DATA, DISTRIBUTIONS AND HYPOTHESES:
EXPLORING DIVERSITY AND DISTURBANCE IN THE TALLGRASS PRAIRIE

BIOL 585, Fall 2011
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Week 1: Plant Responses to Burn Season at Konza Prairie

LAB OVERVIEW

Ecological communities are dynamic – species interactions are constantly shaped by environmental conditions that vary in both space and time. In the past, ecologists emphasized an "equilibrium" approach to understanding the processes determining the distribution and abundances of species, and operated under the assumption that populations and communities are always moving toward a steady state that determined community structure. In recent years, ecologists have recognized that non-equilibrium conditions and variable environments may play keys roles in shaping community diversity. The individual, population and community-level responses to disturbance can vary with the biological attributes of each species, and the extent, frequency and intensity of the disturbance.

Grassland ecosystems provide an excellent model system for exploring the role of disturbance in determining species composition, because fire and grazing disturbances are frequent, natural disturbances that are largely responsible the very existence of the biome: without these disturbances, grasslands would eventually become dominated by woody species (Hartnett and Fay 1998). Instead, fire and grazing events prevent trees and shrubs from establishing, thus allowing the persistence of grasses and forbs that are adapted to resisting, recovering, and even benefiting from these disturbances.

This lab uses data published in Towne and Kemp (2003) to investigate the effects of fire disturbance on plant populations and communities in the tallgrass prairie. You will create and interpret graphical representations of the data to evaluate the central question of the lab (stated below) and a specific set of hypotheses (generated by the class).

The ecological question

How does the timing of fire disturbance impact plant populations and communities in the tallgrass prairie?

<u>Objectives of this lab</u>

1. Develop a quantitative understanding of the effects of disturbance on community structure by examining the data presented in a published manuscript.
2. Present and interpret data in a graphical format using an existing long-term data set.
3. Investigate the sources of variation within a data set, and the consequences of grouping biological units into larger entities for the interpretation of results.

THE ECOLOGICAL CONTEXT: KONZA PRAIRIE

The Konza Prairie Biological Research Station (KPBS) is a 3487-hectare preserve located in northeastern Kansas. The preserve was first established in 1971 and is currently owned by The Nature Conservancy and Kansas State University. KSU operates a field station at the site that serves as the focus of the Konza Prairie Long-Term Ecological Research (LTER) program.

LTER projects are research programs funded by the National Science Foundation to support long-term research on ecological phenomena (http://www.lternet.edu/). There are currently 26 sites in the LTER network in the United States that collective compose the majority of a larger international network (http://www.ilternet.edu/); Konza Prairie was one of the first six site-based programs funded in 1980.

The research at KPBS focuses on understanding the interactions between fire, grazing, and climatic variation in determining ecological patterns and processes in grasslands (www.konza.ksu.edu). KPBS is divided into 52 watersheds that serve as the experimental units for different fire treatments that were initiated in 1977. In 1987, bison were re-introduced to the site to implement year-round grazing treatments. Twice each year, researchers sample plant community composition along permanent transects in multiple watersheds (Fig. 1). The data from these surveys provides unique insights into the longer-term effects of fire and grazing disturbances on plant community dynamics.

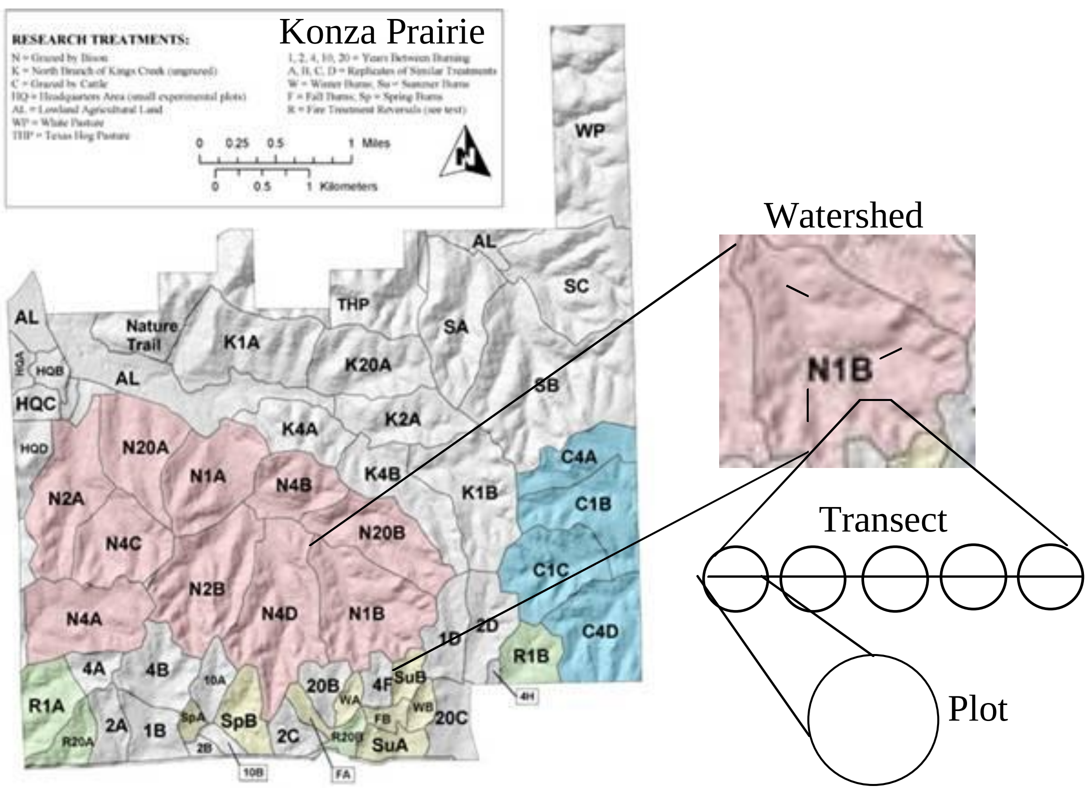


Figure 1. Konza Prairie is divided into watershed units, and each watershed has a different treatment combination of fire frequency and grazing. Long-term research watersheds, such as N1B detailed here, have four permanent transects in the uplands and four permanent transects in the lowlands. Each transect contains five permanent circular plots (Figure and caption from Dalgleish, Woods, and the Ecological Society of America, 2007).

KPBS lies at the southwestern edge of the historical tallgrass prairie region of North America and contains >550 vascular plant species (Towne 2002), including forbs (herbacous dicots), cool and warm-season grasses, and some woody shrubs and trees (Freeman 1998). Lying in the warmer portion of the prairie region, it is dominated by warm-season perennial grasses such as *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem), and *Sorghastrum nutans* (Indiangrass). Warm-season (C_4) grasses emerge in the late spring and early summer and enter the reproductive phase in the late summer or early fall. In contrast, the cool-season (C_3) grasses grow fastest in the late winter / early spring, and reaches reproductive maturity in the late spring – just as the warm-season grasses are starting to grow.

Because prairie plant species vary in the timing of their growth and reproductive periods, the impacts of burning and grazing on any individual species will depend on the time of year that the disturbance occurs. The grasses, in particular, have morphological characteristics that make them particularly resistant to grazing and burning during their vegetative phase: their apical meristem (the area of above-ground growth) is kept close to the ground or even belowground, enabling a plant to produce new leaves and stems after its former above-ground vegetation has been removed. Grass leaves grow from the base of the leaf, near the stem, rather than the tips (as typically happens in dicots), so an individual leaf can regrow if it has been removed. Finally, grasses have belowground meristematic structures called "buds" that are protected from above-ground disturbances and allow the plants to reproduce clonally. These various traits allow many grasses to be relatively resistant to burning and grazing pressure and to rapidly advantage of the resources that become available after a disturbance event has occurred, such as open space, increased light, and increased nutrient availability.

In this lab, we are going to explore a long-term data set on the effects of fire on plant species composition at KPBS. Most specifically, we are going to investigate how the timing of burning influences the relative abundance of different species. We will work through the tables and figures in Towne and Kemp (2003), a paper that summarizes data collected in six different watersheds that were each assigned one of three season-of-burn treatments (Fall, winter, and Spring) over 8 years at KPBS. This paper presents an impressive amount of data that provides a great opportunity for you to experience how dissecting the data in alternative ways and visualizing it in different graphical formats allows you to gain insight into the underlying processes generating the observed patterns.

Today we will only focus on data collected at the upland sites. You will work in pairs to create and interpret graphical representations of the data and answer a series of questions. All of your answers should be prepared in Word document on your laptop, and the graphs you create in Excel should be copied and pasted into this document. Your TA will collect an electronic copy of your assignment at the end of the lab section.

FIGURE SET ACTIVITY

Hypotheses

Based on the information provided above and in the introductory slide show, work with your team to generate hypotheses about the effects of the season-of-burn on tallgrass prairie plant communities and KPBS. Specifically, make a hypothesis that addresses each of the following questions:

i. How does season-of-burn impact the abundance of warm-season grasses?
ii. How does season-of-burn impact the abundance of cool-season grasses?
iii. How does fall burning impact species richness compared to spring burning?

After each group has generated hypotheses for each question, designate an individual to present these hypotheses to the class. The class will reconvene and your TA will write a collective set of hypotheses on the board. Keep these in mind as you proceed through the rest of the lab!

Part 1: Effects of burn season on plant functional types

Plants within a community can be categorized into **functional groups** based on their "ecological role" in their community, which depends on their traits, their responses to the environment and their impacts on the environment. This grouping helps simplify complex, species-rich communities into groups of species that we expect to have similar responses to treatments. In this paper (and many, many other prairie research studies) the authors group plants into **warm-season grasses, cool-season grasses, perennial forbs, annual forbs,** and **woody species** (see glossary for definitions).

Utilizing the "Uplands data only" in Table 1 and Table 2 (provided below), create two different graphs that allow you to most effectively address the following questions:

> i: How does each functional type respond to the different burn treatments? For each functional type, which treatment is most favorable and which is least favorable?
>
> ii: What are the relative contributions of each functional group to the community under each burn treatment?

To do this, you will need to enter the data for each functional group into Excel, and then create the figure using the Graphing Wizard (see your TA if you need help with this). If necessary, you can create multiple graphs for each question.

Species	Uplands		
	Autumn	Winter	Spring
	(%)		
Andropogon gerardii	51.7$^+$	46.9$^+$	49.9$^+$
Bouteloua curtipendula	3.5	2.6	3.0$^-$
Panicum virgatum	1.8	2.3	4.8
Schizachyrium scoparium	24.6$^+$	27.5$^+$	21.1
Sorghastrum nutans	6.7	10.2	20.6$^+$
Sporobolus compositus	0.8$^-$	2.0$^-$	0.9$^-$
Sporobolus heterolepis	3.7$^+$	1.7$^+$	1.7
All warm-season grasses	93.1$^+$	93.7$^+$	102.4$^+$
Carex spp.	17.5$^+$	17.1$^+$	1.4$^-$
Dichanthelium oligosanthes	2.9	8.3	1.0$^-$
Koeleria macrantha	9.3$^+$	2.7	0.2
Poa pratensis	0.1$^-$	0.1$^-$	0.1$^-$
All cool-season graminoids	30.2$^+$	28.3$^+$	2.6$^-$

Table 1. Eight-year average of percent **graminoid** cover exposed to three different seasonal fire regimes.

Species	Uplands Autumn	Winter	Spring
	- - - - - - - - - - (%) - - - - - - - - - -		
Ambrosia psilostachya	2.0	1.3	0.7
Artemisia ludoviciana	0.2⁻	0.7⁻	< 0.1⁻
Brickellia eupatorioides	0.8	1.0	0.8⁻
Physalis pumila	0.5	0.4⁻	0.5
Ruellia humilis	0.3⁻	0.4⁻	0.4
Salvia azurea	5.8+	4.0	5.7
Solidago canadensis	0	0	0
Solidago missouriensis	0.3	0.4⁻	0.4⁻
Symphyotrichum ericoides	17.9+	23.1+	0.5⁻
Symphyotrichum oblongifolium	16.0+	12.8+	0.9⁻
All perennial forbs	51.9+	51.8+	16.1
Amorpha canescens	2.8	0.4	3.3
Dalea canadia	0.2	0.7	0.1
Lespedeza capitata	0.2	0.7	0.1
Lespedeza violaceae	< 0.1	< 0.1	< 0.1
All legume species	7.3	5.4	6.3
All annual forbs	0.2	0.1	0.2
All woody species	0.2	0.2	0.7

Table 2. Eight-year average of percent **forb** cover exposed to three different seasonal fire regimes.

Question 1A. These two types of graphs consist of the same data, but they communicate different messages. Using your graphs, answer the questions listed above that your graphs should address, and explain why you designed your graphs the way that you did.

Question 1B. Do your graphs illustrate any strong trends? If so, provide at least one explanation that could explain these trends. Do these patterns support the hypotheses generated by the class the effects of burn treatment on warm-season and cool-season grasses (questions i and ii)?

<u>Part 2: Effects of burn season on individual species</u>

Next, we will focus on the responses of individual species within each functional group to evaluate if species within these groups show similar responses to burn treatment. **Using the data in Tables 1 and 2, create three graphs to compare the responses of different species to different burn seasons:**

Graph 1: Andropogon gerardii, Sorgastrum nutans, Sporobolus compositus

Graph 2: Carex spp., Dichanthelium oligosanthes, Koeleria macrantha

Graph 3: Salvia azurea, Solidago missouriensis, Symphyotrichum ericoides

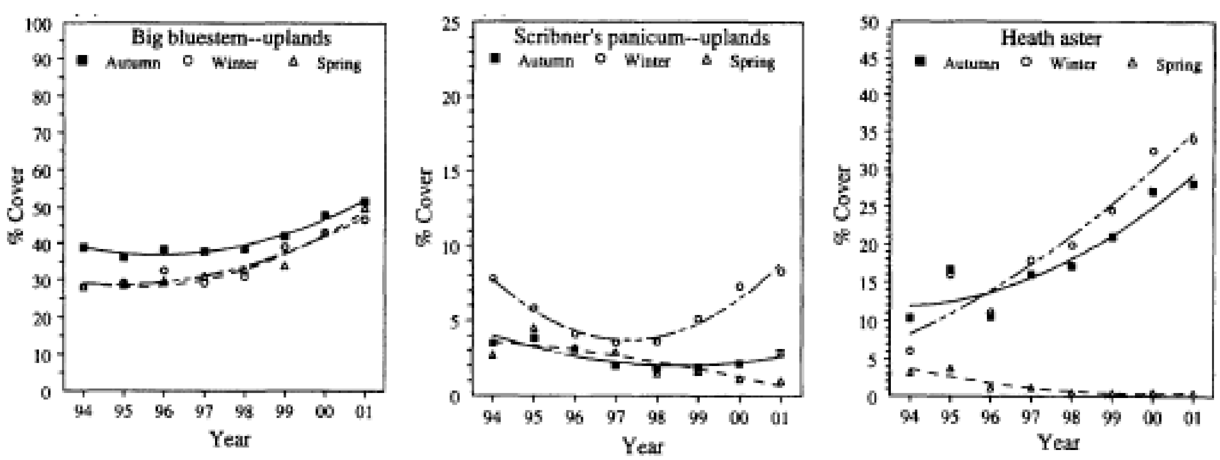
Question 2A. Briefly summarize how each species responds to burn treatment.

Question 2B. What information can you obtain from these graphs that was not evident in the graphs you created in Question 1? Under what circumstances would this additional information be important?

Question 2C. Do species within the plant functional groups respond similarly to the different burn treatments? That is, do you feel confident that you can predict a species' general response to the different burn treatments if you only know its functional group? Why or why not?

Question 2D. Re-visit the class hypotheses, and your answer to Question 1B Is it necessary to revise your answer to Question 1C based on the patterns observed for individual species? If so, write your revised hypotheses below.

<u>Part 3: Trends over time within a single species.</u> Finally, let's zoom in even further to examine the responses of three species in each of the eight years that data were collected:



Figures 2, 3, & 4 (specific panels only). Percent cover of Big bluestem (*A. gerardii*, warm season grass, left panel), Scribner's panicum (*D. oligosanthes*, cool-season grass, middle panel), and Heath aster (*S. ericoides*, perennial forb, right) over 8 years under three different burn treatments: solid square = fall burn, open circle = winter burn, open triangle = spring burn.

Question 3A. Summarize the responses of each species to the different burn treatments.

Question 3B. What information can you obtain from these graphs that was not evident in the graphs you created in Questions 1 and 2? What are the advantages and disadvantages of looking at the data in this way?

Question 3C. Examine the data from the first year of the experiment for each species – those that fall nearest the y-axis on each figure. Does it make sense to you that there are differences among burn treatments before the experiment began? What might explain these differences?

Does this change your interpretation for the patterns you described in 3A? If so, state your revised interpretation(s) below.

Question 3C. Many ecological studies are only conducted over a maximum of 3 years (the typical funding period for NSF). If this experiment had terminated after only three years of data collection, would you have come to different conclusions about the effects of burning on these three species? Would you have different interpretations about the effects of temporal variation?

Part 4. Effects of season of burn on plant species richness and diversity

We can evaluate community-level responses to burn treatment by comparing species diversity and richness in the different treatments (see glossary for definitions). The authors present this data in Fig. 5:

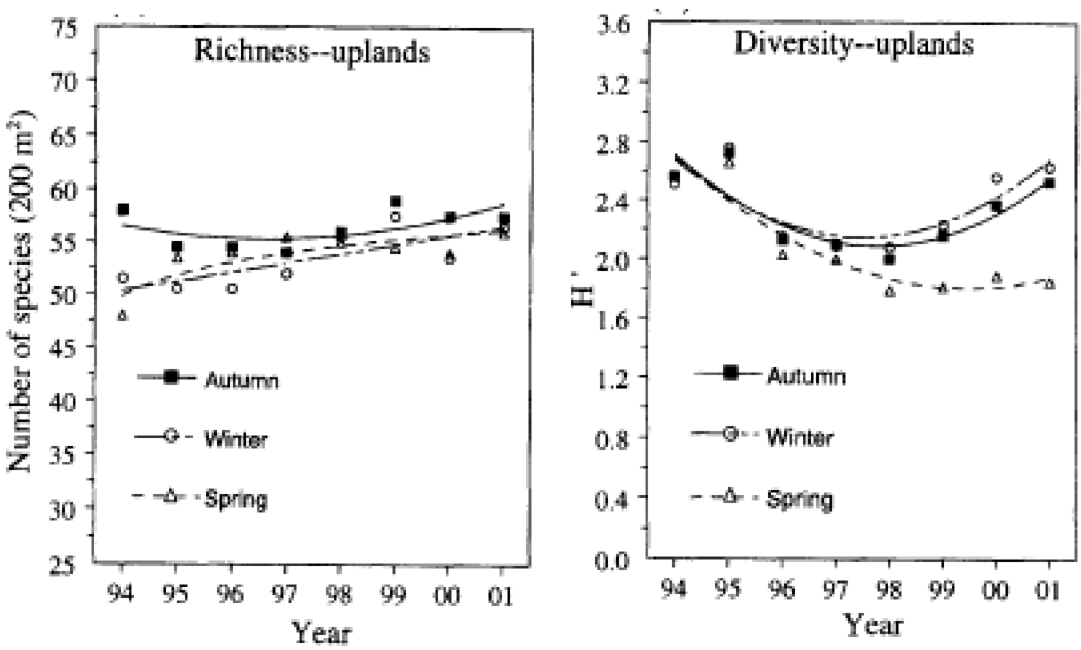


Figure 5. Plant species richness (left panel) and diversity (right panel) in different burn treatments over 8 years.

Question 4A. How does burn season affect species richness? How does it affect species diversity?

Question 4B. Why do we see different patterns for these two different measures of community response? Review the figures you made in Part 1 to propose a hypothesis that explains your answer to the above question.

Part 5: Summary and conclusions

You have now explored prairie plant responses to burn season at the community, functional group, and species biological scales. You have also investigated how these responses change over time. Hopefully, you are coming to the conclusion that it is difficult to address the central ecological question of this lab that is summarized on p.1: ***How does fire disturbance impact plant populations and communities in the tallgrass prairie?***

Question 5A. Take your best shot at answer our central ecological question, incorporating everything you have learned in Questions 1-4.

Question 5B. Consider the list of hypotheses generated by the class. Which of the figures that you have made or interpreted in this exercise support each hypothesis, and which figures refute each hypothesis?

GLOSSARY

Forb: a non-graminoid vascular plant with no woody tissue

Graminoid: Grass or grass-like plant, including the "true" grasses (Poaceae), sedges (Cyperaceae), rushes (Juncaceae), arrow-grasses (Juncaginaceae), and quillworts (*Isoetes*).

Warm-season grass: a grass that grows most vigorously under warm conditions (summer months in the Northern hemisphere) and goes dormant during cooler periods; typically has a C_4 photosynthetic pathway.

Cool-season grass: a grass that grows most vigorously under cooler conditions (late winter/early months in the Northern hemisphere) and goes dormant during warmer periods; typically has a C_3 photosynthetic pathway.

Perennial: one generation exceeds 2 years

Annual: completing a generation in a single year

Richness: the number of different species in a sample

Diversity: a measure of community composition that takes into account species richness and the relative abundance of each species (species evenness)

REFERENCES CITED

Citation for data tables and figures:
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Towne, E.G. 2002. Vascular plants of Konza Prairie Biological Station: an annotated checklist of species in a Kansas tallgrass prairie. Sida 20:269-294.

USEFUL PRAIRIE WEBSITES

Konza Prairie LTER:
http://www.konza.ksu.edu/

UC Berkeley's Grassland Biome:
http://www.ucmp.berkeley.edu/exhibits/biomes/grasslands.php

Grasslands Conservation Council of British Columbia (grasslands of the world page):
http://www.bcgrasslands.org/grasslands_of_the_world.htm