KR bluestem: Restoration to native grasses and forbs

David L. Davidson

1996 - 2016

LANDOWNER REPORT

Ten Years of Ecological Restoration on a Texas Hill Country Site

David Davidson and Patricia Davidson

Ecological Restoration, vol. 26, No. 4, 2008, pp. 331-339

KR Bluestem Restoration Project update -- 2009 to present

In 2007, at the Texas Invasives Conference, Dr. Barron Rector of Texas A&M put forth an hypothesis about the relation between species of grasses and the biotic condition of the soil.

The essence of his hypothesis was that KR - in place for decades - had conditioned the biology of the soil to optimize its success, and to replace KR with native grasses, the biology of the soil would have to be changed to again favor native grasses. To make this change required going through the process of succession, as had occurred in the original formation of native grass prairie.

Between 2007 and 2009, efforts were made to kill KR Bluestem so that it could be replaced by native grasses.
KR bluestem proved to be very difficult to kill.

In 2009, a prescribed burn resulted in soil heating where previously cut juniper had been piled, killing the KR bluestem.

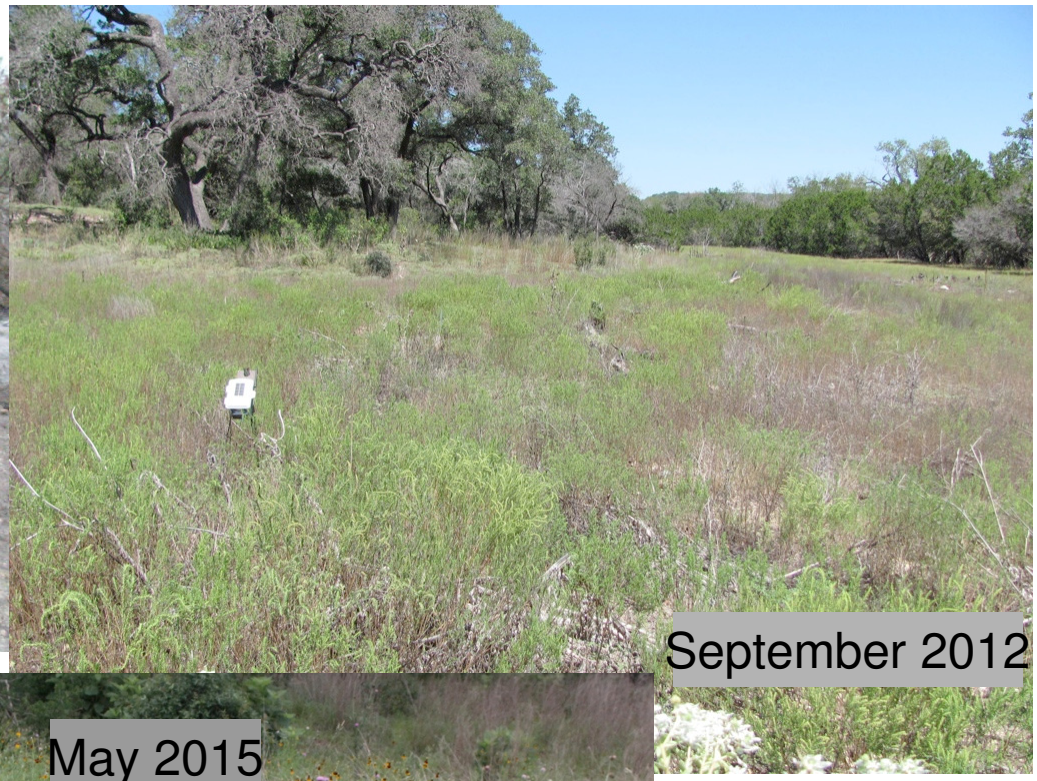
This provided the opportunity to start succession in these burn scars with native grasses and forbs.

Soil Type 8

Restoration Plot #1

April 2015
The year of the thistle

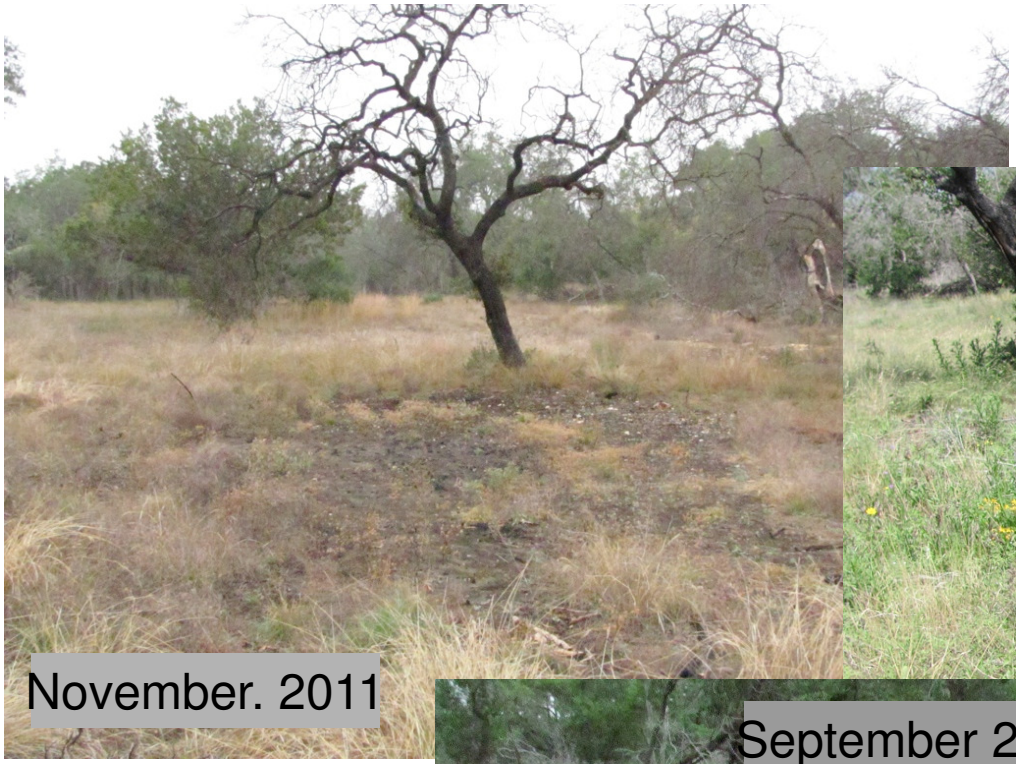

November 2009


September 2012

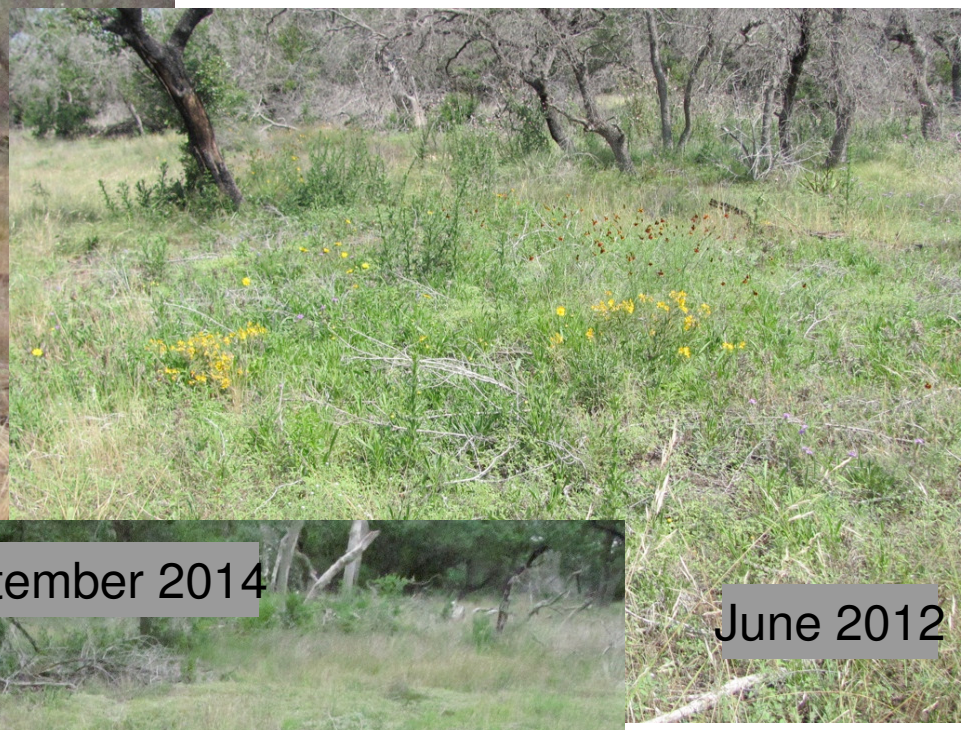
Restoration
Plot #2

Soil Type 11


May 2015



November. 2011



June 2012

September 2014

Restoration
Plot #7

Soil Type 8

Restoration steps

1. Heat the soil to kill the KR bluestem.
2. Clear all big rocks from area.
3. Spread organic matter- compost.
4. Till burn scar to about 4 in. (15 cm).
5. Reseed with native grasses* and forbs**.
6. Sow about 5X recommended density of seeds.
7. Wait for the rain.

* Little bluestem, Indian grass, Grama sideoats, Windmill, other.

** Mixture of wildflowers and bluebonnets.

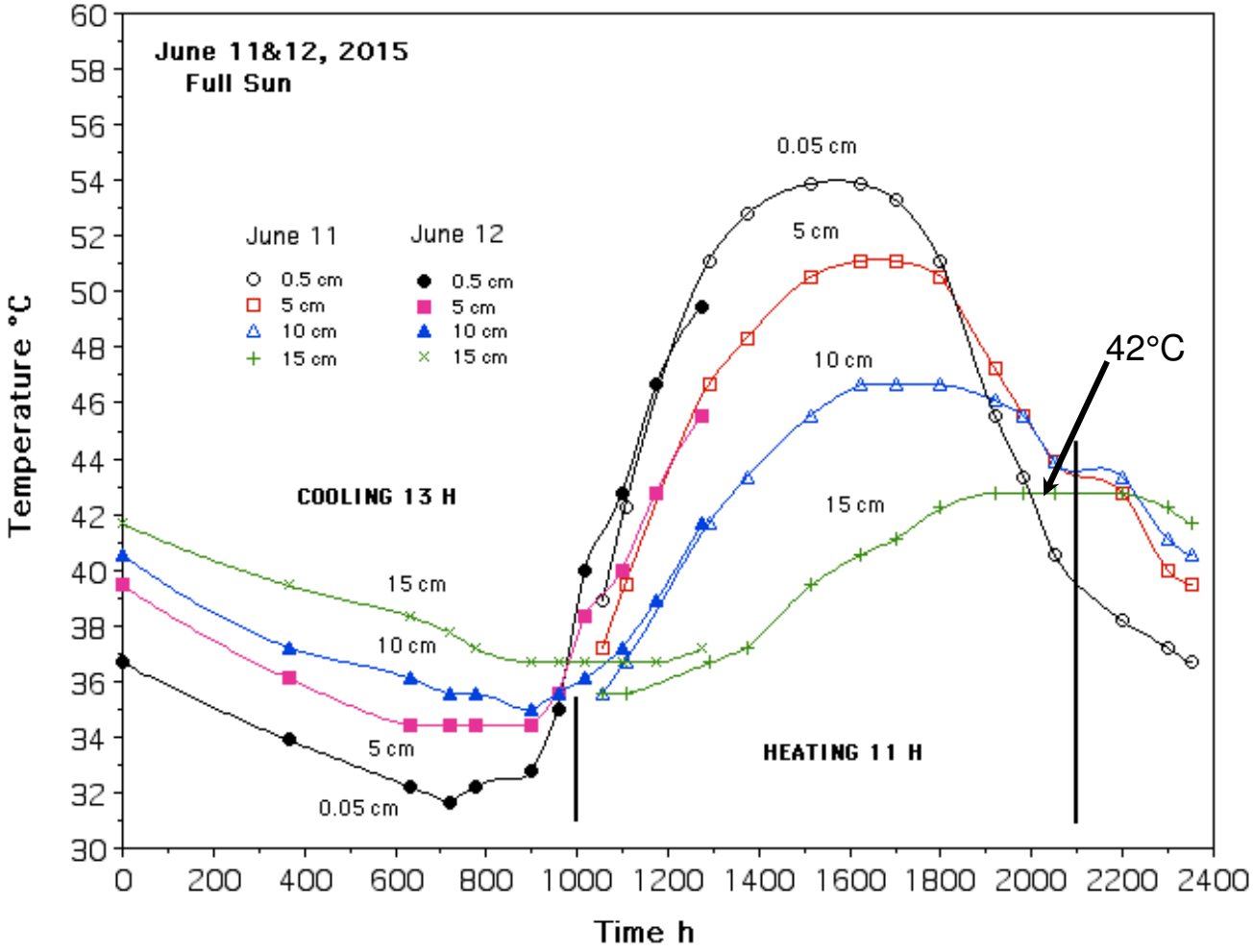
Partial list of uncontrolled variables

(Affects the use of statistics to describe results)

1. Burning brush pile - Temperature and time profile (depends on age and density).
2. Time between burning and reseeding (2 weeks to 4 years).
3. Variations in soil type and unknown prior use (depth & color differences).
4. Soil moisture at reseeding (wet to extremely dry).
5. Rainfall - time after reseeding: 2 weeks, 1 month, 1 year.
6 . Global warming and climate change (soil temperature and moisture).
7. Seed viability at time of reseeding - germination rate?
8. Seed mix used (Little bluestem, Windmill, Grama sideoats, wildflower mixes, other).
9. Level of rodent and bird predation of seeds (unknown).
10. Level of deer browse - Axis + White-tailed deer eating forbs (observed browse) .
11. Variations in soil sampling and technique (difficult to be consistent).
12. Changes in soil testing techniques (Soil biotics, PLFA, Genetic).

Solarization

[slow, controlled heating]



See poster for more details

This restoration appears to be successful.

Why ?

Experimental evidence that invasive grasses use allelopathic biochemicals as a potential mechanism for invasion: chemical warfare in nature

by M.J. Greer, G. W.T. Wilson, K.R. Hickman, and S.M. Wilson
Oklahoma State University
Plant and Soil, v. 385, December 2014, pp. 165-179

Key findings:

"Application of B. ischaemum leachate or litter significantly reduced the germination, growth, and survival of both A. gerardii and S. scoparium, but had no conspecific effects . . . . . ."

"A. gerardii leachate was significantly greater in phenolic content compared to B, ischaemum. Comparison of the leachates (Na, Ca, Mg, K, S, B, P, Fe, Zn, Cu, Mn, Al, Mo, As, Cd, Co, Cr & Pb) indicated that there were no significant differences for any of the elements in A. gerardii or
B. ischaemum leachates."

A. gerardii = Big bluestem
B. ischaemum = KR bluestem
S. scoparium = Little bluestem

My interpretation of these results:

1. KR bluestem is allelopathic to some grasses and forbs.
2. The "allelopathic agent" is biological (not a chemical compound).

Hypothesis

1. Heat is necessary to kill the KR bluestem (plant and roots) and denature the allelopathic agent.

2. The allelopathic agent is probably fungal (not chemical).

Examination of hypothesis

1. Use the apparent success of the restoration plots
as a reference for restored native prairie.
(I have not found any other local native prairie)
2. Test soil for pathogenic fungi.

Phospholipid Fatty Acid Analysis PLFA

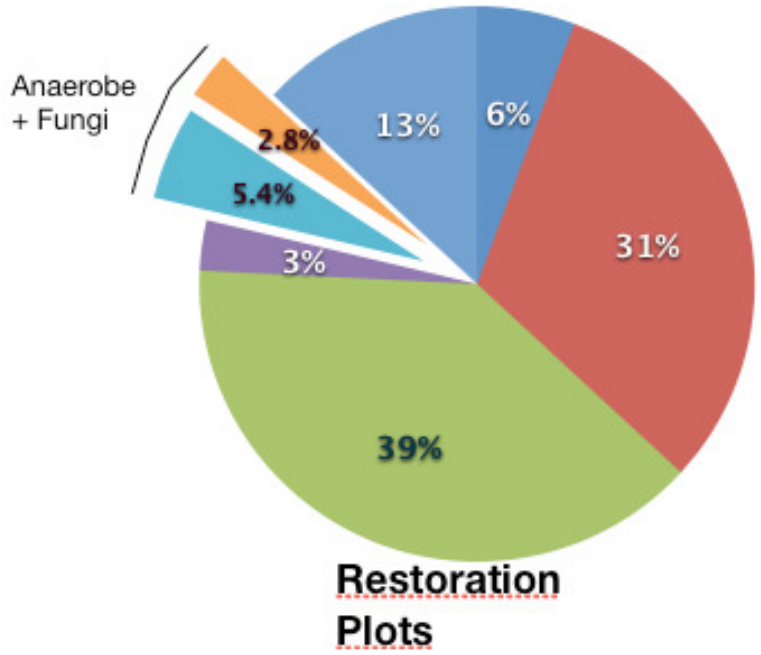
PLFA and NLFA were first used by Oklahoma State University on two commercial Arbuscular Mycorrhiza (AM) Fungal innoculants that I had been using. The innoculants were found to contain large amounts of bacteria, in addition to AM fungi.
AM fungi were found also in soil from KR bluestem and from the Restoration Plots.

I have stopped using the commercial AM fungi innoculants because of these results.

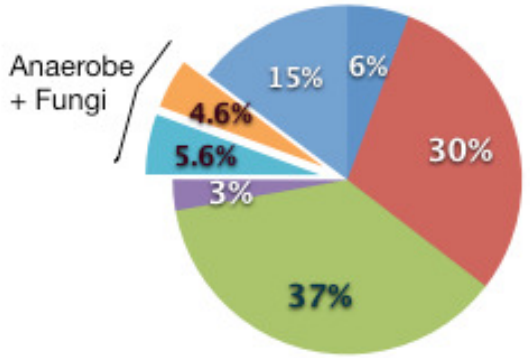
Additional analyses were performed by
Microbial ID Laboratory
Newark, Delaware

PLFA results

ID_Nbr	ID_Only	Sample Code	001: AM Fungi	006 Gram : Positive	002: Gram Negative	004: Eukaryote	005: Fungi	007: Anaerobe	008: Actinomycetes
	Restore plots								
	Averages	8 data	**5.71**	**31.17**	**38.91**	**2.93**	**5.44**	**2.76**	**13.10**
	KR								
	Averages	4 data	**5.74**	**29.75**	**36.79**	**2.89**	**5.61**	**4.61**	**14.79**
	Bare area								
8343	C-DLD15-0616	BARE_AREA	3.38	39.84	34.29		2.58	2.73	17.17
	Solarized								
7933	May 20, 2015	02-S#5	5.90	28.27	37.10	1.74	7.16	3.24	16.47

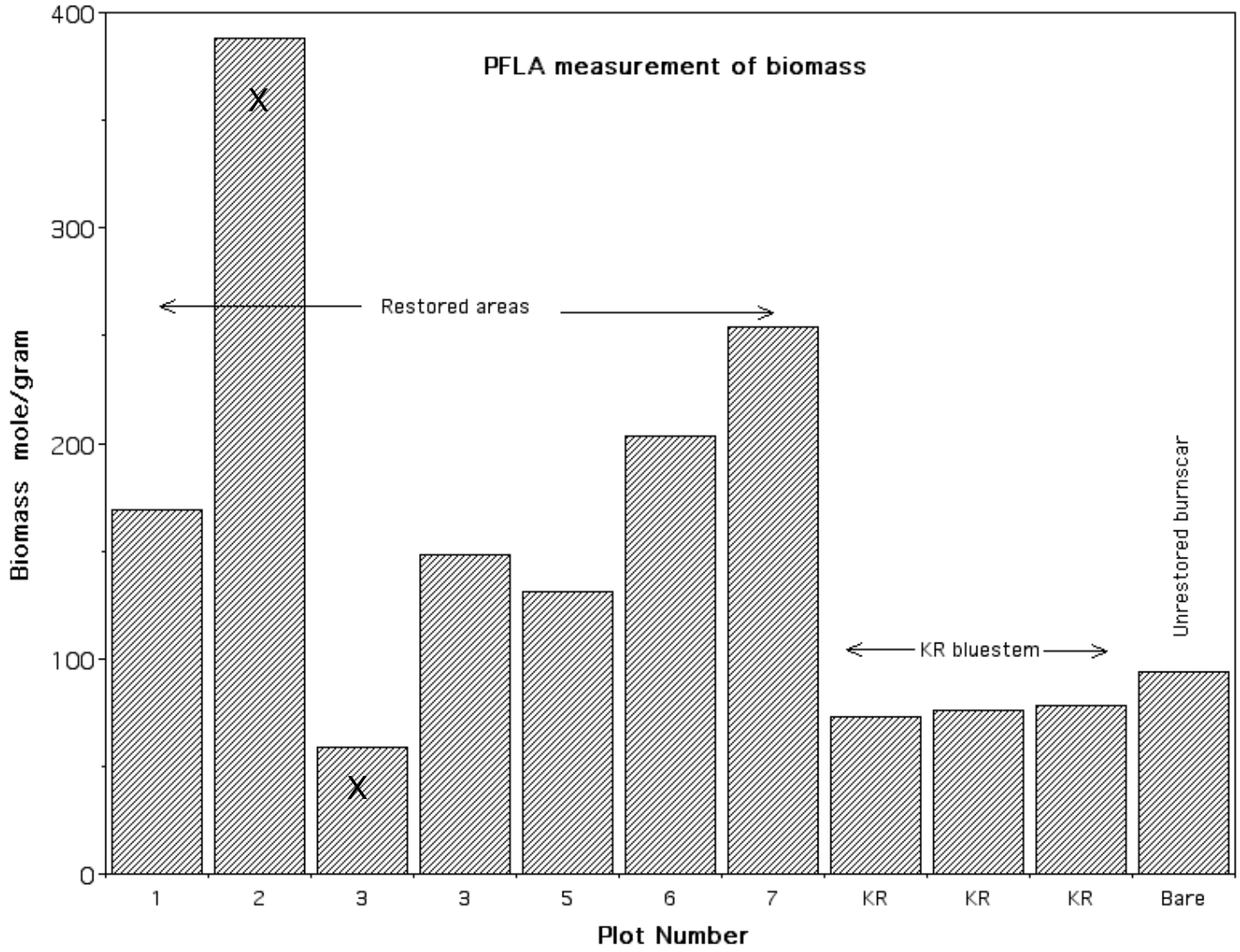


Restoration Plots

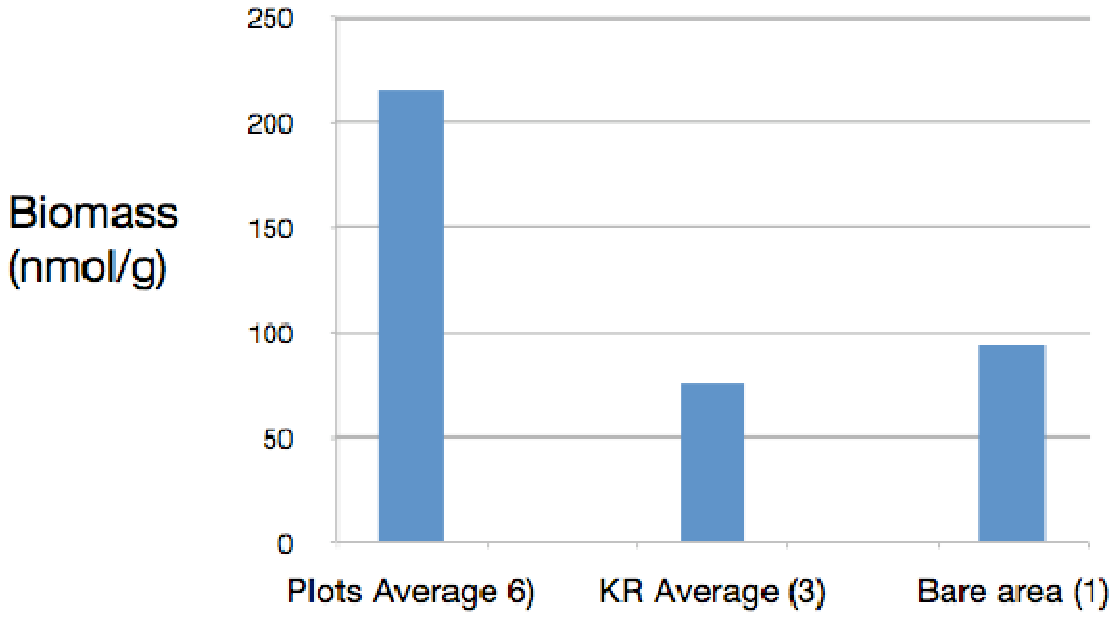


KR

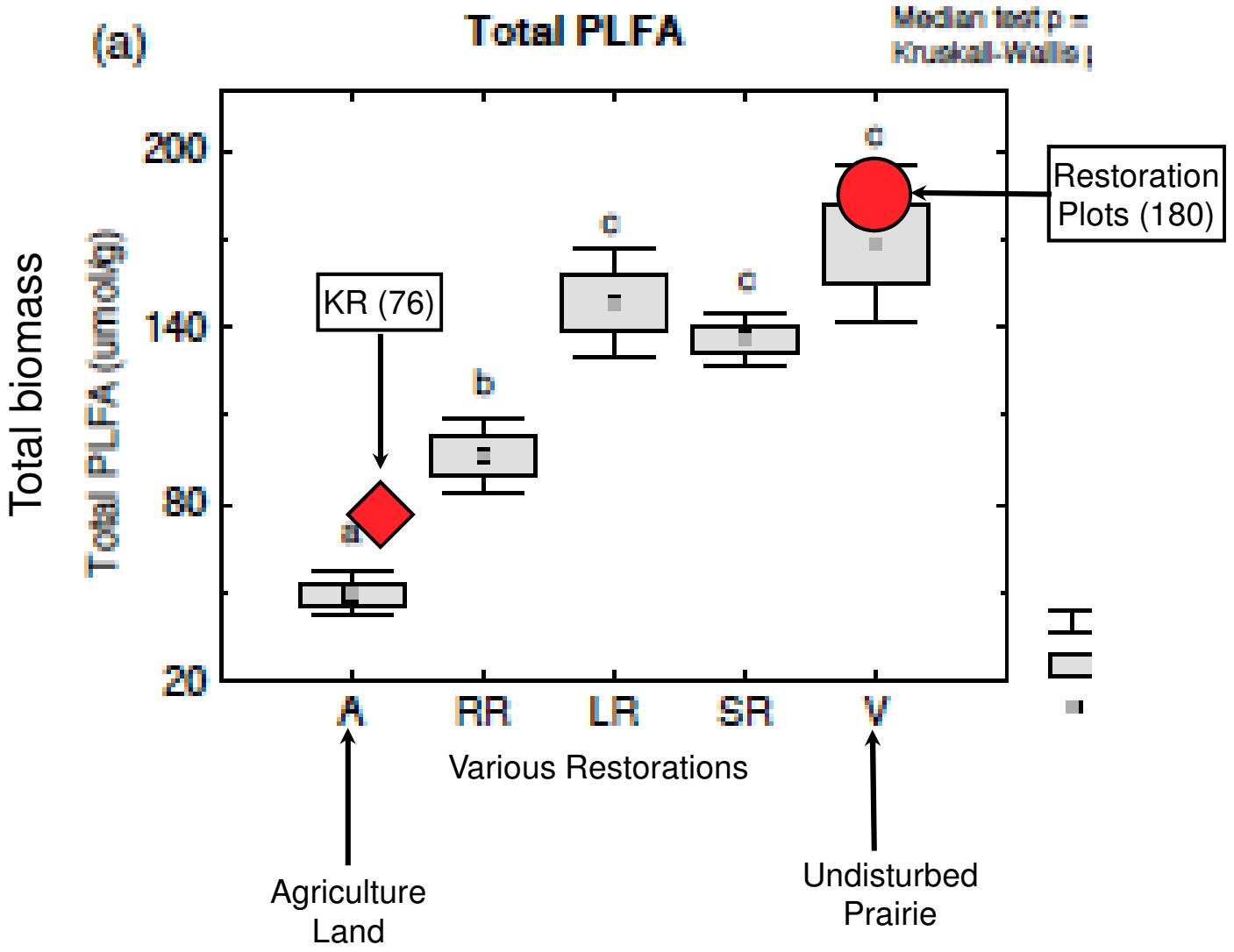
Conclusion: There is not much % difference.


PFLA measurement of biomass
Biomass mole/gram
400
300
200
100
0
Restored areas
KR bluestem
Unrestored burnscar
X
X
1
2
3
3
5
6
7
KR
KR
KR
Bare
Plot Number

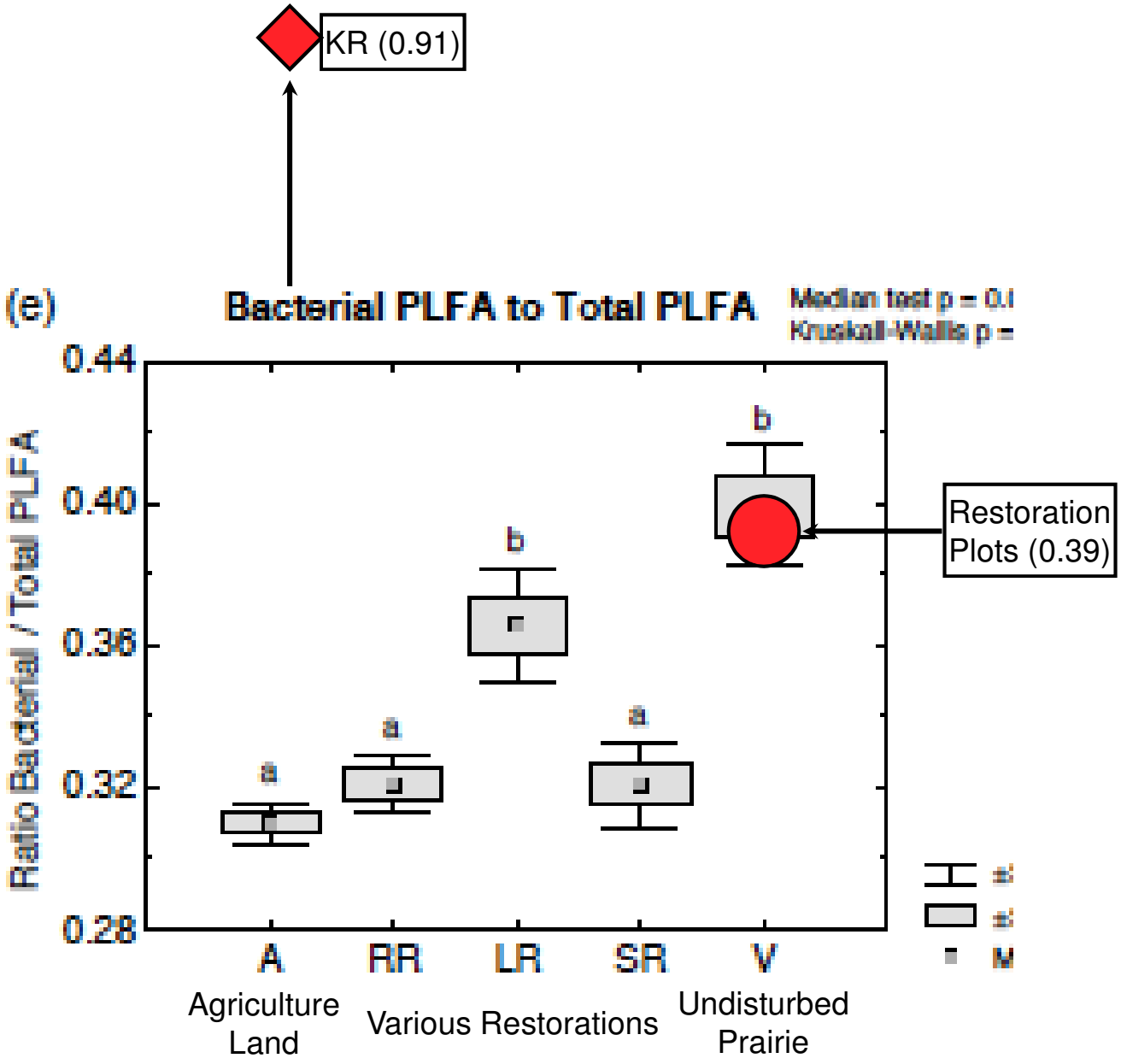
	Moles/gram 2015 Comparison			Peak Numbers				
			Total	3	11	13	33	34
ID_Nbr	ID_Only	Sample Code	Biomass	11:0 anteiso	12:0	13:0 iso	15:4w3c	15:1antiiso w9c
		Plots Average 6)	**215.52**					
		KR Average (3)	**76.10**					
8343	Jun 16, 2015	Bare area (1)	**93.86**					



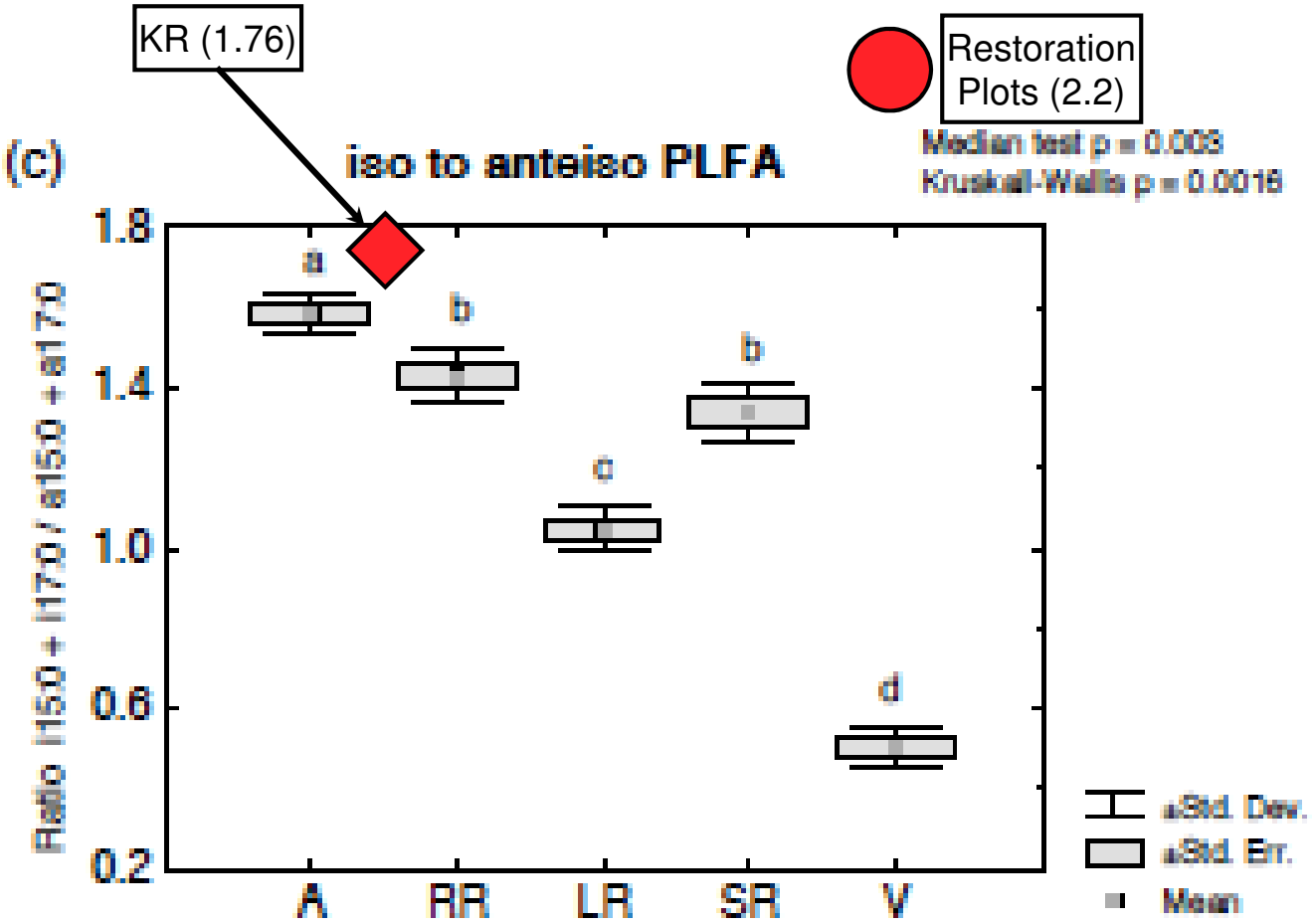
How do these results compare with others ?



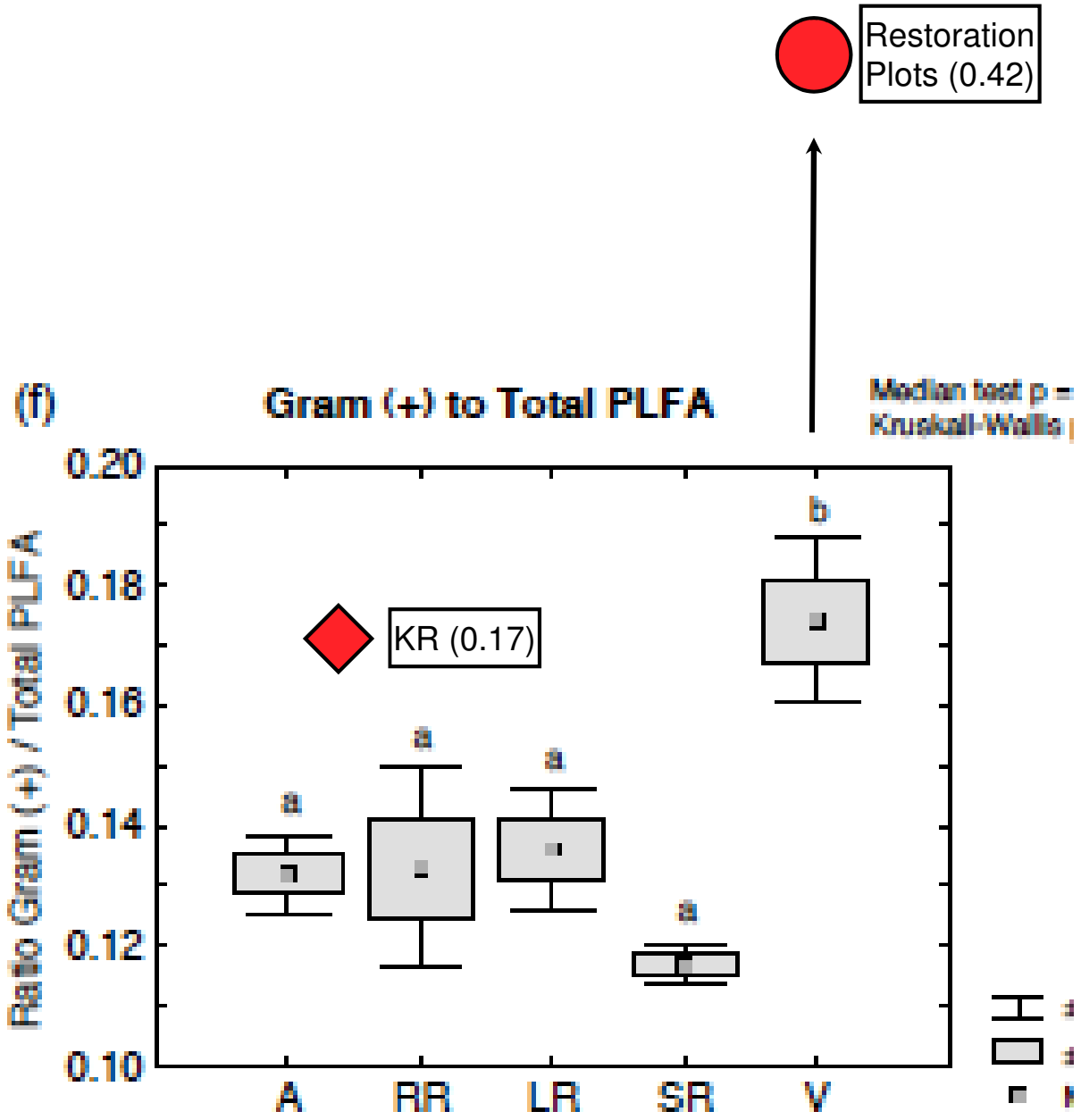
Microbial community PLFA . . in .. . ecosystem restoration in tallgrass prairie soils V.L. McKinley, et al. Soil Biology & Biochemistry (2005) pp. 1946-1958



Microbial community PLFA . . in .. . ecosystem restoration in tallgrass prairie soils V.L. McKinley, et al. Soil Biology & Biochemistry (2005) pp. 1946-1958



Microbial community PLFA . . in .. . ecosystem restoration in tallgrass prairie soils V.L. McKinley, et al. Soil Biology & Biochemistry (2005) pp. 1946-1958



Microbial community PLFA . . in .. . ecosystem restoration in tallgrass prairie soils V.L. McKinley, et al. Soil Biology & Biochemistry (2005) pp. 1946-1958

Conclusion: The restoration process is successful.

Soil conditions and vegetation are similar to native prairie,

Why is KR bluestem allelopathic ?

Examination of KR plants for pathogenic fungi

University of Nebraska (Lincoln) Department of Plant Pathology

Kevin Korus, Plant Pathologist

Sent KR grass plant samples
August 6, 2015

Fusarium fungi were identified either in (or on) the leaves.

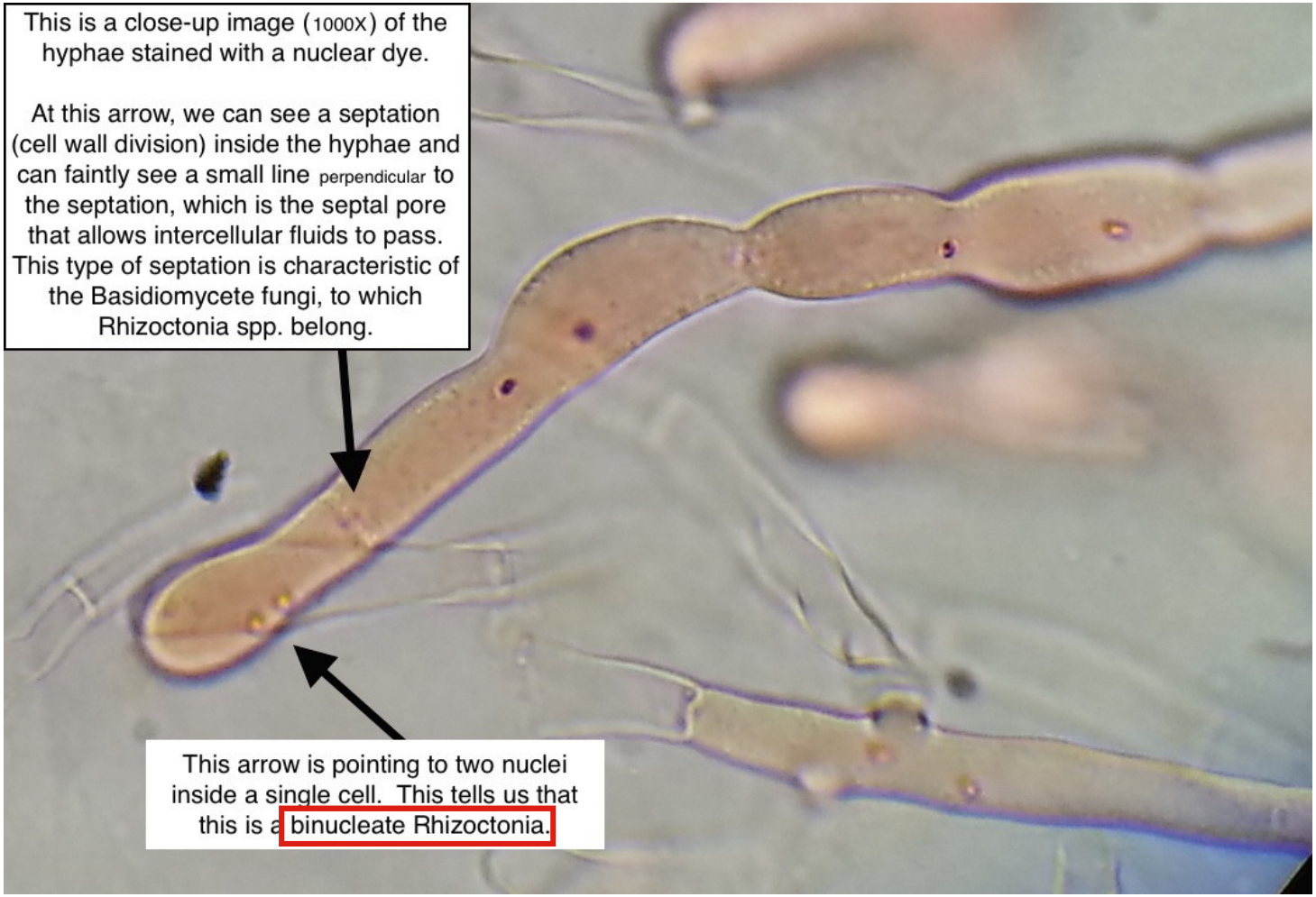
“If found on the leaves, fungi probably infect the roots also.”

University of Nebraska (Lincoln) Department of Plant Pathology
Results from SOIL sample

Sydney Everhart

ASSISTANT PROFESSOR

- PH.D., University of Georgia, 2012
- M.S., University of Central Missouri, 2007



From soil in KR bluestem rhizome

WESTERN LABORATORIES
Disease Test Report

Lab: 46177

Dealer: 00-00

Grower: David Davidson

Field ID: KR hpanan

Crop:

KR bluestem

Date Rec'd 8/28/2015

Date Rep'd 9/9/2015

Soil	Unit	Evaluation	Plant	Evaluation
Pythium	P. ultinum		ND	not detected
~~Phytophthora~~				
Fusarium			29 Ct	moderate
Rhizoctonia			31 Ct	low
	G. gramines			
gaeunomanomyces			28 Ct	moderate

The common name is "Take All" and it is very detrimental to grasses

Harry Kreeft

nematologist / plant pathologist at western laboratories

Parma, Idaho | Research

Current Western Laboratories

Previous University of Idaho, Wageningen UR (University & Research centre)

Education Het Van Hall Instituut

Numbers in Soil are presented in Colony Forming Units per gram dry soil (CFU/g dry soil) or expressed in Ct values. Ct values higher than 30 are usually not a problem. Ct values less than 25 are serious cause of concern.

Harry Kreeft, plant pathologist Western Laboratories Inc.

Fungi pathogen analysis summary

---- Restoration Plots ----

Pathogen	KR bluestem	Burn Scar (Plot #2)	Solarized #5 dethatched	Solarized #5 thatched
Time	40 years	6 years	1 year	1 year
Phythum ultimum	not detected	High	High	Very High
Fusarium oxysporum	Moderate	low	low	low
Rhizoctonia solani AG-8	low	low	low	low
Gaeunomanomyces gramines	Moderate	not detected	not detected	not detected
Phytophthora	not detected	not detected	not detected	not detected

Is this related ?

G. gramines is thought to be the most damaging pathogen, particularly in conjunction with R. solani and F. oxysporum

“Interactions between diseases are very common where one disease increases the effects and damage from other diseases.”
-- Harry Kreeft --

Conclusion: Pathogenic fungi are associated with KR bluestem.
G. gramines may be the most damaging

> Association does not prove causation. <

However, I have no other hypotheses to test.

Conclusions

as of Nov. 2015

Heat is needed to kill KR bluestem prior to reseeding with native grasses and forbs because:

1. The allelopathic nature of KR limits restoration options.
2. The allelopathic agents are probably soil pathogens.
3. Soil pathogens are killed by heating the soil.
4. High density seeding is required to prevent KR reinvasion.
5. When heat and compost are used to restore the soil, reseeding success is limited by rainfall.

What I would like to know

(Maybe you can help)

1. What is the effect of the pathogens identified on **native grasses** and **forbs** ?
2. Does soil type influence the pathogens related to KR bluestem ?
3. Does brush pile burning kill all of the soil pathogens ?
4. What is the necessary minimum reseeding density ?
5. How can the reseeding weather be better predicted ?
6. Is succession accelerated by the restoration process ?
7. Where did the Pythium ultinum originate and is it of concern ?

There is more to be learned