1	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		1	1	1	1	0	0	0	0	0	1
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Comus drummondii</i>		0	0	0	1	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	1	1	1	1	0	1	0	1	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	1	1	0	1	1	1	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		1	1	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	1	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	1	0	0	0	0	0	0	0	0
<i>Mirabilis albidia</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	1	0	0	0	0	0	0	0	1
<i>Panicum virgatum</i>		0	1	0	0	0	1	0	0	1	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	1	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	1	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	1	0	1	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		1	1	1	1	1	0	0	1	1	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	1	0	0	0	0
<i>Solidago speciosa</i>		0	0	1	0	0	0	1	0	0	0
<i>Sorghastrum nutans</i>		0	0	1	1	1	1	1	1	1	1
<i>Sporobolus compositus</i>		0	0	0	0	0	1	0	0	1	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		1	1	1	1	1	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		1	1	1	1	0	0	0	0	0	0
<i>Viola nephrophylla</i>		1	0	0	0	0	0	0	0	0	0

Table A.10. Presence/Absence data by species at Konza Prairie (39 months, ridge).

Site		Konza Prairie Biological Station									
Time since fire		39 months									
Topographic position		Ridge									
Species	Plots	100	101	102	103	104	105	106	107	108	109
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		1	0	0	0	0	1	1	1	1	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	1	0	0	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		1	0	0	1	1	1	0	1	1	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	0	0	1	0	0	0	1	1	1
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		1	1	0	0	0	0	1	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	1	0	1	0	0	1	0	0	1
<i>Echinacea purpurea</i>		0	0	1	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedysotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	1	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	1	1
<i>Liatis punctata</i>		1	0	1	0	0	1	1	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	1	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	1	0	0	0	0	0
<i>Panicum virgatum</i>		1	0	0	1	0	1	1	0	0	0
<i>Pedimelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	1	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	1	1
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	1	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		1	0	1	1	1	1	1	1	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		1	1	1	1	0	0	1	0	0	1
<i>Sporobolus compositus</i>		0	0	0	1	1	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	1	0	1	1	0	0	0	1	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	1	1	1	0	0	1	1	1	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table A.11. Presence/Absence data by species at Konza Prairie (39 months, midslope).

Site		Konza Prairie Biological Station									
Time since fire		39 months									
Topographic position		Midslope									
Species	Plots	110	111	112	113	114	115	116	117	118	119
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	1	0	0	0	0	0	1	1	1
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		1	1	1	1	1	1	0	0	0	1
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	1	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	1	1	1	0	0	1	1	1	1
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	1	0	1	0	0	0	0	0	1
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Comus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		1	0	0	1	1	1	0	1	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	1	1	0	0	0	0	0	1	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	1	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		1	0	1	0	0	0	0	0	1	1
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	1	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Mirabilis albidia</i>		0	1	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	1	0	1	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		1	0	0	1	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	1	0	1	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		1	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		1	1	1	1	1	1	0	0	1	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		0	0	1	1	1	1	1	1	1	1
<i>Sporobolus compositus</i>		1	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		1	0	0	0	0	0	0	1	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	1	1	1	1	1	0	0	0	1
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table A.12. Presence/Absence data by species at Konza Prairie (39 months, valley).

Site		Konza Prairie Biological Station									
Time since fire		39 months									
Topographic position		Valley									
Species	Plots	120	121	122	123	124	125	126	127	128	129
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	1	0	1	0	0	1	1	0
<i>Amorpha canescens</i>		0	1	0	0	1	1	1	0	1	0
<i>Andropogon gerardii</i>		1	1	0	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	1	1	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		1	0	0	1	0	1	0	0	1	1
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		1	0	0	0	0	0	0	0	0	1
<i>Baptisia australis</i>		0	1	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	1	0	1	0	0	0	1	1	1
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		1	0	0	0	0	0	0	0	1	1
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	1	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		1	1	0	1	1	1	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	1	0	1	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	1	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	1
<i>Liatris punctata</i>		0	0	0	0	0	0	0	1	0	1
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum califomicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	1	0	0	0	0	1	0	0
<i>Mirabilis albidia</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		1	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		1	1	1	1	1	0	0	0	0	0
<i>Pediemelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	1	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	1	1	0	0	0	1	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	0	1	0	0	0	0	0	0	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	1	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		1	1	1	0	1	0	0	1	1	0
<i>Sporobolus compositus</i>		1	1	1	1	0	0	1	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	1	0	0	0	0	1	0	1
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		1	0	0	0	0	0	0	0	1	1
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	1

Table A.13. Presence/Absence data by species at Konza Prairie (291 months, ridge, midslope, and valley).

Site		Konza Prairie Biological Station								
Time since fire		291 months								
Topographic position		Ridge			Midslope			Valley		
Species	Plots	130	131	132	133	134	135	136	137	138
<i>Achillea millefolium</i>		0	0	1	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		1	0	1	1	1	0	1	0	0
<i>Amorpha canescens</i>		1	0	0	0	0	0	1	0	0
<i>Andropogon gerardii</i>		1	1	1	1	1	1	1	1	1
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	1	0	1	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	0	0	1	0	1	0	0	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		1	0	0	1	0	0	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	1	0	1	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0
<i>Dichantheum oligosanthes</i>		0	0	0	0	0	0	0	0	1
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	1	0	1	0	0	1
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0
<i>Mirabilis albidia</i>		0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	1	0	0	0	0	0
<i>Panicum virgatum</i>		0	1	1	0	0	0	1	1	1
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	1	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	1	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	1	1	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	1	0	0	0	0	0	0	1
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	1	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	1	0
<i>Sorghastrum nutans</i>		0	0	0	0	1	0	0	0	0
<i>Sporobolus compositus</i>		0	1	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		1	0	1	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	1	0	1	0	0	1	1	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	1	0

Table A.14. Presence/Absence data by species at Smoky Valley (27 months).

Site		Smoky Valley Ranch									
Time since fire		27 months									
Topographic position		n/a									
Species	Plots	139	140	141	142	143	144	145	146	147	148
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	0	0	0	0	1	1
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		0	0	0	0	0	0	0	0	0	0
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	1
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	1	1	1	1	1	1	1	1	1
<i>Bouteloua dactyloides</i>		0	0	0	0	1	0	1	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0	0	0	0	0	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	1	0	0	1	0	0	0	0	1
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum califomicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Mirabilis albidia</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Pediemelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	1	0	0	0	1	0	0
<i>Schizachyrium scoparium</i>		0	0	0	0	0	0	0	0	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus compositus</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	0	0	1	0	0	1	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table A.15. Presence/Absence data by species at Smoky Valley (no prior burn).

Site		Smoky Valley Ranch									
Time since fire		No prior burn									
Topographic position		n/a									
Species	Plots	149	150	151	152	153	154	155	156	157	158
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	1	1	1	1	0	0	0	1
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		1	0	0	0	0	0	0	0	0	0
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		1	0	1	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	1	0	1	0	0	1	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	1	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1	1	1	1	1	1	1	1	1	1
<i>Bouteloua dactyloides</i>		0	0	1	1	1	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0	0	0	0	0	0	0	0
<i>Chenopodium spp.</i>		1	0	0	0	0	1	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	1	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	1	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Mirabilis albida</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	1	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	1	0	0	1	0	1
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	1	0	0	1
<i>Schizachyrium scoparium</i>		0	0	0	0	0	0	0	0	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	1
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus compositus</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	1	1	0	0	0	1	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		1	0	0	0	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

APPENDIX B

Appendix B consists of standing biomass (live and dead) data for all 158 plots from Konza Prairie Biological Station and Smoky Valley Ranch collected in the summer of 2015. The unit associated with the number is grams/0.0625 m². The standing biomass was clipped from an area of 0.25 m by 0.25 m.

Table B.1. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (3 months, ridge).

Site		Konza Prairie Biological Station												
Time since fire		3 months												
Topographic position		Ridge												
Species	Plots	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	0	0.2	0	0	0.45	0	0	0.3	0
<i>Amorpha canescens</i>		0	0	0	1.49	0	0	0	0	0	0	3.43	0	0
<i>Andropogon gerardii</i>		10.2	5	10.88	8.07	3.11	7.84	8.17	19.03	7.71	1.45	1.03	3.81	8.83
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0.18	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0.33	0.26	0	0.46	0.06	1.35	0.28	0	2.62	0.78	2.02	0.1	0.22
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0	0	0	2.69
<i>Carex brevior</i>		0	0.06	0.22	1.2	0	0	0.13	0.13	0	0	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		2.94	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0.32	0.64	0	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	13.06	0
<i>Eupatorium altissimum</i>		0	0	2.98	1.54	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0.07
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	2.13	0	0	0	0	0	0	0	0	0.97	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0.12	0	0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		3.66	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		1.07	0	0	0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0.71	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0.7	0	0	4.16	3.48	0.62	0	0.92	0	0	2.95	1.1	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		8.43	5.89	8.03	5.27	1.16	2.21	2.97	0.94	0.63	1.57	0.92	0	0
<i>Sporobolus compositus</i>		0.32	0	0	0	0	0	0	0	0	0	0	0	1.53
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	0	0.21	0	0.81	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	1.71	0.62	2.1	0.09	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0.33	0	0	0	0	0	0	0	0	0	0

Table B.2. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (3 months, midslope).

Site		Konza Prairie Biological Station												
Time since fire		3 months												
Topographic position		Midslope												
Species	Plots	14	15	16	17	18	19	20	21	22	23	24	25	26
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	1.56	0	0	0	0	0	0	0.13	0	0	0
<i>Amorpha canescens</i>		0	0	7.98	0	3.65	0	0	0	0	0	1.51	0	0
<i>Andropogon gerardii</i>		10.66	6.18	6.95	7.64	13.03	1.13	11.45	12.44	9.6	0.32	10.1	6.65	18.32
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	3.87	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	1.27	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		1.55	0	0	0	0	0	0	0	0	0.25	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0.63	0.35	0	1.52	2.42	1.15	0	0	0.12	1.24	0.64	4.6	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0.03	1.08	0.73	0.58	0.22	0	0	0	0	1	0.45	0.07
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	3.29	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0.21	0	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		5.75	0	0	0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0.83	0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0	0	0.28	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0.21	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	5.79	3.8	0.6	0	1.34	0	5.72	0	4.54	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0.66	0	0	0	0	0	2.11	0	0.93	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		14.81	0.76	0	2.62	0.76	3.15	0	0	7.2	0	3.33	1.11	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0.19	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	1.05	0	0	0
<i>Sorghastrum nutans</i>		0	5.38	0.86	0.77	6.55	1.16	0	0	1.61	4.45	0	2.34	0
<i>Sporobolus compositus</i>		0	0.29	0	0	0	0	0	0	0	0	0	0	4.62
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0.26	0	0	0	0	0	0	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0.61	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0	0	0	0

Table B.3. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (3 months, valley).

Time since fire		3 months												
Topographic position		Valley												
Species	Plots	27	28	29	30	31	32	33	34	35	36	37	38	39
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	0.2	0.27	0.55	0	0	0.04	0	0	0.21
<i>Amorpha canescens</i>	14.63	0	0	0	0	0	0	0.49	0	0.73	0.47	0	0	0
<i>Andropogon gerardii</i>	20.66	12.18	9.18	11.55	13.93	9.45	4.68	4.15	11.42	5.14	10.29	7.89	18.48	
<i>Anemone caroliniana</i>		0	0	0	0	0.23	0	0.27	1.34	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	5.86	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0.11	0	0.09	0.02	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	0	0	0	0.99	0	0.4	0	0.91	0.11	0	0	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0.38	0.9	0.54	1.08	0	0	0	0	0.3	8.88	0.68
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0.66	0	0	0	0	0	0	0.21
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>	8.44	0	0	0	0	0	0	0	0	0	13.95	0.22	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0	0.67	1.2	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	5.32	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	18.08	0.55	3.71	0	9.02	0	3.54	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0	0	0	0.55
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0.63	0	0	0	0	0
<i>Salsola ibenica</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	0	0.03	0	0.69	0	3.02	0	1.16	4.66	0.04	0	0.62
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>	2.53	6.21	2.26	0	5.1	0	0	4.76	3.12	2.95	0	1.13	5.57	
<i>Sporobolus compositus</i>		0	1.08	0	0	0	0	0	0.9	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	0	0	0	0	0	0	0	0	0.83	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Vermonia baldwinii</i>		0	0	0.65	0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0	0	0	0

Table B.4. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (15 months, ridge).

Site		Konza Prairie Biological Station									
Time since fire		15 months									
Topographic position		Ridge									
Species	Plots	40	41	42	43	44	45	46	47	48	49
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	0	0	0.11	0.11	0	2.04
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		2.81	3.61	1.94	0.75	0.34	0.56	1.63	1.94	4.22	1.51
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0.23	0.42	1.27	0.82	0.69	1.26	0.23	0.17	3.98	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0	0	0	0	0	0.41	1.52	0.82
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	2.88	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	0.13	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	5.15	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		1.09	0.23	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0.02	0	0	0	0
<i>Liatris punctata</i>		1.41	3.85	0	0.6	0	2.14	0	1.99	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	4.75	15.08	0	0	0	1.87	4.74
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	3.47	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0.91	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0.39	0	0	0	2.17	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0.93	3.92	0.72	0.08	0.71	7.37	5.21	0	0.64	0.65
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	3.37
<i>Sorghastrum nutans</i>		0.89	2.64	0.8	7.13	0	5.81	0	0.53	4.13	0
<i>Sporobolus compositus</i>		0	0.01	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum oblongifolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0.45	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.5. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (15 months, midslope).

Site		Konza Prairie Biological Station									
Time since fire		15 months									
Topographic position		Midslope									
Species	Plots	50	51	52	53	54	55	56	57	58	59
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0.62	0	0	0	0	1.3	0	0
<i>Amorpha canescens</i>		0	0	0	6.22	0	0	0	0	0	0
<i>Andropogon gerardii</i>		2.02	9.61	8.48	9.48	13.66	1.16	10.98	5.7	8.85	2.97
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	33.69	0
<i>Bouteloua curtipendula</i>		1.09	0.85	0	0.8	2.67	2.54	0.42	0.17	0.63	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0.42	0	0	0	0.14	0.97	1.55	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	0.09	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	2.81	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	3.83
<i>Liatris punctata</i>		0	0	0	0	0	1.67	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		3.92	0	0	0	0	0	0	0	0	0
<i>Pediemelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	2.32	0.12	3.07	0	4.52	0	0	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	2.11
<i>Solidago speciosa</i>		0	0	0	0	0.87	0	0	0	0	0
<i>Sorghastrum nutans</i>		0.49	0.66	0	4.17	3.93	7.17	1.18	1.77	3.06	2.93
<i>Sporobolus compositus</i>		0	0	0	0	0	0	0.24	0.05	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum oblongifolium</i>		0	0	0	0	0	0	0	1.27	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	6.85	0.47	0	0	0

Table B.6. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (15 months, valley).

Site		Konza Prairie Biological Station									
Time since fire		15 months									
Topographic position		Valley									
Species	Plots	60	61	62	63	64	65	66	67	68	69
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	1.14	0	0	0.35	0	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		5.08	8.94	2.52	6.38	2.02	2.02	10.37	4.53	2.92	4.98
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0.03	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	0	0.33	0	0	0	0	0	0	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0.37	0	0.41	0.99	0.58	0.12	0	0	0.12	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Comus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0.47	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	5.33	0	0	0	8.71	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0.67	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0.69	0	0	0	0	0	0.07	0.88	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	1.17	0	0.15	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0.08	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0.7	0.17	0	2.49	0	0.16	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	1.08	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0.18	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0.11	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		3.78	0.25	9.01	1.78	1.47	0.94	0	0	0.98	15.9
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		7.63	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0.81	0
<i>Sorghastrum nutans</i>		0.14	0	1.29	4.53	10.61	13.03	0	1.1	6.31	6.55
<i>Sporobolus compositus</i>		0	0	0	0.15	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	0.91	0	5.78	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.7. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (27 months, ridge).

Site		Konza Prairie Biological Station									
Time since fire		27 months									
Topographic position		Ridge									
Species	Plots	70	71	72	73	74	75	76	77	78	79
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		1.42	0.61	0.72	0.1	0	0.29	0	1.41	0	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0.4	0
<i>Andropogon gerardii</i>		7.76	3.99	5.26	1.44	4.1	0.05	6.22	1.36	2.84	1.23
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0.25	0	0	0.85	0.18	0.67	0	0	0.07	1.21
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0.57	0.43	0	0	0	0	0.28	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0.53	0.59	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0.2	0	0	0	1.74	5.69	8.14	1.36
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	6.92	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Pediemelum tenuiflorum</i>		0	3.15	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	0.32	0	0	0.62	1.02	0	3.46	0	6.01
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		1.88	0.78	2.08	0.8	0	0	0	0	0	0
<i>Sporobolus compositus</i>		0.1	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum oblongifolium</i>		2.01	3.32	0.48	1.29	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0.06	0	0	0.07	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		2.92	1	2.68	2.16	1.03	0	0.13	0	0	0.94
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.8. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (27 months, midslope).

Site		Konza Prairie Biological Station									
Time since fire		27 months									
Topographic position		Midslope									
Species	Plots	80	81	82	83	84	85	86	87	88	89
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0.1	1.49	0	0.69	0	0	0	0.44	0
<i>Amorpha canescens</i>		0	2.61	0	0	0	0	16.16	0	0	0
<i>Andropogon gerardii</i>		1.25	3.57	2.69	0.8	2.17	2.61	6.97	0	7.74	3.21
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0.87	0.52	0.29	0.23	0.65	0.52	0	0.51	0.16	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0.37	0.32	0.25	0	0	0.07	0.73	0.04	1.15
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Comus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	7.07
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0.18	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0.45	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	2.33	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	1.93	0	0	0	0.12	2.32
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	4.04	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0.86	0	0	0	0	0	0.92	0.42	0.24
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0.49	0	0	3.71	0.29
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0.61	0.06	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	0	0.29	4.5	0.21	3.46	0	0.67	0.76	4.98
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0.89
<i>Sorghastrum nutans</i>		4.12	0.31	0	0.24	0	1.1	0	0.04	0.23	0
<i>Sporobolus compositus</i>		0	0	0	0	0	0	0	0.3	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0.57	0.16	1.15	2.28	1.85	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0.07	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		2.65	1.51	3.99	0	0	0	0	0.46	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.9. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (27 months, valley).

Site		Konza Prairie Biological Station									
Time since fire		27 months									
Topographic position		Valley									
Species	Plots	90	91	92	93	94	95	96	97	98	99
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0.26	0	0.37	0	0	0	0	0
<i>Amorpha canescens</i>		0	0	0	0	0.03	0	0	19.75	0	0
<i>Andropogon gerardii</i>		2.1	0	1.43	2.4	0.63	1.61	3.5	8.26	1.49	9.67
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	15.07	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	0.84	0	0	0	0	0	0	0.53	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		4.85	0.81	0.29	0.52	0	0	0	0	0	4.13
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0.43	0	0	0.5	0	0	0	0.3	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0.7	7.55	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	2.69	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	1.1	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	2.89	0	0	0.27	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	3.52	0.7	6.14	0.36	0	0	0.31	2.89	0.38
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0.28	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0.43	0	0	0
<i>Sorghastrum nutans</i>		0	0	1.13	0.16	3.14	0	1.63	0.83	0	0.44
<i>Sporobolus compositus</i>		0	0	0	0	0	1.14	0	0	1.69	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		4.66	3.52	4.75	0.32	0.06	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0.61	1.37	0.64	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.10. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (39 months, ridge).

Site		Konza Prairie Biological Station									
Time since fire		39 months									
Topographic position		Ridge									
Species	Plots	100	101	102	103	104	105	106	107	108	109
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		3.34	0	0	0	1.35	0	0	5.82	0	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	2.11	0	0	0
<i>Andropogon gerardii</i>		8.75	4.62	3.33	2.2	14.97	8.64	10.61	8.27	5.5	4.15
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		5.32	0	0	0	0	4.65	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0.77	0	0	0	0	0	0	2.22	0.18	3.79
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0.29	0.44	0	0	0	0	1.36	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0.42	0	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	2.6	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0.01	0.04
<i>Liatris punctata</i>		0	0	4.22	0	0	0	0.51	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0.27	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0.36	0	0	0	0	0
<i>Panicum virgatum</i>		6.39	0	0	6.17	0	2.23	0.29	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	1.8	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0.29	0	0	1.38	1.3	0.78	0.36	0.21	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		2.21	2.59	6.46	1.3	0	0	6.99	0	0	0
<i>Sporobolus compositus</i>		0	0	0	1.39	1.33	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum oblongifolium</i>		0	2.59	0	2.37	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	2.25	0	0	0	0	5.65	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.11. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (39 months, midslope).

Site		Konza Prairie Biological Station									
Time since fire		39 months									
Topographic position		Midslope									
Species	Plots	110	111	112	113	114	115	116	117	118	119
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0.35	0	0	0	0	0	0	4.47	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		1.79	1.03	2.51	0.58	13.33	4.98	13.31	1.76	1.92	4.55
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		2.38	0	0	13.84	0.75	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	1.15	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		1.1	4.96	0	1.85	0	0	1.19	3.81	1.15	3.95
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0.55	0	0.37	0	0	0	0	0	0.02
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0.22	0.64	0	0	0.36	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0.28
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0.49	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	9.23	0	1.9	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		8.14	1.11	0.13	8.21	0.26	1.51	0	0	0.98	0.75
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		0	0	8.09	6.47	0.5	9	5.77	6.13	9.12	3.55
<i>Sporobolus compositus</i>		0.19	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum oblongifolium</i>		0.47	0	0	0	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	1.32	0.04	0.79	0.11	0	0	0	0	2.06
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.12. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (39 months, valley).

Site		Konza Prairie Biological Station									
Time since fire		39 months									
Topographic position		Valley									
Species	Plots	120	121	122	123	124	125	126	127	128	129
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	0	0	0	1.56	0	0
<i>Amorpha canescens</i>		0	0	0	0	0.06	0	0	0	3.11	0
<i>Andropogon gerardii</i>		6.25	9.52	0	13.78	5.7	24.5	13.35	7.22	10.44	1.38
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0.75	0.74	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	0	0	7.5	0	0	0	0	4.81	1.62
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0.07	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	25.16	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		3.4	0	0	0.55	0	0	0	1.49	1.01	6.06
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0.31	0	0	0	0	0	0	0	1.36	2.27
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		1.72	1.44	0	1.88	0.74	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	13.08	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0.2	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatis punctata</i>		0	0	0	0	0	0	0	0	0	0.18
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0.67	0	0	0	0	4.19	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		4.28	3.54	0.36	10.7	7.9	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0.19	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	0	2.6	0	0	0	0	0	0	4.04
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0.04	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		1.02	0.36	0	0	10.01	0	0	10.43	0.12	0
<i>Sporobolus compositus</i>		0.62	1.13	2.49	2.86	0	0	1.78	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	1.2	0	0	0	0	0.94	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0.38	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	1.59

Table B.13. Standing biomass data (grams/0.0625 m²) by species at Konza Prairie (291 months, ridge, midslope, and valley).

Site		Konza Prairie Biological Station								
Time since fire		291 months								
Topographic position		Ridge			Midslope			Valley		
Species	Plots	130	131	132	133	134	135	136	137	138
<i>Achillea millefolium</i>		0	0	0.07	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0.29	0	0.95	0	0	0	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	1.45	0	0
<i>Andropogon gerardii</i>		8.35	7.75	10.94	10.35	18.02	19.3	5.35	12.02	0
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	3.48	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		0	0	0	0.38	0	0.36	0	0	0
<i>Bouteloua dactyloides</i>		0	0	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0.73	0	0	1.28	0	0	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0
<i>Comus drummondii</i>		0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	0	0.68
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	7.38
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0
<i>Liatis punctata</i>		0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	2.21	0	0	0	1.83	0	48.12
<i>Pediemelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	1.62	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0.57	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0.25	0.37	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0
<i>Schizachyrium scoparium</i>		0	2.52	0	0	0	0	0	0	0.59
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	1.04	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		0	0	0	0	0	0	0	0	0
<i>Sporobolus compositus</i>		0	0.17	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	4.2	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	3.44	0	0	0.54	0.35	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0

Table B.14. Standing biomass data (grams/0.0625 m²) by species at Smoky Valley (27 months).

Time since fire		27 months									
Topographic position		n/a									
Species	Plots	139	140	141	142	143	144	145	146	147	148
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		0	0	0	0	0	0	0	0	0	0
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	1.45
<i>Artemisia ludoviciana</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>		24.93	5.81	10.8	15.85	1.95	19.45	0	5.65	3.66	7.74
<i>Bouteloua dactyloides</i>		0	0	0	0	5.69	0	5.11	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0	0	0	0	0	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0.18	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	1.66	0	0	0	0.3	0	0
<i>Schizachyrium scoparium</i>		0	0	0	0	0	0	0	0	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus compositus</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphotrichum oblongifolium</i>		0	0	0	0	0	2.27	0	0	1.14	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

Table B.15. Standing biomass data (grams/0.0625 m²) by species at Smoky Valley (no prior burn).

Site		Smoky Valley Ranch									
Time since fire		No prior burn									
Topographic position		n/a									
Species	Plots	149	150	151	152	153	154	155	156	157	158
<i>Achillea millefolium</i>		0	0	0	0	0	0	0	0	0	0
<i>Ambrosia artemisiifolia</i>		0	0	1.22	0	0.37	0	0	0	0	0
<i>Amorpha canescens</i>		0	0	0	0	0	0	0	0	0	0
<i>Andropogon gerardii</i>		0	0	0	0	0	0	0	0	0	0
<i>Anemone caroliniana</i>		0	0	0	0	0	0	0	0	0	0
<i>Apocynum cannabinum</i>		0	0	0	0	0	0	0	0	0	0
<i>Aristida purpurea</i>	0.15	0	0	0	0	0	0	0	0	0	0
<i>Artemisia filifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Artemisia ludoviciana</i>		0	4.16	0	0.4	0	0	1.51	0	0	0
<i>Asclepias syriaca</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias tuberosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Asclepias verticillata</i>		0	0	0	0	0	0	0	0	0	0
<i>Baptisia australis</i>		0	0	0	0	0	0	0	0	0	0
<i>Bouteloua curtipendula</i>	3.56	26.5	0	15.05	17.28	14.04	6.64	23.37	12.39	26.98	
<i>Bouteloua dactyloides</i>		0	0	2.2	0	0	0	0	0	0	0
<i>Bromus inermis</i>		0	0	0	0	0	0	0	0	0	0
<i>Carex brevior</i>		0	0	0	0	0	0	0	0	0	0
<i>Chenopodium spp.</i>		0	0	0	0	0	0	0	0	0	0
<i>Cornus drummondii</i>		0	0	0	0	0	0	0	0	0	0
<i>Dalea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Dicentra cucullaria</i>		0	0	0	0	0	0	0	0	0	0
<i>Dichanthelium oligosanthes</i>		0	0	0	0	0	0	0	0	0	0
<i>Echinacea purpurea</i>		0	0	0	0	0	0	0	0	0	0
<i>Eupatorium altissimum</i>		0	0	0	0	0	0	0	0	0	0
<i>Geranium carolinianum</i>		0	0	0	0	0	0	0	0	0	0
<i>Hedyotis nigricans</i>		0	0	0	0	0	0	0	0	0	0
<i>Helianthus maximiliani</i>		0	0	0	0	0	0	0	0	0	0
<i>Hordeum pusillum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza stuevei</i>		0	0	0	0	0	0	0	0	0	0
<i>Lespedeza violacea</i>		0	0	0	0	0	0	0	0	0	0
<i>Liatris punctata</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum berlandieri</i>		0	0	0	0	0	0	0	0	0	0
<i>Linum sulcatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Lythrum californicum</i>		0	0	0	0	0	0	0	0	0	0
<i>Mimosa nutallii</i>		0	0	0	0	0	0	0	0	0	0
<i>Nepeta cataria</i>		0	0	0	0	0	0	0	0	0	0
<i>Oenothera speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Oxalis violacea</i>		0	0	0.07	0	0	0	0	0	0	0
<i>Panicum virgatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Pediomelum tenuiflorum</i>		0	0	0	0	0	0	0	0	0	0
<i>Physalis heterophylla</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i>		0	0	0	0	0	0	0	0	0	0
<i>Prunus americana</i>		0	0	0	0	0	0	0	0	0	0
<i>Rhus glabra</i>		0	0	0	0	0	0	0	0	0	0
<i>Rosa arkansana</i>		0	0	0	0	0	0	0	0	0	0
<i>Ruellia humilis</i>		0	0	0	0	0	0	0	0	0	0.2
<i>Ruellia strepens</i>		0	0	0	0	0	0	0	0	0	0
<i>Salsola iberica</i>		0	0	0	0	0	0	0	0	0	1.15
<i>Schizachyrium scoparium</i>		0	0	0	0	0	0	0	0	0	0
<i>Silphium laciniatum</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago canadensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago missouriensis</i>		0	0	0	0	0	0	0	0	0	0
<i>Solidago speciosa</i>		0	0	0	0	0	0	0	0	0	0
<i>Sorghastrum nutans</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus compositus</i>		0	0	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>		0	0	0.57	0.41	0	0	0.78	0	0	0
<i>Symphyotrichum ericoides</i>		0	0	0	0	0	0	0	0	0	0
<i>Symphyotrichum oblongifolium</i>	1.91	0	0	0	0	0	0	0	0	0	0
<i>Verbesina alternifolia</i>		0	0	0	0	0	0	0	0	0	0
<i>Vernonia baldwinii</i>		0	0	0	0	0	0	0	0	0	0
<i>Viola nephrophylla</i>		0	0	0	0	0	0	0	0	0	0

APPENDIX C

Appendix C consists of the latitude and longitude coordinates for each sampled plot at Konza Prairie Biological Station and Smoky Valley Ranch. The datum for these coordinates is North American Datum (NAD) 1983. The plot codes can be decoded as follows:

Table C.1. Plot codes.

Symbol	Meaning
K	Konza Prairie Biological Station
S	Smoky Valley Ranch
F	Disturbance by fire
U5	No previous record of burn
1	Previously burned in 2015
2	Previously burned in 2014
3	Previously burned in 2013
4	Previously burned in 2012
5	Previously burned in 1991
R	Ridge topographic position
M	Midslope topographic position
V	Valley topographic position
-number (1, 2, 3, etc.)	Replicate plot

Table C.2. Latitude and longitude coordinates for each sampled plot.

Plot Code	Latitude	Longitude	Plot Code	Latitude	Longitude	Plot Code	Latitude	Longitude
KF1R-1	39.0897	-96.5551	KF2M-5	39.0979	-96.5588	KF4R-8	39.0684	-96.5651
KF1R-2	39.0893	-96.5543	KF2M-6	39.0975	-96.5586	KF4R-9	39.0684	-96.5651
KF1R-3	39.0877	-96.5542	KF2M-7	39.0765	-96.6044	KF4R-10	39.0685	-96.565
KF1R-4	39.0818	-96.5567	KF2M-8	39.077	-96.606	KF4M-1	39.0736	-96.5638
KF1R-5	39.0811	-96.5567	KF2M-9	39.0671	-96.594	KF4M-2	39.0736	-96.5634
KF1R-6	39.0786	-96.555	KF2M-10	39.067	-96.5938	KF4M-3	39.0738	-96.563
KF1R-7	39.0754	-96.6104	KF2V-1	39.0728	-96.6043	KF4M-4	39.0722	-96.5639
KF1R-8	39.0759	-96.6094	KF2V-2	39.073	-96.6036	KF4M-5	39.0729	-96.5638
KF1R-9	39.0728	-96.6027	KF2V-3	39.0723	-96.6031	KF4M-6	39.0698	-96.5641
KF1R-10	39.0732	-96.6015	KF2V-4	39.0982	-96.5587	KF4M-7	39.0696	-96.5643
KF1R-11	39.0669	-96.581	KF2V-5	39.098	-96.559	KF4M-8	39.0684	-96.565
KF1R-12	39.0671	-96.5809	KF2V-6	39.0977	-96.5592	KF4M-9	39.0684	-96.5648
KF1R-13	39.0668	-96.5791	KF2V-7	39.0764	-96.6045	KF4M-10	39.0688	-96.5647
KF1M-1	39.0895	-96.5551	KF2V-8	39.0768	-96.6061	KF4V-1	39.0735	-96.5636
KF1M-2	39.0893	-96.5545	KF2V-9	39.0673	-96.5941	KF4V-2	39.0736	-96.5633
KF1M-3	39.0878	-96.5542	KF2V-10	39.0672	-96.5938	KF4V-3	39.0736	-96.5627
KF1M-4	39.0817	-96.5568	KF3R-1	39.0964	-96.5777	KF4V-4	39.0731	-96.5636
KF1M-5	39.0811	-96.5569	KF3R-2	39.0966	-96.578	KF4V-5	39.0729	-96.5636
KF1M-6	39.0785	-96.5551	KF3R-3	39.0966	-96.578	KF4V-6	39.0695	-96.564
KF1M-7	39.0753	-96.6104	KF3R-4	39.0967	-96.5778	KF4V-7	39.0694	-96.5642
KF1M-8	39.0758	-96.6095	KF3R-5	39.0752	-96.5962	KF4V-8	39.0682	-96.5649
KF1M-9	39.0729	-96.6024	KF3R-6	39.0752	-96.5965	KF4V-9	39.0683	-96.5648
KF1M-10	39.0729	-96.6015	KF3R-7	39.0787	-96.5978	KF4V-10	39.0685	-96.5647
KF1M-11	39.0672	-96.581	KF3R-8	39.0787	-96.5978	KF5R-1	39.075	-96.5752
KF1M-12	39.0672	-96.5807	KF3R-9	39.0743	-96.5944	KF5R-2	39.0755	-96.5756
KF1M-13	39.0671	-96.579	KF3R-10	39.074	-96.5944	KF5R-3	39.0746	-96.5766
KF1V-1	39.0893	-96.5551	KF3M-1	39.0965	-96.5777	KF5M-1	39.075	-96.5753
KF1V-2	39.0894	-96.5546	KF3M-2	39.0968	-96.5779	KF5M-2	39.0753	-96.5756
KF1V-3	39.0879	-96.5541	KF3M-3	39.0966	-96.578	KF5M-3	39.0745	-96.5768
KF1V-4	39.0816	-96.557	KF3M-4	39.0963	-96.5778	KF5V-1	39.0752	-96.5756
KF1V-5	39.0811	-96.5572	KF3M-5	39.0748	-96.5961	KF5V-2	39.0751	-96.5758
KF1V-6	39.0785	-96.5553	KF3M-6	39.0751	-96.5965	KF5V-3	39.0744	-96.5769
KF1V-7	39.0752	-96.6102	KF3M-7	39.0787	-96.5977	SF3R-1	38.8351	-101.0062
KF1V-8	39.0757	-96.6095	KF3M-8	39.0787	-96.5977	SF3R-2	38.8348	-101.0069
KF1V-9	39.0728	-96.6021	KF3M-9	39.0743	-96.5942	SF3R-3	38.8345	-101.0072
KF1V-10	39.0728	-96.6014	KF3M-10	39.0739	-96.5944	SF3R-4	38.8346	-101.0067
KF1V-11	39.0673	-96.5812	KF3V-1	39.0966	-96.5772	SF3R-5	38.8355	-101.0058
KF1V-12	39.0671	-96.5805	KF3V-2	39.097	-96.5778	SF3R-6	38.8354	-101.0052
KF1V-13	39.0677	-96.5784	KF3V-3	39.0968	-96.5777	SF3R-7	38.8351	-101.0055
KF2R-1	39.0732	-96.6044	KF3V-4	39.0962	-96.5773	SF3R-8	38.8355	-101.0065
KF2R-2	39.0731	-96.6031	KF3V-5	39.0749	-96.596	SF3R-9	38.8361	-101.0064
KF2R-3	39.0721	-96.6028	KF3V-6	39.0749	-96.5967	SF3R-10	38.8361	-101.0057
KF2R-4	39.0979	-96.5583	KF3V-7	39.0786	-96.5974	SU5R-1	38.8368	-101.0069
KF2R-5	39.0979	-96.5587	KF3V-8	39.0786	-96.5972	SU5R-2	38.8367	-101.0075
KF2R-6	39.0974	-96.5586	KF3V-9	39.0746	-96.5943	SU5R-3	38.837	-101.007
KF2R-7	39.0769	-96.6043	KF3V-10	39.074	-96.5947	SU5R-4	38.8366	-101.0066
KF2R-8	39.077	-96.6061	KF4R-1	39.0728	-96.5639	SU5R-5	38.837	-101.0061
KF2R-9	39.0671	-96.599	KF4R-2	39.0738	-96.5635	SU5R-6	38.8374	-101.0057
KF2R-10	39.067	-96.5937	KF4R-3	39.0738	-96.5631	SU5R-7	38.8378	-101.0055
KF2M-1	39.0731	-96.6043	KF4R-4	39.0732	-96.5642	SU5R-8	38.8369	-101.0058
KF2M-2	39.0731	-96.6033	KF4R-5	39.0729	-96.5641	SU5R-9	38.8367	-101.0052
KF2M-3	39.0722	-96.6034	KF4R-6	39.0699	-96.5642	SU5R-10	38.8366	-101.0058
KF2M-4	39.0979	-96.5584	KF4R-7	39.0699	-96.5644			