



Northern Great Plains Fire Ecology Program Review

1997-2007

Natural Resource Report NPS/NRDS/NRDS—2010/112



ON THE COVER

Andy Thorstenson and Rod Skalsky collect fire behavior and temperature data during a prescribed fire at Wind Cave National Park, SD.

Photograph by: NPS Northern Great Plains Fire Ecology Program

Northern Great Plains Fire Ecology Program Review

1997-2007

Natural Resource Report NPS/NRDS/NRDS—2010/112

Cody Wienk

National Park Service
Midwest Regional Office
601 Riverfront Dr.
Omaha, NE 68102

Andy Thorstenson, Jon Freeman, and Dan Swanson

National Park Service
Northern Great Plains Fire Management Office
Wind Cave National Park
26611 US Hwy 385
Hot Springs, SD 57747

November 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/NRPM>).

Please cite this publication as:

Wienk, C., A. Thorstenson, J. Freeman, and D. Swanson. 2010. Northern Great Plains fire ecology program review: 1997-2007. Natural Resource Data Series NPS/NGPN/NRDS—2010/112. National Park Service, Fort Collins, Colorado.

TABLE OF CONTENTS

Executive Summary	vi
Introduction	1
Badlands National Park.....	3
Monitoring Units.....	3
Western wheatgrass mixed-grass prairie (AGSM)	3
Woody draws (FRPE)	3
Chokecherry/Plum shrubland (PRAM).....	3
Non-native prairie – Kentucky bluegrass (POPR).....	3
Non-native prairie – Japanese brome (BRJA)	4
Prescribed Fires.....	4
Monitoring Plots	6
Monitoring Results.....	9
Prescribed Fire Units.....	9
Monitoring Units.....	27
Park-wide Summary.....	34
Precipitation	36
Devils Tower National Monument	37
Monitoring Units.....	37
Non-native grass prairie – Kentucky bluegrass (POPR).....	37
Ponderosa pine forest (PIPO).....	37
Prescribed Fires.....	37
Monitoring Plots	39
Monitoring Results.....	41
Prescribed Fire Units.....	41
Monitoring Units.....	61
Park-wide Summary.....	67
Precipitation	68
Knife River Indian Villages National Historic Site	69
Monitoring Units.....	69
Green ash/boxelder woodland (FRPE)	69
Needle-and-thread/sedge mixed-grass prairie (STCO).....	69
Prescribed Fires.....	69
Monitoring Plots	71
Monitoring Results.....	73
Prescribed Fire Units.....	73
Monitoring Units.....	85
Park-wide Summary.....	88
Precipitation	89
Mount Rushmore National Memorial	91
Monitoring Units.....	91
Ponderosa pine forest (PIPO).....	91

Treatments.....	91
Monitoring Plots	92
Monitoring Results.....	93
Lafferty Gulch.....	93
Old Growth	96
Precipitation	97
Scotts Bluff National Monument.....	99
Monitoring Units.....	99
Juniper woodlands (JUSC)	99
Sideoats grama/needlegrass mixed-grass prairie (BOCU)	99
Western snowberry shrubland (SYOC)	99
Needlegrass/sedge mixed-grass prairie (STCO).....	99
Prescribed Fires.....	100
Monitoring Plots	101
Monitoring Results.....	103
Prescribed Fire Units.....	103
Monitoring Units.....	125
Park-wide Summary.....	132
Precipitation	133
Theodore Roosevelt National Park	135
Monitoring Units.....	135
Crested wheatgrass - native prairie interface (AGCR)	135
Silver sagebrush shrubland (ARCA)	135
Cottonwood/Rocky Mountain juniper forest (PODE)	135
Green needlegrass mixed-grass prairie (STVI).....	136
Snowberry shrubland (SYOC).....	136
Prescribed Fires.....	136
Monitoring Plots	138
Monitoring Results.....	141
Prescribed Fire Units.....	141
Monitoring Units.....	153
Park-wide Summary.....	158
Precipitation	159
Wind Cave National Park	161
Monitoring Units.....	161
Native mixed-grass prairie (ANSC & AGSM).....	161
Non-native prairie - Kentucky bluegrass (POPR)	161
Ponderosa pine forest (PIPO).....	161
Prescribed Fires.....	162
Monitoring Plots	164
Monitoring Results.....	167
Prescribed Fire Units.....	167
Monitoring Units.....	187
Park-wide Summary.....	195
Precipitation	197
Multi-Park Summary	199

Native Prairie & Shrublands	199
Non-native Grasslands	201
Ponderosa Pine Forest.....	204
Herbaceous Vegetation	204
Tree Density.....	206
Fuel Load	208
All Plots	210
Conclusion	213
General Observations.....	213
Recommendations.....	213
Acknowledgements.....	215

EXECUTIVE SUMMARY

The Northern Great Plains (NGP) Fire Ecology program provides fire ecology support for ten national park units in North Dakota, South Dakota, Nebraska, and Wyoming. These include Fort Union Trading Post National Historic Site (FOUS), Theodore Roosevelt National Park (THRO), Knife River Indian Villages National Historic Site (KNRI), Badlands National Park (BADL), Jewel Cave National Monument (JECA), Mount Rushmore National Memorial (MORU), Wind Cave National Park (WICA), Scotts Bluff National Monument (SCBL), Agate Fossil Beds National Monument (AGFO), and Devils Tower National Monument (DETO).

From 1997 to 2007, more than 46,000 acres were treated with prescribed fire and mechanical fuels reduction projects in NGP parks. This report presents results and analyses completed by the NGP Fire Ecology program relating to these fuels projects. AGFO, JECA, and FOUS are not included in this report because little or no fuels work has occurred in these parks.

This report is organized by park. Each park section begins with a description of the monitoring units (vegetation types) that have been a part of the monitoring program. Next are a table and map of all fuels projects that occurred in the respective park between 1997 and 2007. This is followed with a table and map of all fire monitoring plots in the park as of 2007. The bulk of each section is comprised of the monitoring results. These are presented first for each prescribed fire unit, then for each monitoring type, and finally in a park-wide data summary. Results are given in bar graphs and tables. If three or more plots are included in the analysis, standard error bars are included on the graph. For prescribed fire units and monitoring types, results are presented first by vegetation lifeform, then by dominant genera or species. Tables include pre- and post-treatment data as well as percent change in the variable of interest. The park-wide summary includes cover of native and non-native species, and a graphical representation showing relative cover of native and non-native species over time. The last page of each section includes a graph of annual precipitation at the park from 1997 to 2007.

The individual park sections are followed by a multi-park summary. Data from several parks were combined to summarize trends across the entire plot network. These analyses were completed covering broad vegetation groups including native prairie, non-native grasslands, and ponderosa pine forest. At this broad level, it was only practical to summarize the data by vegetation lifeform. We also included a summary of vegetation cover (i.e. lifeform), of all plots in the network that have been treated with prescribed fire.

The final section of the report includes our general observations and recommendations. We did not include much interpretation of the data in the park or multi-park sections, but rather provided our overall interpretations in the final section. They include our most interesting and surprising observations, our successes, and our challenges.

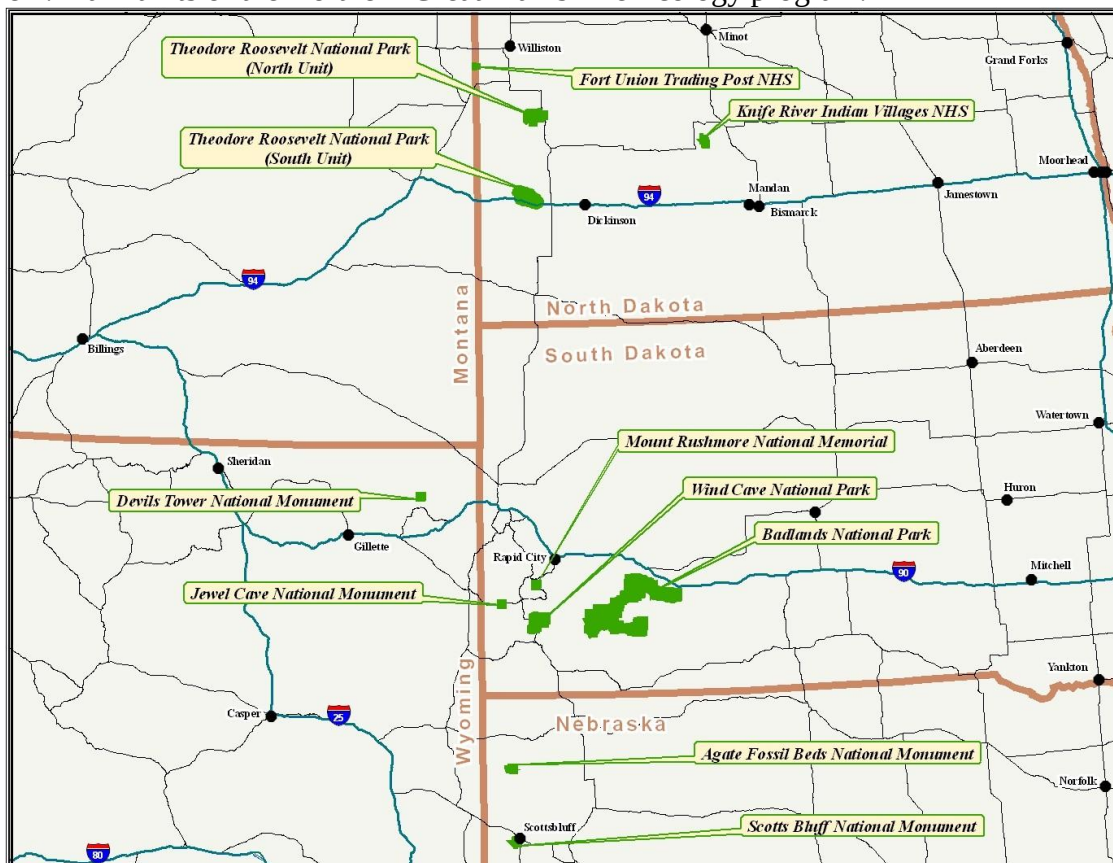
Over the past 10 years, many hours were spent collecting, entering, analyzing, and summarizing these data. We hope that this information provides a baseline from which the program can move into the next decade of fire monitoring in the parks of the Northern Great Plains.

INTRODUCTION

The National Park Service (NPS) first implemented a fire effects monitoring program in the Pacific West Region in 1989 to document baseline vegetation information, to detect trends in vegetation populations, to ensure that resource management objectives are met, and to aid in refining parks' fire management programs. The Northern Great Plains (NGP) program was established in 1996 and has since grown to a network of more than 195 monitoring plots in 10 NPS units. These plots are established in forest stands, shrublands, and grasslands. The majority of the monitoring protocols follow those set in the NPS Fire Monitoring Handbook (2003), although we have begun to increasingly use alternative protocols to answer park-specific questions. The NPS standard monitoring protocols include measuring understory vegetation cover, density of trees and shrubs, diameter at breast height (DBH) of trees, and surface fuel loading. Alternative protocols are used to measure the same set of variables, but on modified plots and transects. Long-term photo monitoring points have also been used when appropriate to capture changes on the landscape.

This report represents the culmination of more than ten years of work in Northern Great Plains parks. Information and analyses for each park is included first, followed by a few analyses with data from multiple parks. For each park, there is information about monitoring units, prescribed fires, monitoring plots, monitoring results at the burn unit and park level, and annual precipitation.

Figure 1. Park units of the Northern Great Plains Fire Ecology program.





BADLANDS NATIONAL PARK

MONITORING UNITS

Western wheatgrass mixed-grass prairie (AGSM)

This vegetation type is found extensively throughout BADL. Stands have moderate to complete herbaceous cover, between 40-100%. Western wheatgrass (*Pascopyrum smithii*) is strongly dominant in ungrazed stands, less so in stands subjected to annual grazing by large ungulates. Species dominance can vary locally within a stand, depending on soils and use factors (Von Loh et al. 1999). Dominant graminoids are western wheatgrass, blue grama (*Bouteloua gracilis*), and green needlegrass (*Nassella viridula*). Shrubs are plains prickly pear (*Opuntia polyacantha*), skunkbush sumac (*Rhus trilobata*), and silver sagebrush (*Artemisia cana*). Common forbs include fringed sagewort (*Artemisia frigida*), heath aster (*Symphyotrichum ericoides*), common yarrow (*Achillea millefolium*), and Missouri goldenrod (*Solidago missouriensis*).

Woody draws (FRPE)

This habitat type encompasses several different plant communities as described in Van Loh et al. (1999). Vegetation communities grouped into this monitoring type are based on a Green Ash-Elm Woody Draw and the surrounding communities. Associated edge communities in drier areas are Rocky Mountain Juniper/Little-seed Ricegrass Woodland and Ponderosa Pine/Rocky Mountain Juniper Woodland. Stands typically have closed canopies dominated by green ash (*Fraxinus pennsylvanica*) with some American elm (*Ulmus americana*). Cottonwood (*Populus deltoides*) and peachleaf willow (*Salix amygdaloides*) will be present if there is a spring or seep. Shrubs are sparse in the understory, but form dense communities along the edges of draws. Shrubs include chokecherry (*Prunus virginiana*), western snowberry (*Symphoricarpos occidentalis*), skunkbush sumac and poison ivy (*Toxicodendron rydbergii*). The herbaceous component includes Kentucky bluegrass (*Poa pratensis*), western wheatgrass, and big bluestem (*Andropogon gerardii*) (Von Loh et al. 1999).

Chokecherry/Plum shrubland (PRAM)

American plum (*Prunus americana*) stands, occasionally mixed with chokecherry, occupy mesic draws, typically at the head of green ash or Rocky Mountain juniper woodland types. A few stands are also found at the seep zone on the edge of sandhills, mesic hillslope slumps, and in old river oxbows. Stands are near 100% cover wherever they occur and are very dense and compact in the draws occupied. A variety of other shrubs are usually present and western snowberry with poison ivy typically forms a border around the taller shrubs. Herbaceous species cover is sparse with Kentucky bluegrass, western wheatgrass, and green needlegrass the most common species noted.

Non-native prairie – Kentucky bluegrass (POPR)

Stands typically have moderate herbaceous cover, ranging from 40-90% and very dense litter over the ground surface. Areas tend to be dominated by one non-native grass species, often planted. The dominant grass is Kentucky bluegrass. Other non-native species associated with these areas include smooth brome (*Bromus inermis*), crested wheatgrass (*Agropyron cristatum*) Japanese brome (*B. japonicus*), cheatgrass (*B. tectorum*), alfalfa (*Medicago sativa*), yellow

sweetclover (*Melilotus officinalis*), and common mullein (*Verbascum thapsus*). At the edge and occasionally interspersed are western wheatgrass, needle and thread (*Hesperostipa comata*), and green needlegrass. Very few native forbs or shrubs are seen in this type (Von Loh et al. 1999).

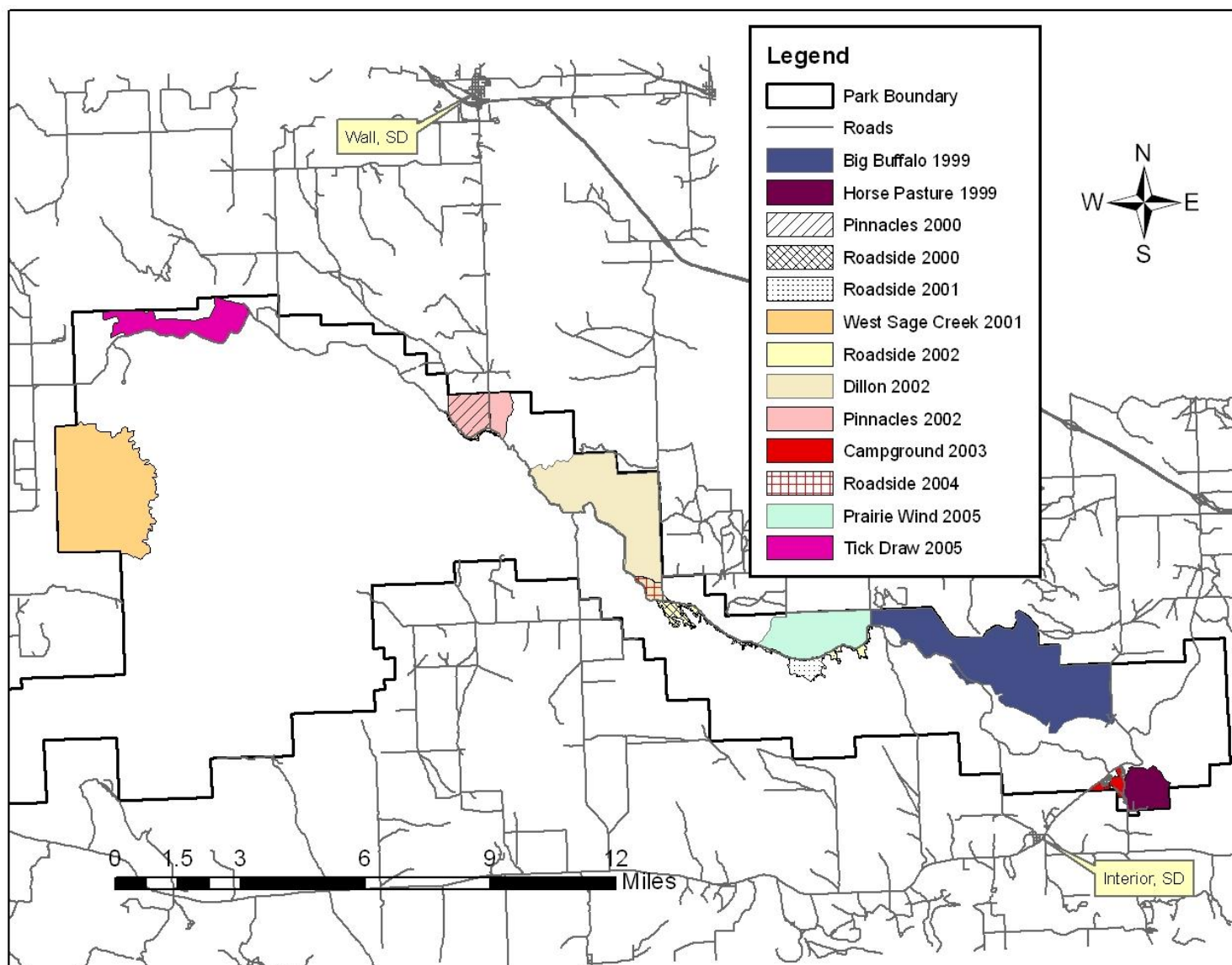
Non-native prairie – Japanese brome (BRJA)

A blend of tall-grass and short-grass prairies, typically dominated by *Bromus* spp., grasses include: Japanese brome, cheatgrass, western wheatgrass, needle and thread, and green needlegrass. Other species include: blue grama, sideoats grama (*B. curtipendula*), little bluestem (*Schizachyrium scoparium*), and big bluestem. Shrubs include prickly pear and skunkbush sumac. Forbs include fringed sagewort, silver sagebrush, heath aster, common yarrow, and Missouri goldenrod.

PRESCRIBED FIRES

Burn Unit	Date(s)	Season	Size
Picnic	10/9/96	Fall	640
Horse Pasture	8/18/99	Fall	660
Big Buffalo	9/9/99	Fall	4785
Roadside	4/17 & 5/1/00	Spring	433
Pinnacles (west)	4/27/00	Spring	550
Roadside	5/8/01	Spring	304
W. Sage Creek	10/16 & 10/28/01	Fall	3572
Roadside	4/25/02	Spring	330
Pinnacles (east & west)	5/9/02	Spring	848
Dillon	11/21/02	Fall	3132
Campground	9/23/03	Fall	185
Roadside	4/13-14 & 4/26-27/04	Spring	422
Tick Draw	9/16/04	Fall	488
Tick Draw	10/3/05	Fall	1447
Prairie Wind	10/14/05	Fall	1393



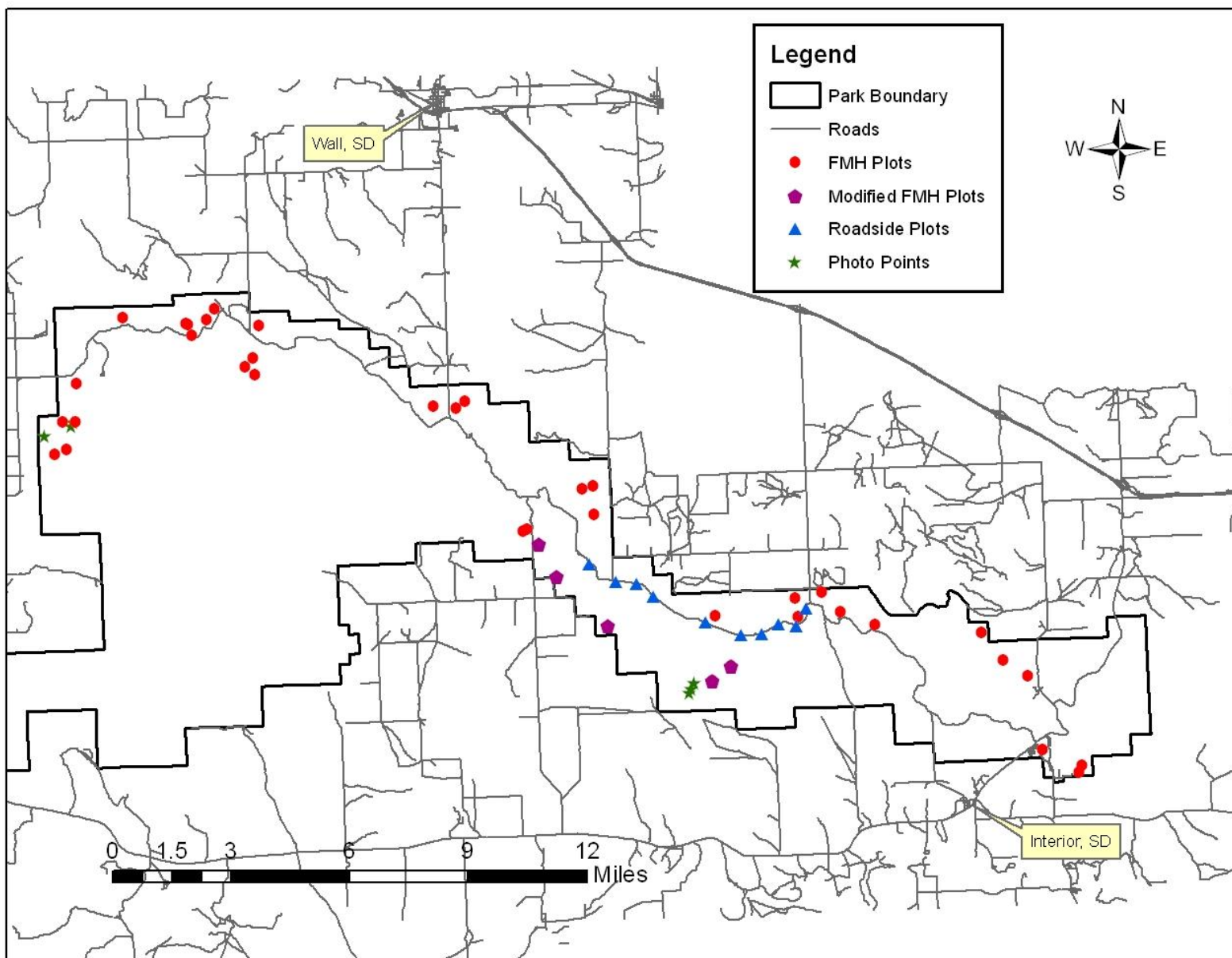


MONITORING PLOTS

Burn Unit	Monitoring Unit	Plot ID	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Conata II	Photo Point	PP1							V				
Conata II	Photo Point	PP2							V				
Conata II	Photo Point	PP3							V				
W Sage Creek	Photo Point	PP4						V	V	V			V
W Sage Creek	Photo Point	PP5						V	V	V			V
W Sage Creek	Photo Point	PP6							V	V			V
Pinnacles	Kentucky Bluegrass	POPR-01				V		V	B/V	V		V	
Pinnacles	Kentucky Bluegrass	POPR-02				V		V	B/V	V		V	
Pinnacles	Kentucky Bluegrass	POPR-03				V	B/V	V	B/V	V		V	
Roberts	Kentucky Bluegrass	POPR-04								V			
Tick Draw	Kentucky Bluegrass	POPR-05								V		B/V	V
Roadside	Smooth Brome	BRIN-14						V	V	V	B/V		
Roadside	Smooth Brome	BRIN-14.5						V	B/V	V	V		
Roadside	Smooth Brome	BRIN-15						V	V	V	B/V		
Roadside	Smooth Brome	BRIN-15.5						B/V	V	V	V		
Roadside	Smooth Brome	BRIN-16						V	V	V	B/V		
Roadside	Smooth Brome	BRIN-17						V	V	V	B/V		
Roadside	Smooth Brome	BRIN-18.5					B	V	B/V	V	V		
Roadside	Smooth Brome	BRIN-19						V	V	V	B/V		
Roadside	Smooth Brome	BRIN-19.5					B	V	B/V	V	V		
Roadside	Smooth Brome	BRIN-20.5						V	V	V	V		
W Sage Creek	Plum/Chokecherry	PRUN-01					V	B/V	V	V			V
W Sage Creek	Plum/Chokecherry	PRUN-02					V	B/V	V	V			V
Tick Draw	Plum/Chokecherry	PRUN-03								V		B/V	V
Tick Draw	Plum/Chokecherry	PRUN-04								V		B/V	V
Big Buffalo	Western Wheatgrass	AGSM-03	V		V	B/V	V	V			V		
Big Buffalo	Western Wheatgrass	AGSM-04	V		V	B/V	V	V			V		
Big Buffalo	Western Wheatgrass	AGSM-05	V		V	B/V	V	V			V		
Horse Pasture	Western Wheatgrass	AGSM-06		V		B/V	V	V			V		
Tick Draw	Western Wheatgrass	AGSM-07		V						V		B/V	V
Big Buffalo	Western Wheatgrass	AGSM-08		V		B/V	V	V			V		

Burn Unit	Monitoring Unit	Plot ID	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Sage Creek	Western Wheatgrass	AGSM-09	V										
Sage Creek	Western Wheatgrass	AGSM-10	V										
Sage Creek	Western Wheatgrass	AGSM-11	V										
Big Buffalo	Western Wheatgrass	AGSM-12				B/V	V	V			V		
Big Buffalo	Western Wheatgrass	AGSM-13				B/V	V	V			V		
Horse Pasture	Western Wheatgrass	AGSM-14				B/V	V	V			V		
W Sage Creek	Western Wheatgrass	AGSM-15					V	B/V	V	V			V
W Sage Creek	Western Wheatgrass	AGSM-16					V	B/V	V	V			V
Campground	Western Wheatgrass	AGSM-17					V		V	B/V	V	V	
Dillon	Western Wheatgrass	AGSM-18						V	B/V	V	V		
Dillon	Western Wheatgrass	AGSM-19						V	B/V	V	V		
Dillon	Western Wheatgrass	AGSM-20						V	B/V	V	V		
Conata II	Western Wheatgrass	AGSM-21							V				
Conata II	Western Wheatgrass	AGSM-22							V				
Tick Draw	Western Wheatgrass	AGSM-24								V		B/V	V
Tick Draw	Western Wheatgrass	AGSM-25								V	B/V	B/V	V
Prairie Wind	Western Wheatgrass	AGSM-26									V	B/V	V
Prairie Wind	Western Wheatgrass	AGSM-27									V	B/V	V
Prairie Wind	Western Wheatgrass	AGSM-28									V	B/V	V
Conata I	Upland Mixed-grass	GFV-1											V
Conata I	Upland Mixed-grass	GFV-02											V
Conata I	Upland Mixed-grass	GFV-03											V

V = Plot visit; B = Burned

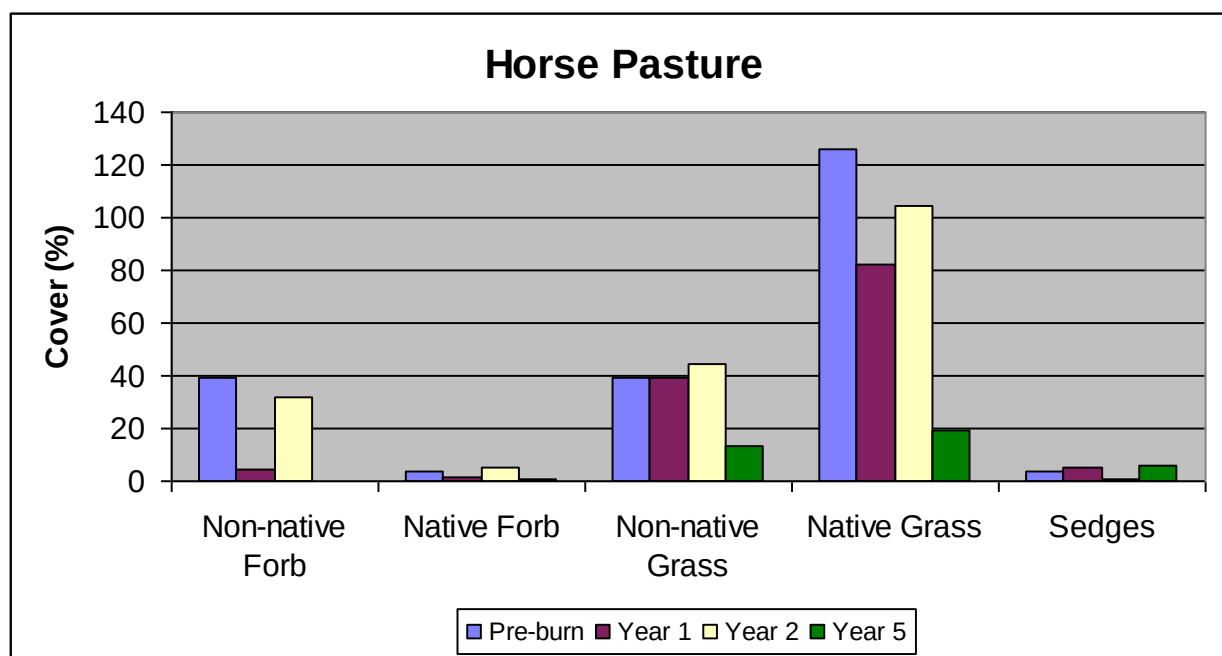


MONITORING RESULTS

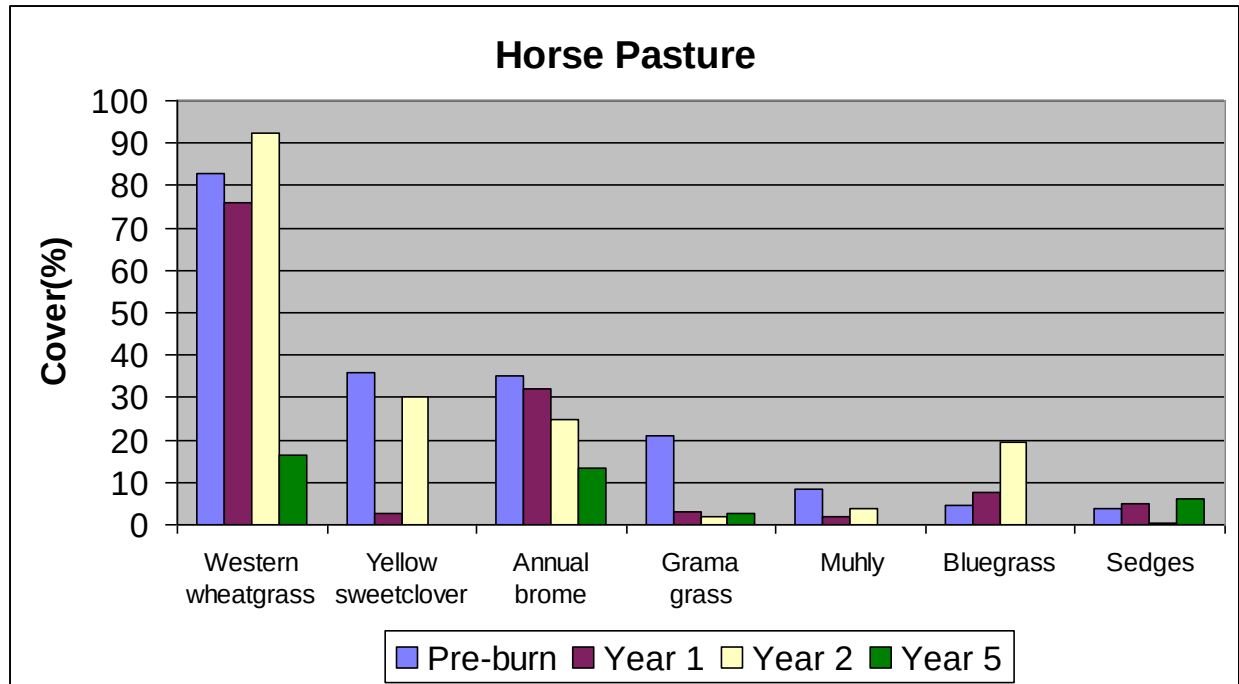
Prescribed Fire Units

Horse Pasture

Two western wheatgrass plots were installed in Horse Pasture. Standard error bars are not included because of the small sample size.



HORSE PASTURE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	39.0	31.5	-19%	0.0	-100%
<i>Native Forb</i>	4.0	5.5	38%	0.5	-88%
<i>Non-native Grass</i>	39.5	44.5	13%	13.5	-66%
<i>Native Grass</i>	126.0	104.5	-17%	19.5	-85%
<i>Sedges</i>	4.0	0.5	-88%	6.0	50%



The table below presents change in cover from pre-burn conditions for the six most common genera. *Italicized rows indicates non-native genera.*

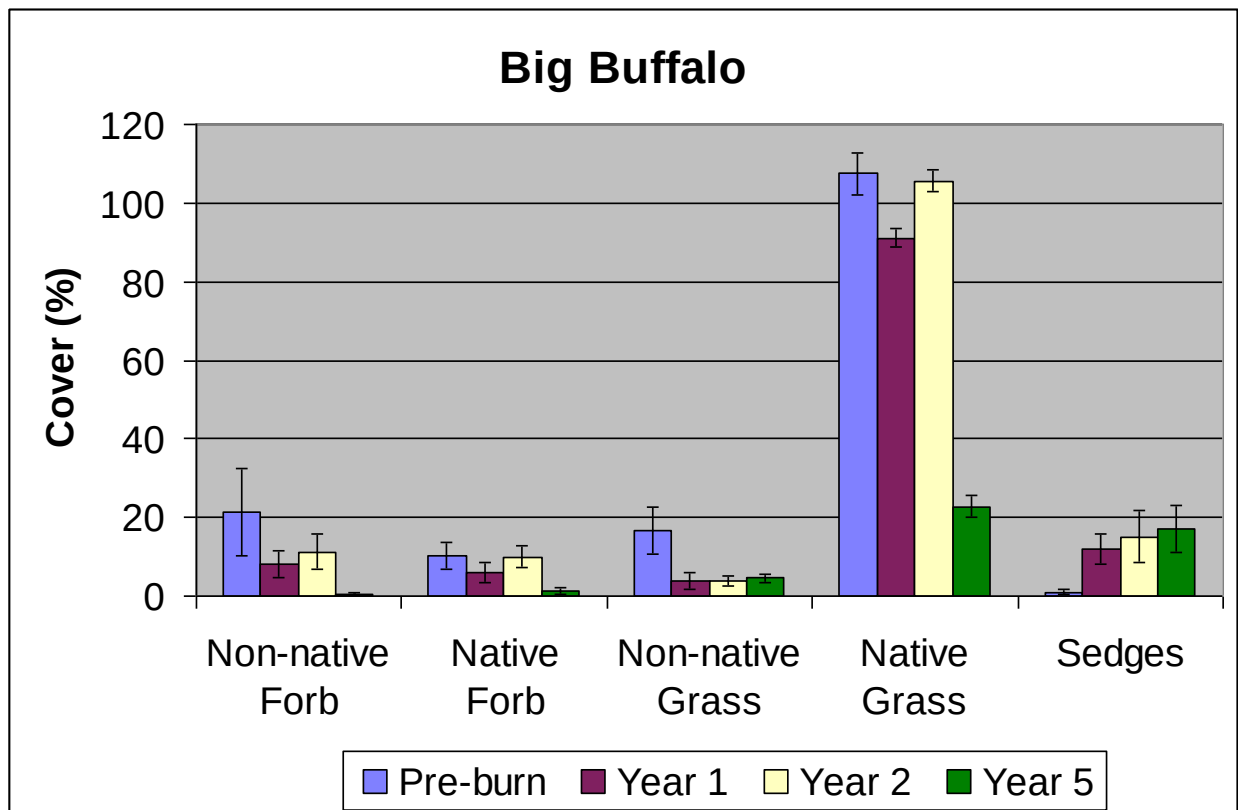
HORSE PASTURE					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	83.0	92.5	11%	16.5	-80%
<i>Yellow sweetclover</i>	36.0	30.0	-17%	0.0	-100%
<i>Annual brome</i>	35.0	25.0	-29%	13.5	-61%
Grama grass	21.0	2.0	-91%	2.5	-88%
Plains muhly	8.5	4.0	-53%	0.0	-100%
Green needlegrass	4.5	4.5	0%	0.5	-89%
<i>Kentucky bluegrass</i>	4.5	19.5	333%	0.0	-100%
Sedges	4.0	0.5	-88%	6.0	50%

Big Buffalo

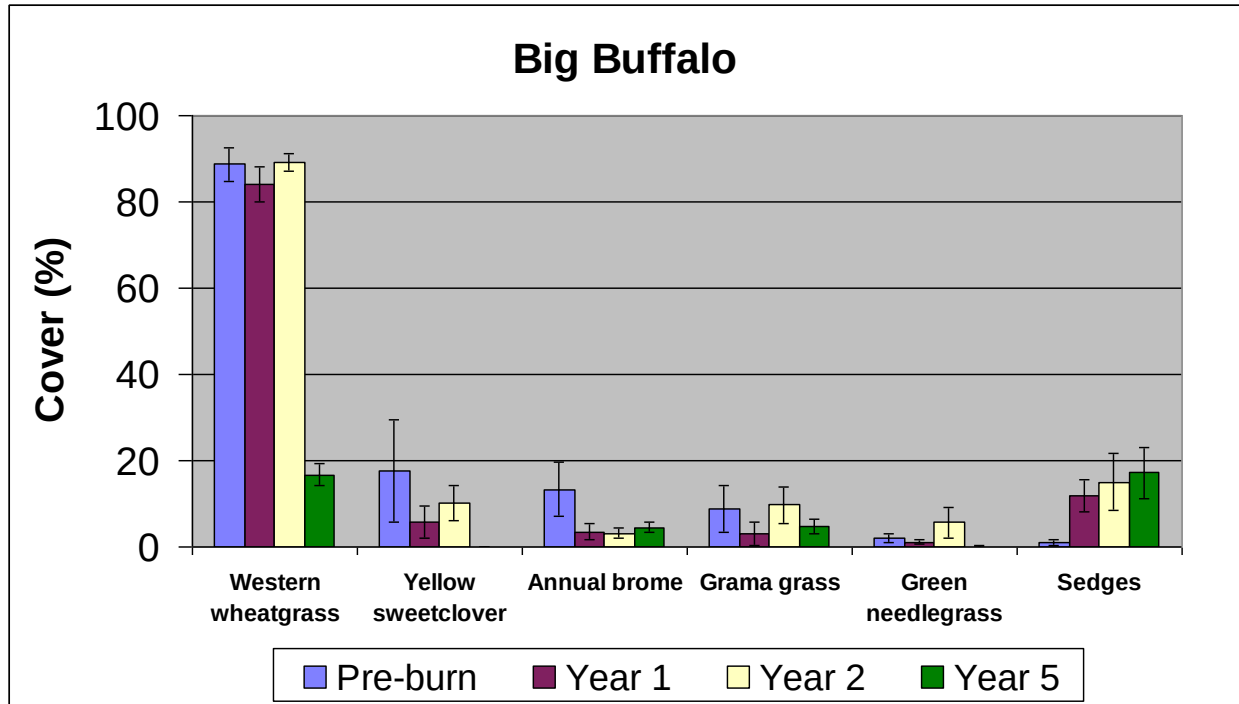
Six western wheatgrass plots were installed in Big Buffalo. Means and standard errors for the burn unit are shown in the figures below.

Prescribed fire objectives:

- Reduce exotic grass species by 25-50% for a spring burn; 10-30% if burned in the fall.
- Increase the native perennial grass cover by 10-30%.
- Reduce blackthorn honey locust and Russian olive trees and shrubs by 20-40%.
- Burn 60% to 75% of the project area.



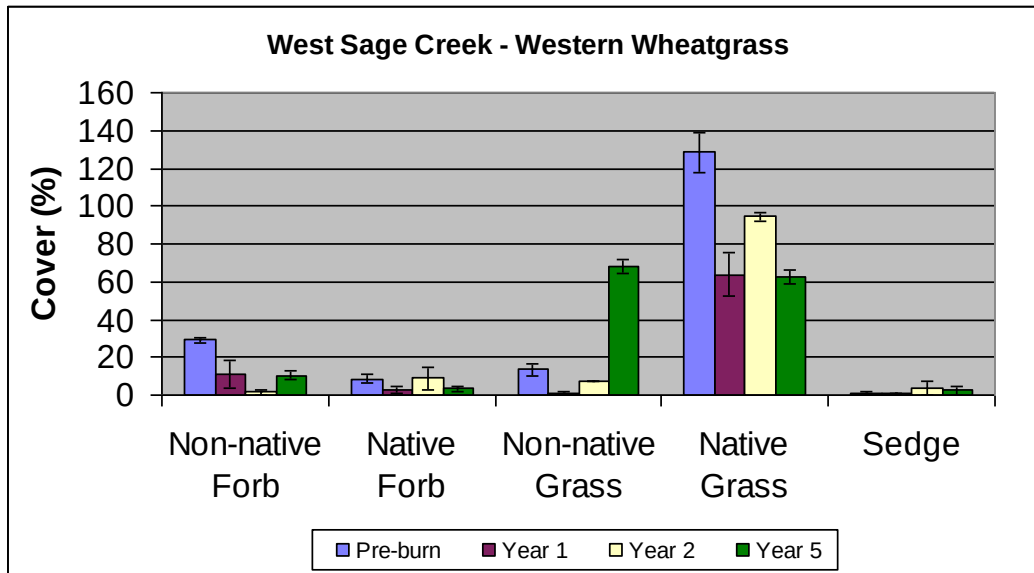
BIG BUFFALO					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	21.3	11.2	-48%	0.5	-98%
<i>Native Forb</i>	10.3	10.0	-3%	1.2	-89%
<i>Non-native Grass</i>	16.7	3.8	-77%	4.5	-73%
<i>Native Grass</i>	107.5	105.7	-2%	22.7	-79%
<i>Sedges</i>	1.0	15.0	1400%	17.2	1617%



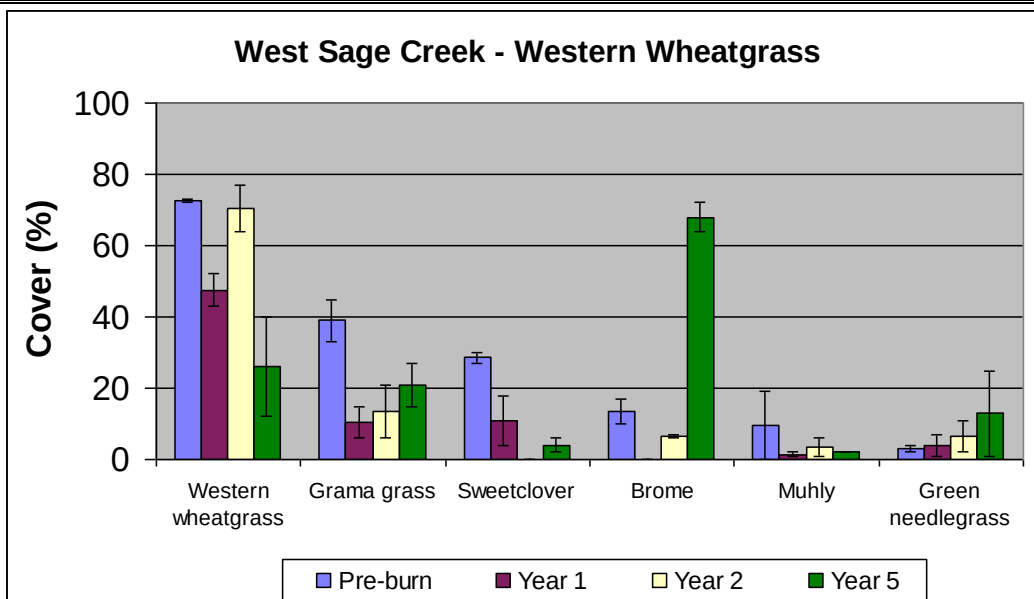
BIG BUFFALO					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	88.7	89.2	0.6%	16.7	-81%
Yellow sweetclover	17.7	10.2	-43%	0.0	-100%
Annual brome	13.3	3.2	-76%	4.5	-66%
Grama grass	8.8	9.7	9%	4.7	-47%
Green needlegrass	2.0	5.7	183%	0.2	-92%
Sedges	1.0	15.0	1400%	17.2	1617%

West Sage Creek

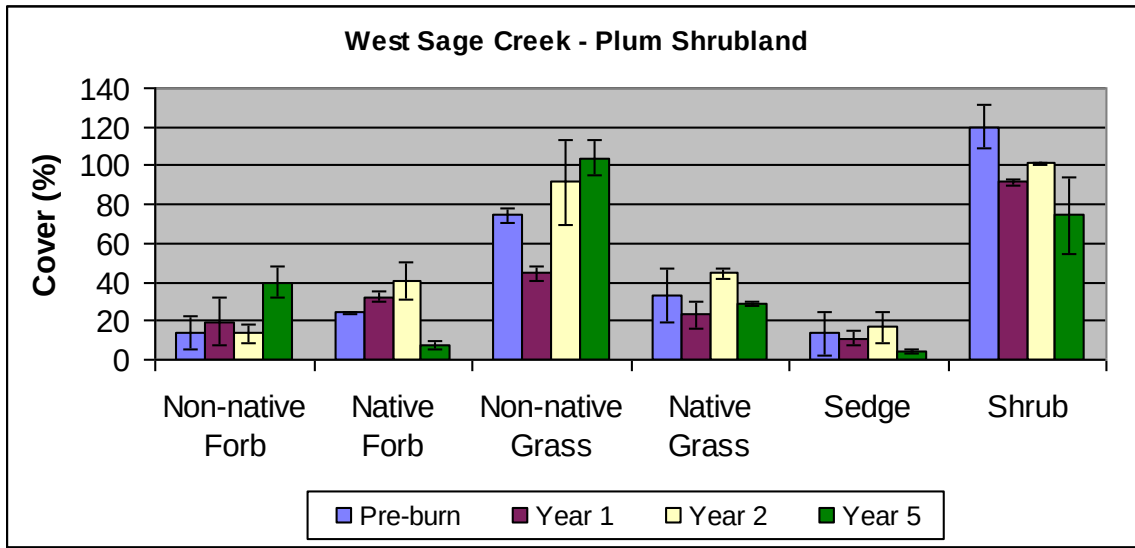
There are two western wheatgrass and two plum/chokecherry plots in the West Sage Creek unit. Even though the sample size is small, standard error bars are included in the following figures because in most cases variability is relatively small.



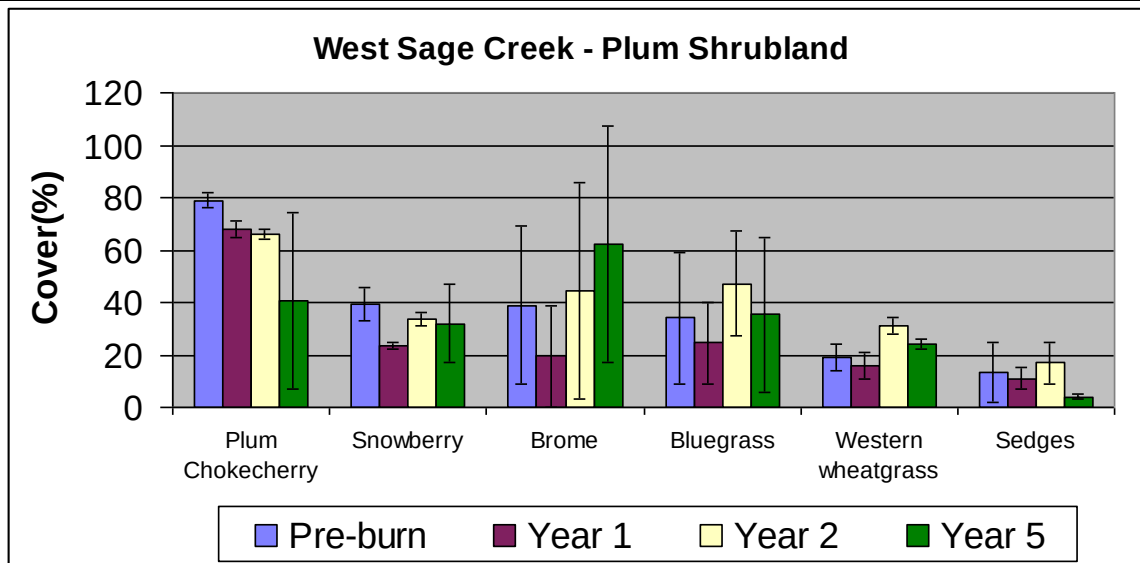
WEST SAGE CREEK					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	29.0	1.5	-95%	10.5	-64%
<i>Native Forb</i>	8.5	9.0	6%	3.5	-59%
<i>Non-native Grass</i>	13.5	7.0	-48%	68.0	404%
<i>Native Grass</i>	128.5	94.5	-26%	62.5	-51%
<i>Sedges</i>	1.0	3.5	250%	2.5	150%



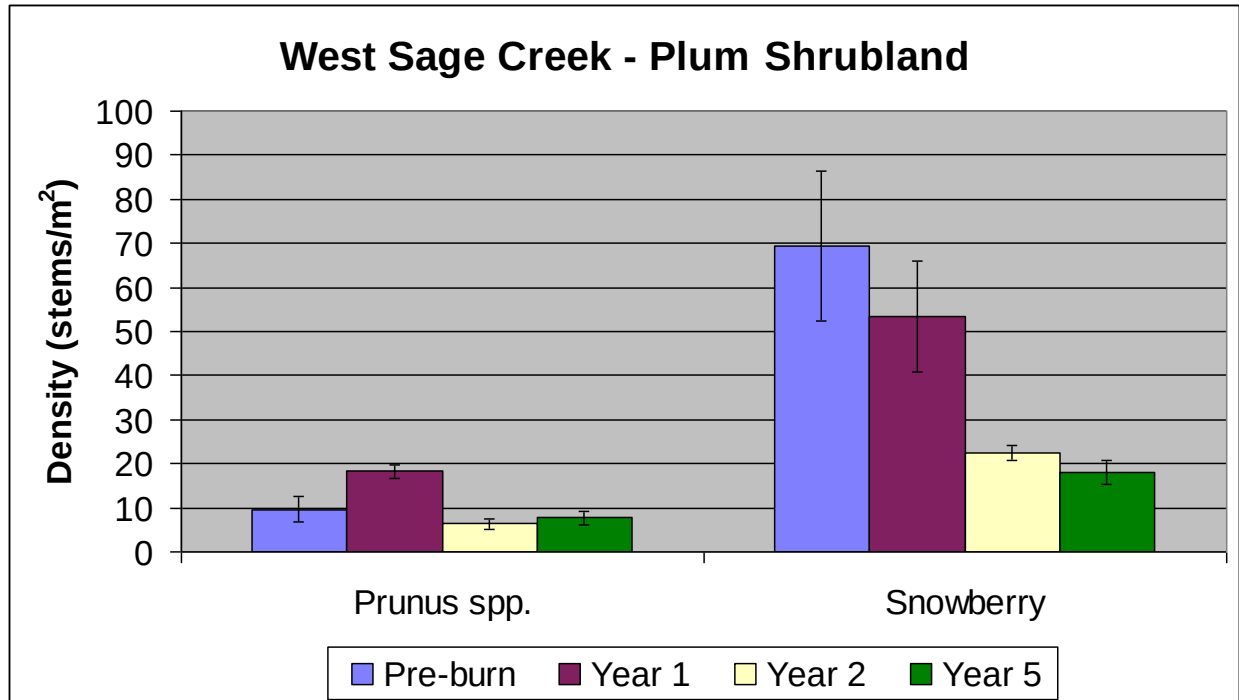
WEST SAGE CREEK					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Western wheatgrass</i>	72.5	70.5	-3%	26.0	-64%
<i>Grama grasses</i>	39.0	13.5	-65%	21.0	-46%
<i>Yellow sweetclover</i>	28.5	0.0	-100%	4.0	-86%
<i>Annual brome</i>	13.5	6.5	-52%	68.0	404%
<i>Plains muhly</i>	9.5	3.5	-63%	2.0	-79%
<i>Green needlegrass</i>	3.0	6.5	117%	13.0	333%



WEST SAGE CREEK					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	13.5	13.5	0%	40.0	196%
<i>Native Forb</i>	24.5	40.5	65%	7.5	-69%
<i>Non-native Grass</i>	74.5	91.5	23%	104.0	40%
<i>Native Grass</i>	33.0	44.5	35%	29.0	-12%
<i>Sedge</i>	13.5	17.0	26%	4.0	-70%
<i>Shrub</i>	120.0	101.0	-16%	74.5	-38%



WEST SAGE CREEK					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Plum/chokecherry</i>	79.0	66.0	-16%	40.5	-49%
<i>Snowberry</i>	39.5	33.5	-15%	32.0	-19%
<i>Annual brome</i>	39.0	44.5	14%	62.0	59%
<i>Kentucky bluegrass</i>	34.0	47.0	38%	35.5	4%
<i>Western wheatgrass</i>	19.0	31.0	63%	24.0	26%
<i>Sedges</i>	13.5	17.0	26%	4.0	-70%

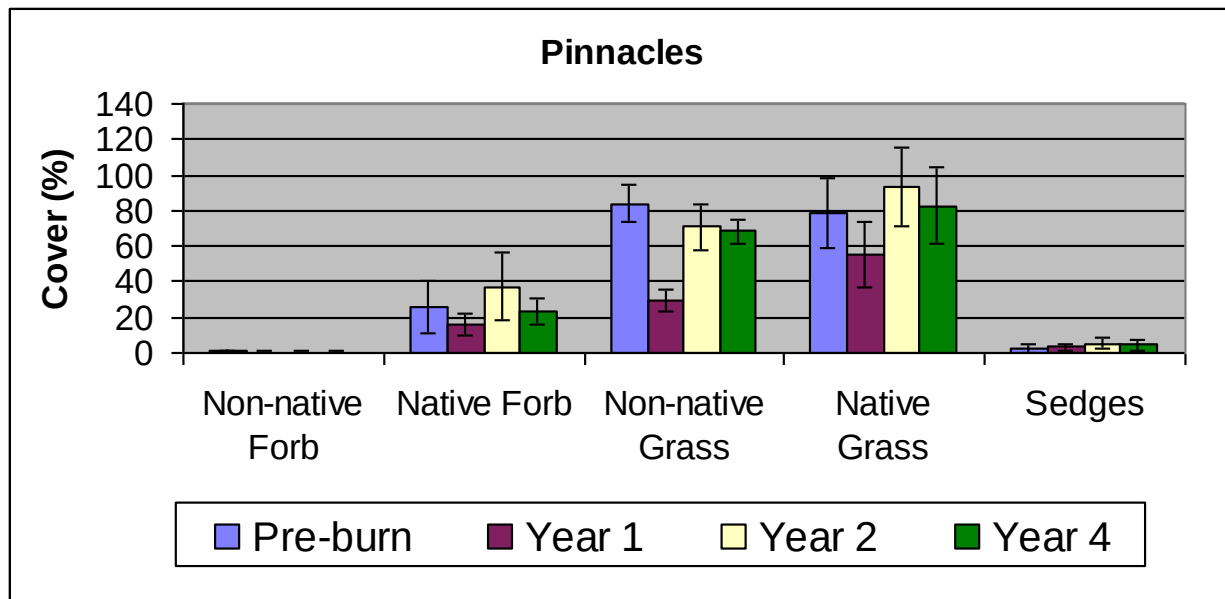


WEST SAGE CREEK					
stems/m ²	Pre-burn density	Year 1 Density	Change	Year 5 Density	Change
Plum/chokecherry	9.6	18.2	89%	7.7	-20%
Snowberry	69.5	53.4	-23%	18.1	-74%



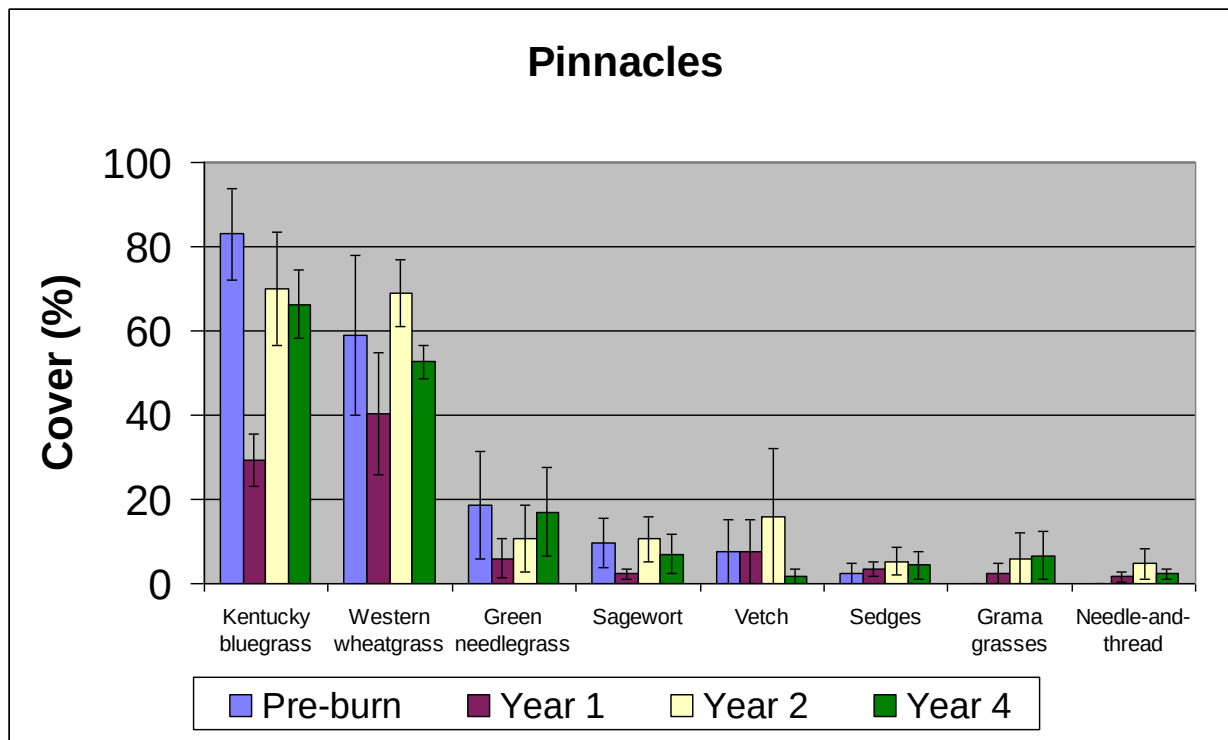
Pinnacles

Three Kentucky bluegrass plots have been installed in the Pinnacles unit. One of the plots has burned twice and the other two have burned once. Presented below are data from the 2002 prescribed fire. Mean and standard error are reported for the three plots.



	PINNACLES				
	Pre-burn cover	Yr 2 Cover	Change	Yr 4 Cover	Change
<i>Non-native Forb</i>	0.7	0.3	-50%	0.3	-50%
<i>Native Forb</i>	25.3	37.3	47%	23.7	-7%
<i>Non-native Grass</i>	83.7	70.7	-16%	68.3	-18%
<i>Native Grass</i>	78.7	93.0	18%	82.7	5%
<i>Sedges</i>	2.3	5.3	129%	4.3	86%

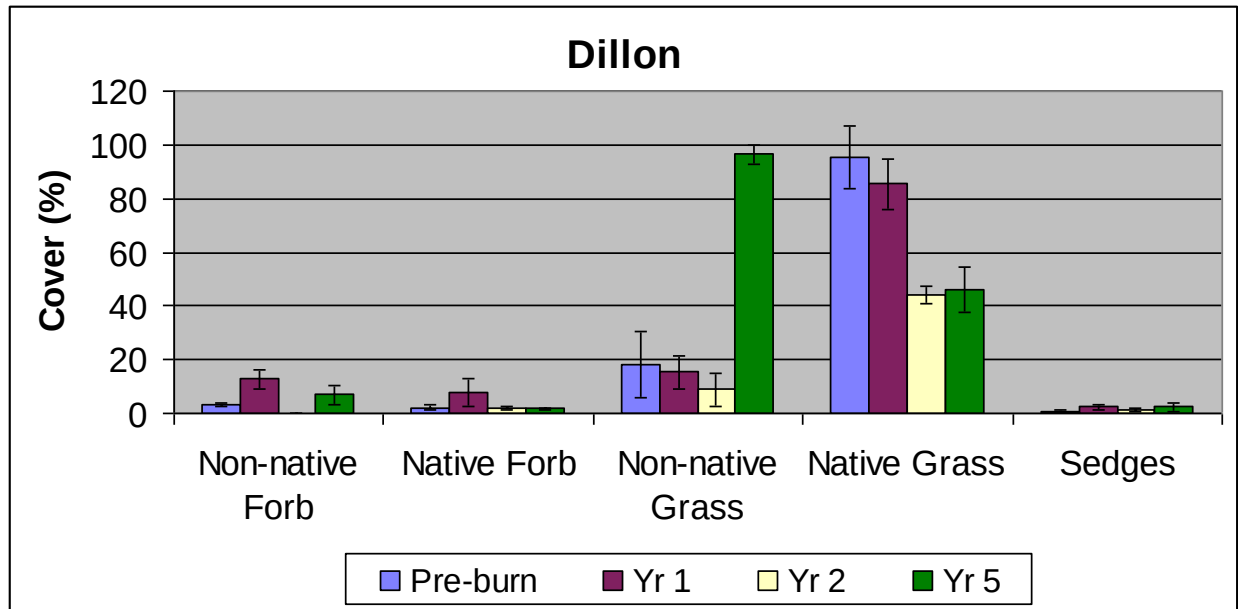




PINNACLES					
	Pre-burn cover	Yr 2 Cover	Change	Yr 4 Cover	Change
<i>Kentucky bluegrass</i>	83.0	70.0	-16%	66.3	-20%
<i>Western wheatgrass</i>	59.0	69.0	17%	52.7	-11%
<i>Green needlegrass</i>	18.7	10.7	-43%	17.0	-9%
<i>Sagewort</i>	9.7	10.7	10%	7.0	-28%
<i>Vetch</i>	7.7	16.0	109%	1.7	-78%
<i>Sedges</i>	2.3	5.3	129%	4.3	86%
<i>Grama grasses</i>	0.0	6.0	+	6.7	+
<i>Needle-and-thread</i>	0.0	4.7	+	2.3	+

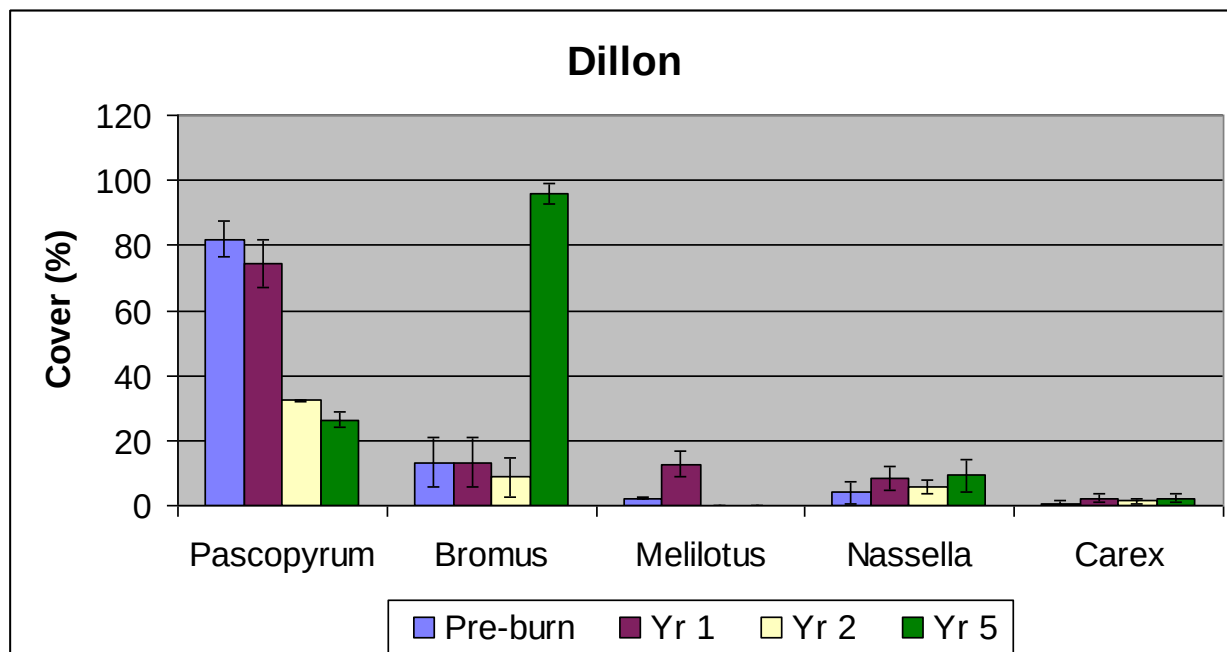
Dillon

Three western wheatgrass plots were installed in the Dillon unit. Smooth brome and annual bromes were present on these plots, but the annual bromes (primarily Japanese brome) dominated the plots five years post fire.



	DILLON				
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	3.0	0.0	-100%	7.0	133%
<i>Native Forb</i>	2.0	1.7	-17%	1.7	-17%
<i>Non-native Grass</i>	18.3	9.0	-51%	96.3	425%
<i>Native Grass</i>	95.3	44.0	-54%	46.0	-52%
<i>Sedges</i>	0.7	1.3	100%	2.3	250%





DILLON					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	82.0	32.3	-61%	26.3	-68%
<i>Brome</i>	13.3	8.7	-35%	96.0	620%
<i>Yellow sweetclover</i>	2.3	0.0	-100%	0.0	-100%
Green needlegrass	4.0	6.0	50%	9.3	133%
Sedges	0.7	1.3	100%	2.3	250%

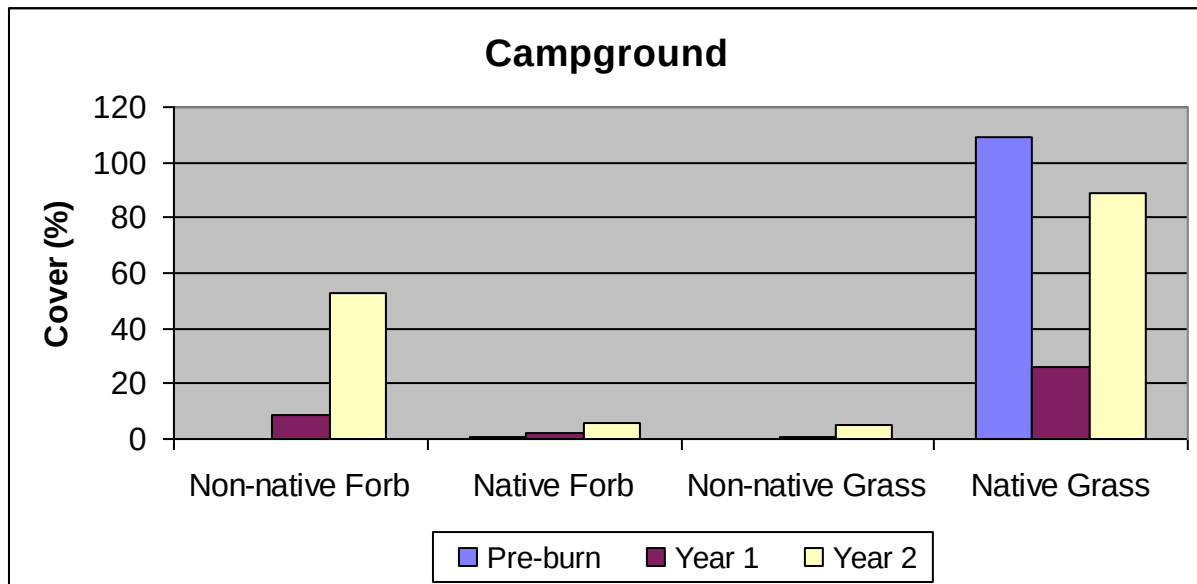


Campground

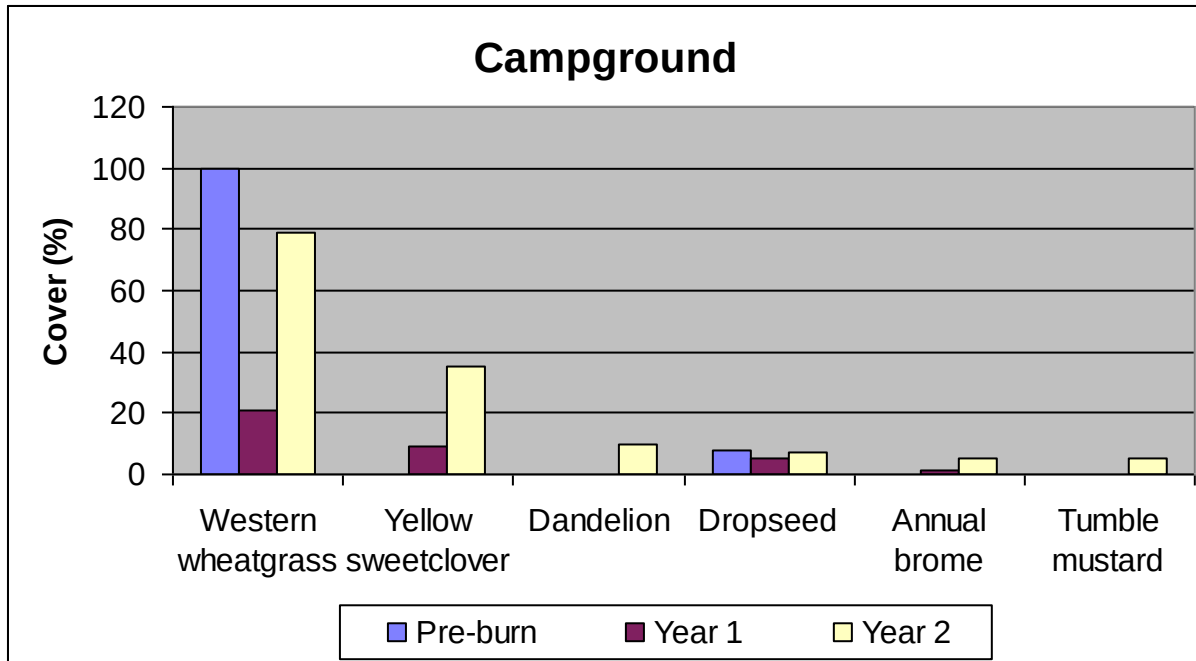
Only one western wheatgrass plot was installed in the Campground unit. The figures below show the data from this single plot.

Prescribed Fire Objectives (Burn Plan)

- Increase relative cover of native grasses by 10 to 25% 1-yr. post burn.
- Increase relative cover of native forbs by 10 to 25% 1-yr. post burn.
- Maintain increase of relative cover of native grass and forbs 5-yrs. Post burn
- Reduce total fuel load 60 to 80% immediate post-burn.
- Burn 80-95% of the unit.



CAMPGROUND			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	0	53	++
<i>Native Forb</i>	1	6	500%
<i>Non-native Grass</i>	0	5	+
<i>Native Grass</i>	109	89	-18%

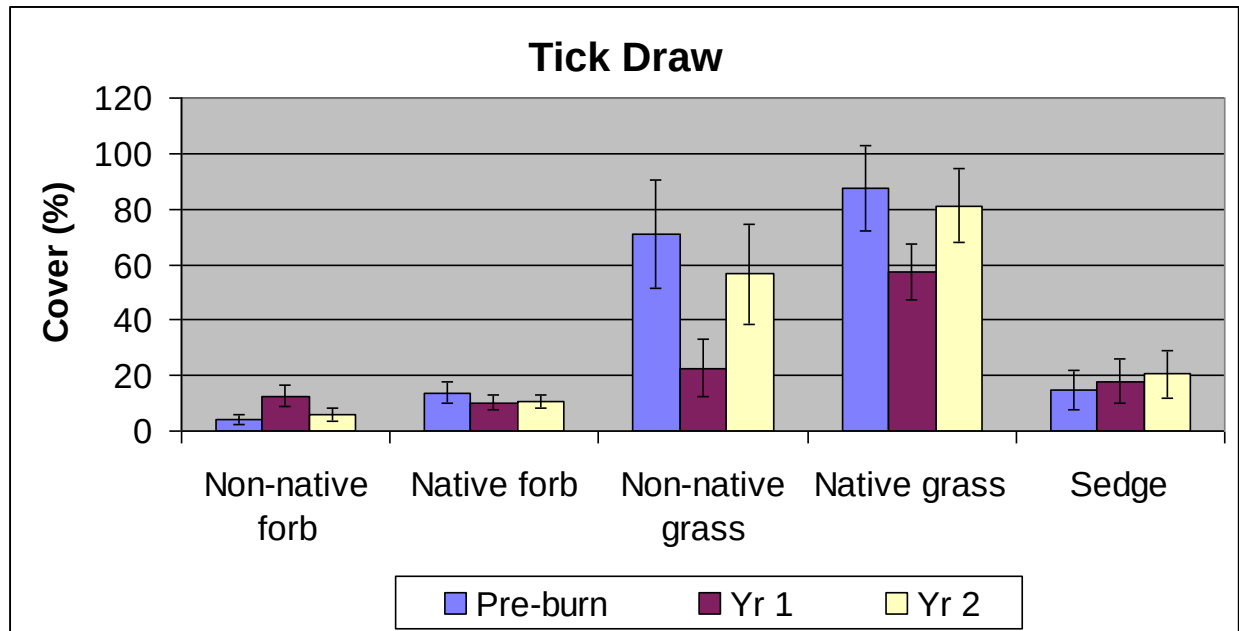


CAMPGROUND			
	Pre-burn Cover	Yr 2 Cover	Change
Western wheatgrass	100	79	-21%
<i>Yellow sweetclover</i>	0	35	+
<i>Dandelion</i>	0	10	+
Dropseeds	8	7	-13%
<i>Annual brome</i>	0	5	+
<i>Tumble mustard</i>	0	5	+



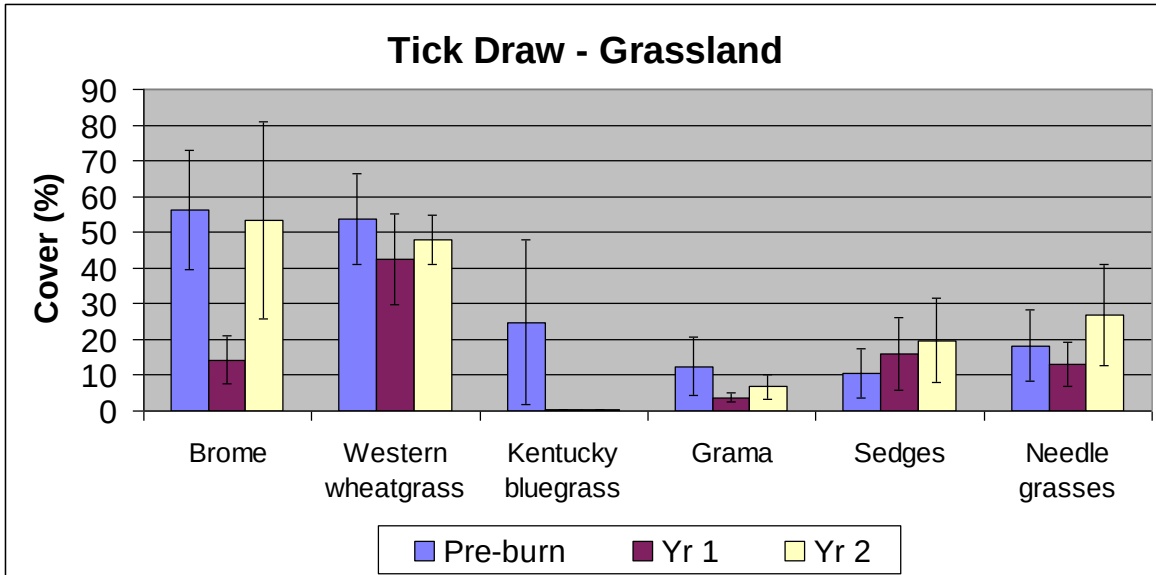
Tick Draw

Six plots have been installed in the Tick Draw unit: three western wheatgrass, 1 Kentucky bluegrass, and two plum shrubland. All six plots were analyzed together for the lifeform/nativity summary. For the genus-level summary the four grassland plots were analyzed together while the two shrub plots were analyzed together.

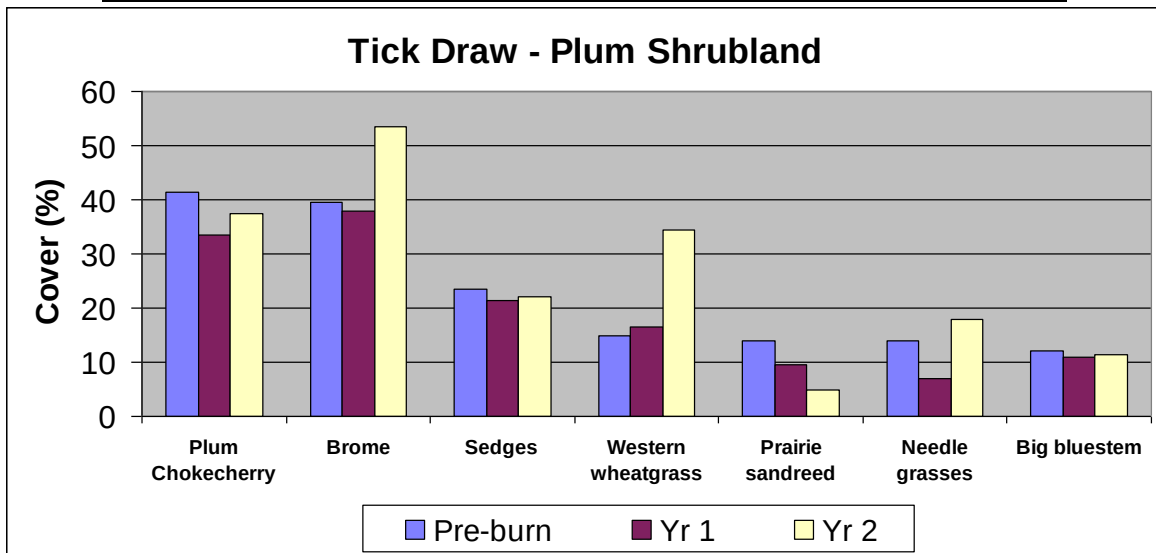


TICK DRAW			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	4.2	5.8	40%
<i>Native Forb</i>	13.8	10.7	-23%
<i>Non-native Grass</i>	70.8	56.7	-20%
<i>Native Grass</i>	87.3	81.2	-7%
<i>Sedges</i>	14.8	20.5	38%

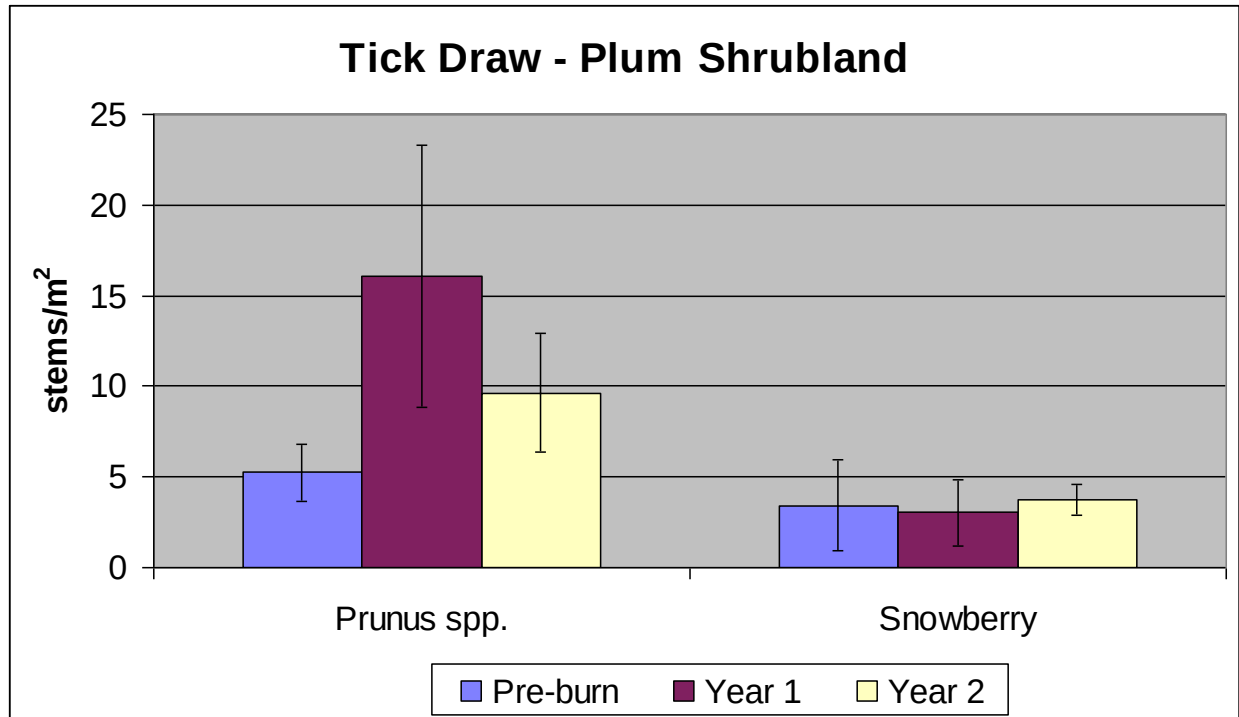




TICK DRAW - GRASSLAND			
	Pre-burn Cover	Yr 2 Cover	Change
Annual brome	56.3	53.3	-5%
Western wheatgrass	53.8	48.0	-11%
Kentucky bluegrass	24.8	0.3	-99%
Grama grasses	12.5	6.8	-46%
Sedges	10.5	19.8	88%
Needle grasses	18.3	26.8	47%



TICK DRAW - PLUM SHRUBLAND			
	Pre-burn Cover	Yr 2 Cover	Change
Plum/chokecherry	41.5	37.5	-10%
Annual brome	39.5	53.5	35%
Sedges	23.5	22.0	-6%
Western wheatgrass	15.0	34.5	130%
Prairie sandreed	14.0	5.0	-64%
Needle grasses	14.0	18.0	29%
Big bluestem	12.0	11.5	-4%

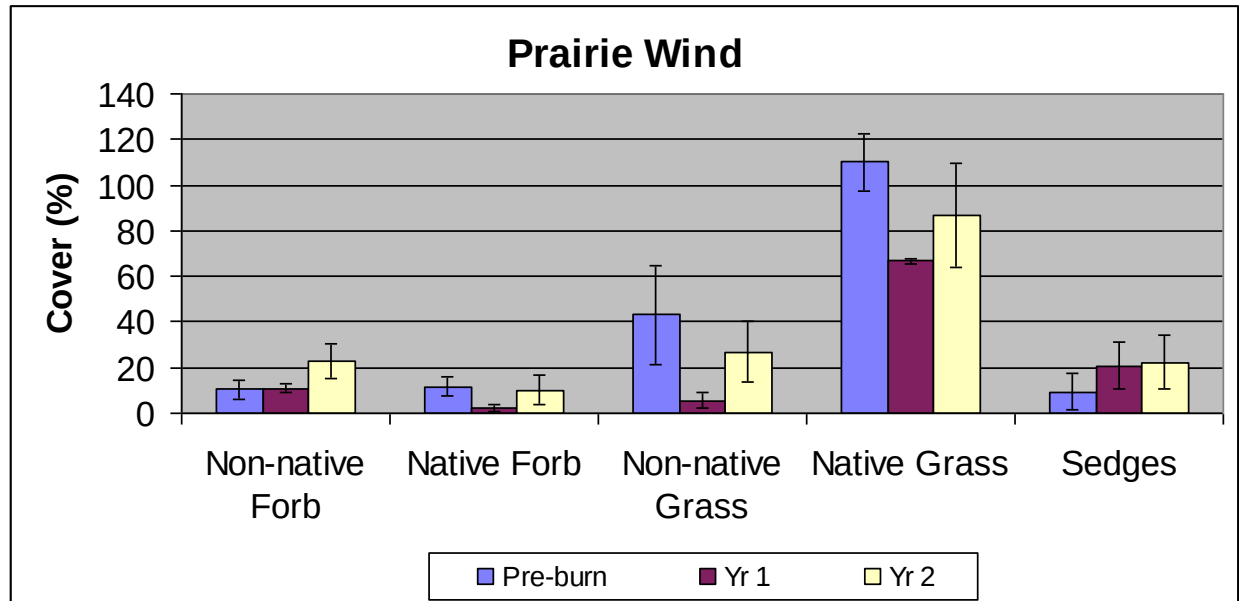


TICK DRAW – PLUM SHRUBLAND			
stems/m ²	Pre-burn Density	Year 1 Density	Change
Plum/chokecherry	5.2	16.1	207%
Snowberry	3.4	3.0	-12%



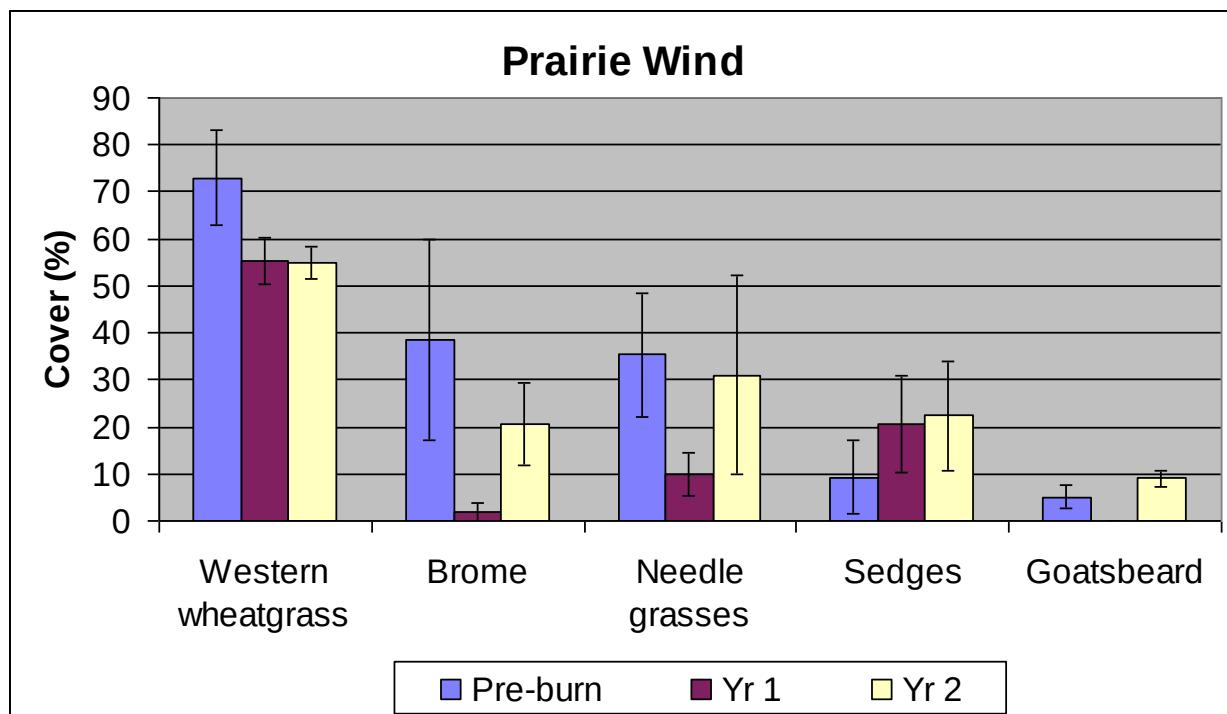
Prairie Wind

Three western wheatgrass plots were installed in the Prairie Wind unit in 2004. The area was in a severe drought that year, which had a large impact on the herbaceous vegetation communities in the park. The plots were revisited in 2005, a year with average precipitation, and the unit was burned in the fall. The following two figures show data from 2005-2007. The third figure includes data from 2004 to illustrate drought impacts.

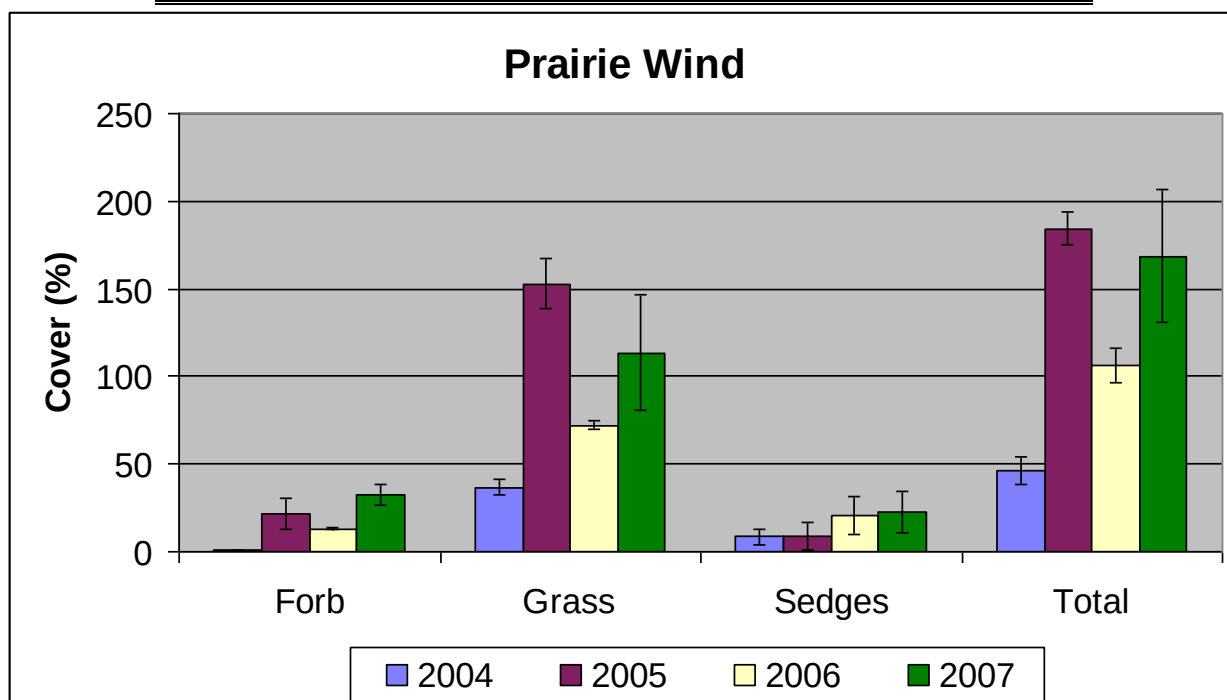


PRAIRIE WIND			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	10.3	22.7	119%
<i>Native Forb</i>	11.7	10.0	-14%
<i>Non-native Grass</i>	43.0	27.0	-37%
<i>Native Grass</i>	110.0	86.7	-21%
<i>Sedges</i>	9.3	22.3	139%





PRAIRIE WIND			
	Pre-burn Cover	Yr 2 Cover	Change
Western wheatgrass	73.0	55.0	-25%
<i>Annual brome</i>	38.7	20.7	-47%
Needle grasses	35.3	31.0	-12%
Sedges	9.3	22.3	139%
<i>Goatsbeard</i>	5.0	9.0	80%



Monitoring Units

Western Wheatgrass Mixed-Grass Prairie

Prescribed Fire Objectives (from monitoring type description)

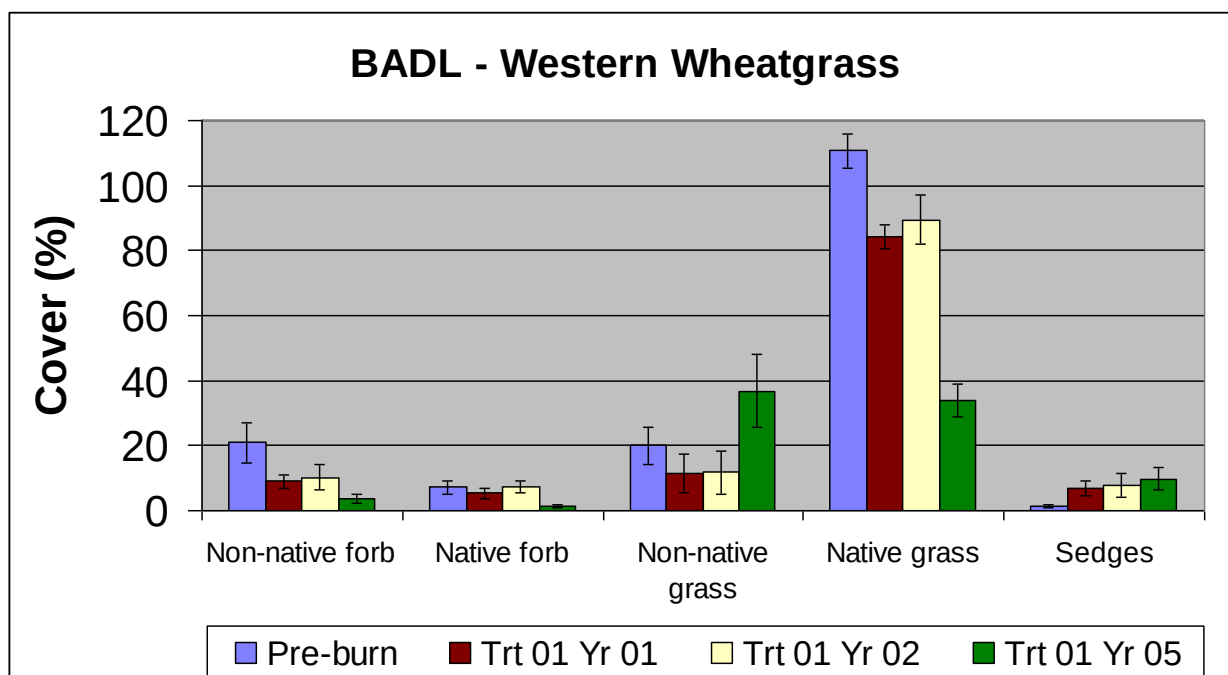
Immediate Post Burn

- Burn 60-80% of the burnable project area.

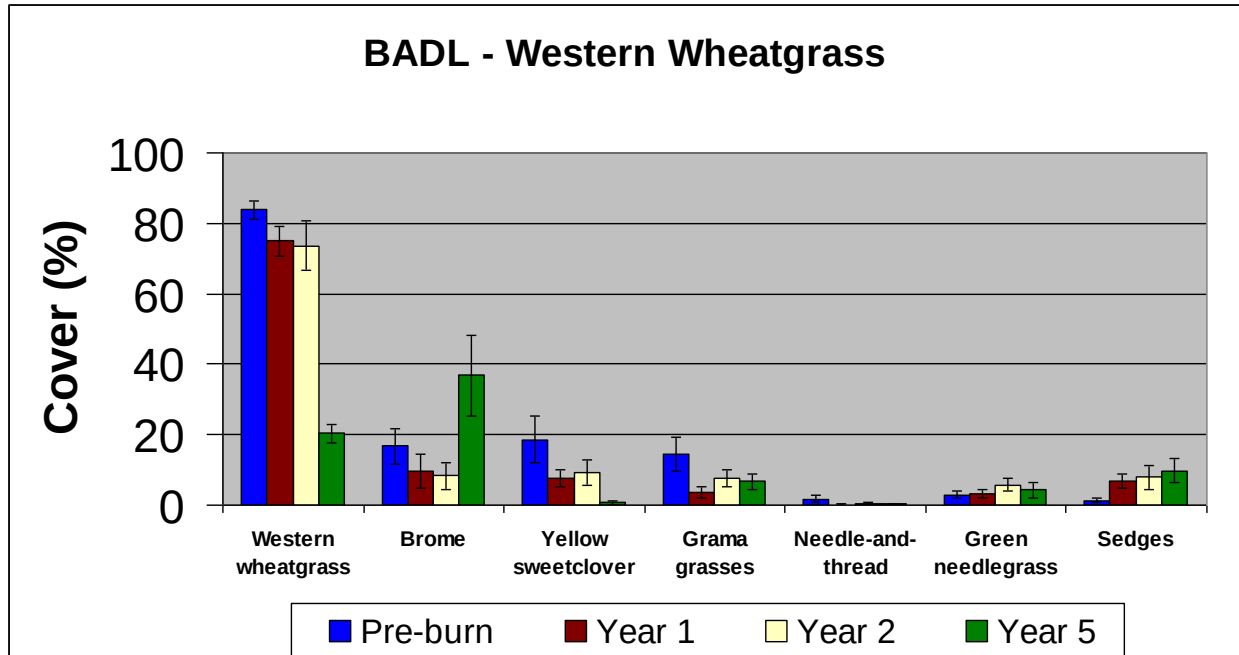
Two Years Post Burn

- Reduce relative cover of non-native grasses by at least 20%
- Increase relative cover of native grasses by at least 10%
- Increase relative cover of native forbs by at least 30%

Twenty two western wheatgrass plots have been installed at BADL. Thirteen of these plots have burned and have been visited five years post-fire. The following summary includes these thirteen plots.



Western Wheatgrass Prairie					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	21.0	10.2	-51%	3.5	-84%
<i>Native Forb</i>	7.2	7.2	1%	1.5	-78%
<i>Non-native Grass</i>	20.1	11.8	-41%	36.8	84%
<i>Native Grass</i>	110.8	89.5	-19%	33.7	-70%
<i>Sedges</i>	1.4	7.8	467%	9.8	606%



Western Wheatgrass Prairie					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	83.8	73.7	-12%	20.3	-76%
<i>Brome</i>	16.7	8.3	-50%	36.8	120%
<i>Yellow sweetclover</i>	18.6	9.3	-50%	0.6	-97%
Grama grasses	14.5	7.5	-48%	6.7	-54%
Needle-and-thread	1.7	0.5	-73%	0.2	-86%
Green needlegrass	3.0	5.7	90%	4.3	44%
Sedges	1.4	7.8	467%	9.8	606%

Woody Draws

No woody draw plots have burned.

Chokecherry/Plum Shrubland

Prescribed Fire Objectives (from monitoring type description)

Immediate Post Burn

- Reduce total down and dead woody fuel load by 20-60%

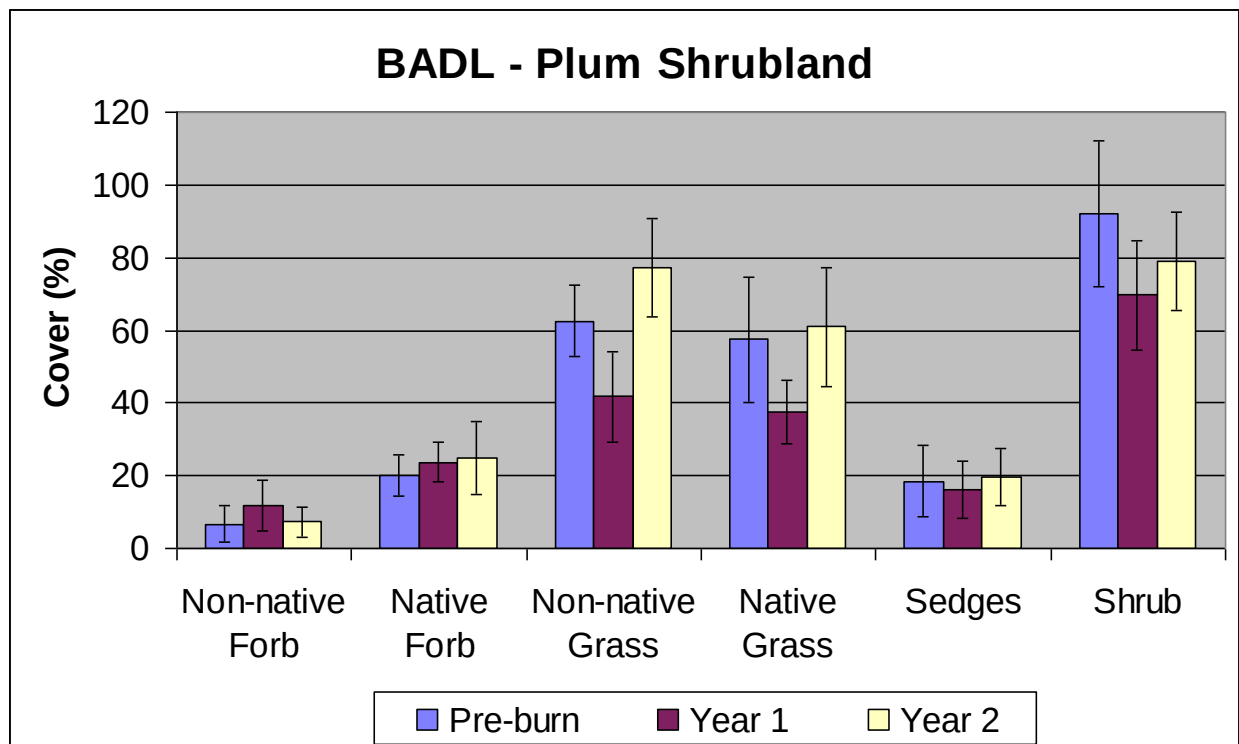
One Year Post Burn

- Increase density of desired woody browse species by 30 to 50%

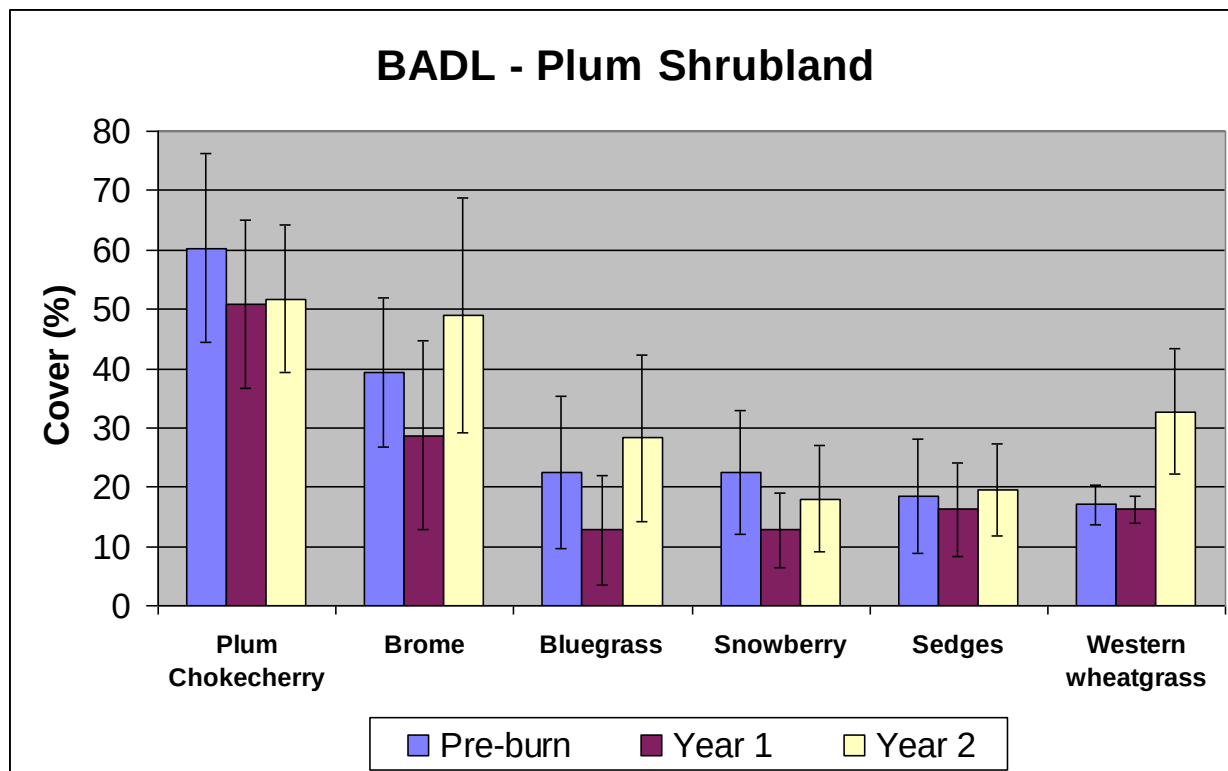
Five Years Post Burn

- Maintain density of mature woody browse species.

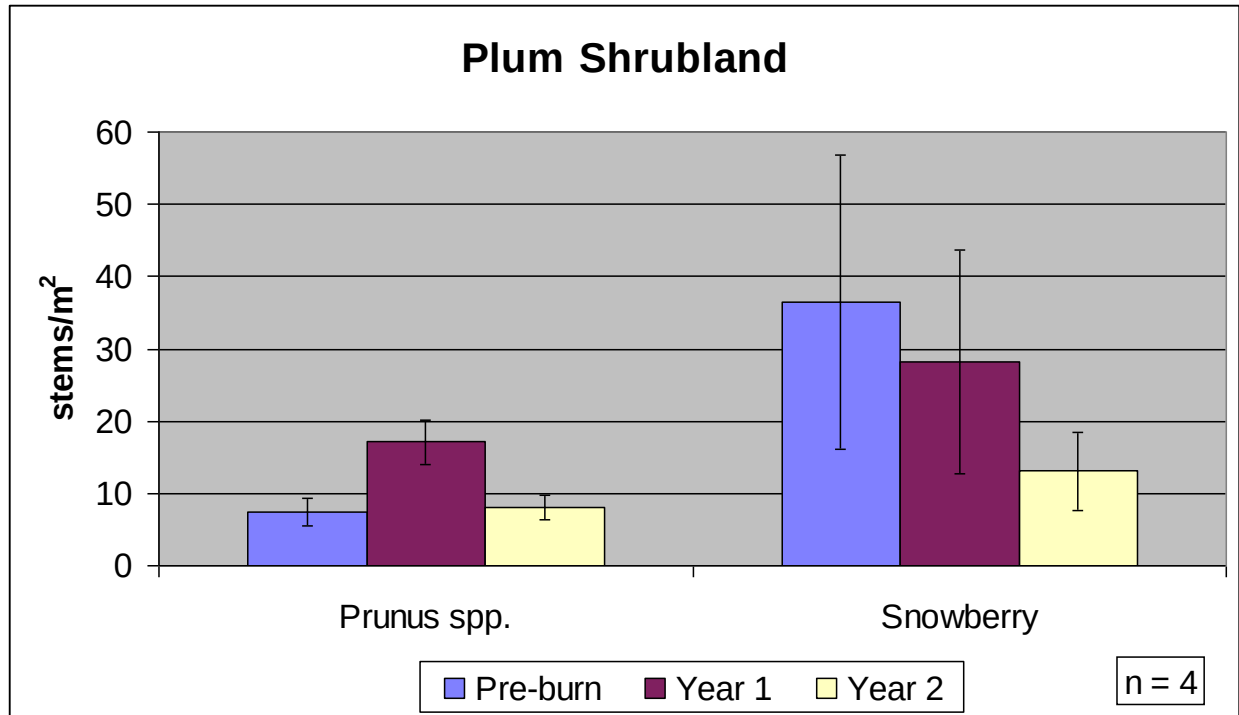
Four shrubland plots have been installed at BADL and all have been visited two years post fire. The following summary includes all four plots.



PLUM SHRUBLAND			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	6.8	7.3	7%
<i>Native Forb</i>	20.0	24.8	24%
<i>Non-native Grass</i>	62.5	77.3	24%
<i>Native Grass</i>	57.5	61.0	6%
<i>Sedges</i>	18.5	19.5	5%
<i>Shrub</i>	92.0	79.0	-14%



PLUM SHRUBLAND			
	Pre-burn Cover	Yr 2 Cover	Change
Plum/Chokcherry	60.3	51.8	-14%
<i>Brome</i>	39.3	49.0	25%
<i>Kentucky bluegrass</i>	22.5	28.3	26%
Snowberry	22.5	18.0	-20%
Sedges	18.5	19.5	5%
Western wheatgrass	17.0	32.8	93%



PLUM SHRUBLAND			
stems/m ²	Pre-burn Density	Year 1 Density	Change
Plum/Chokcherry	7.4	17.1	131%
Snowberry	36.5	28.2	-23%



Kentucky Bluegrass Grassland

Prescribed Fire Objectives

Immediate Post Burn

- Burn 80-100% of the burnable project area.

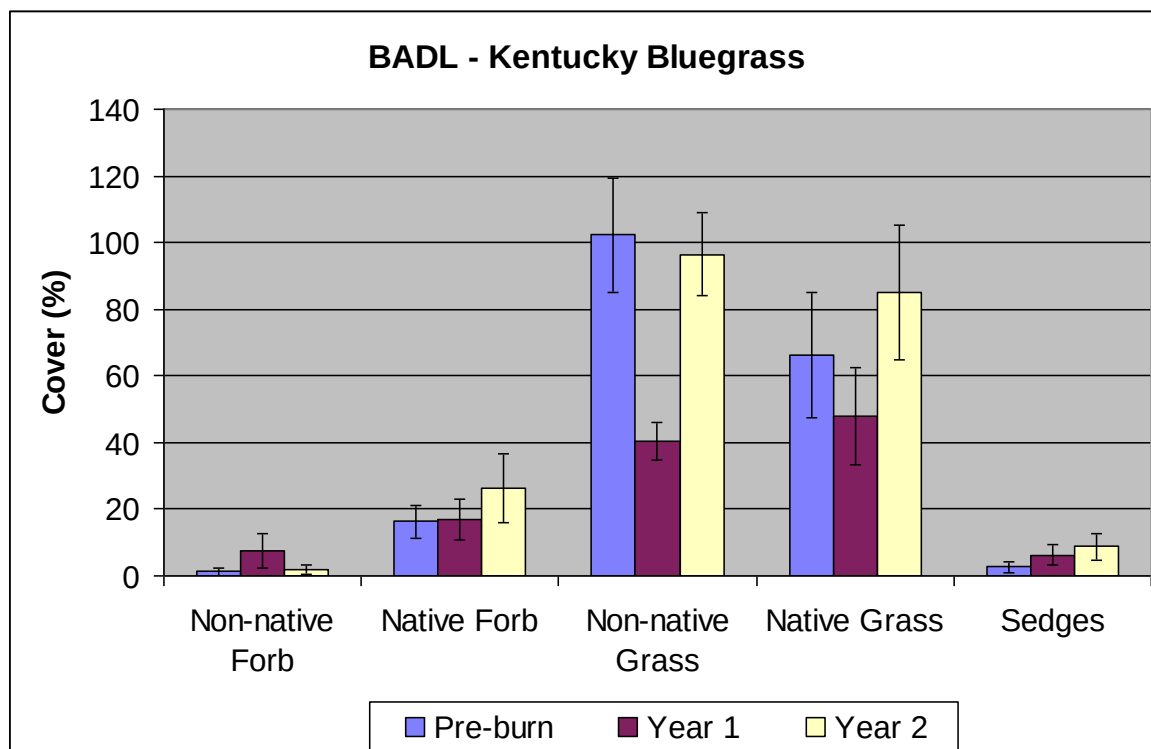
One Year Post Burn

- Reduce relative cover of non-native grasses by at least 30%
- Increase relative cover of native grasses by at least 10%
- Increase relative cover of native forbs by at least 10%

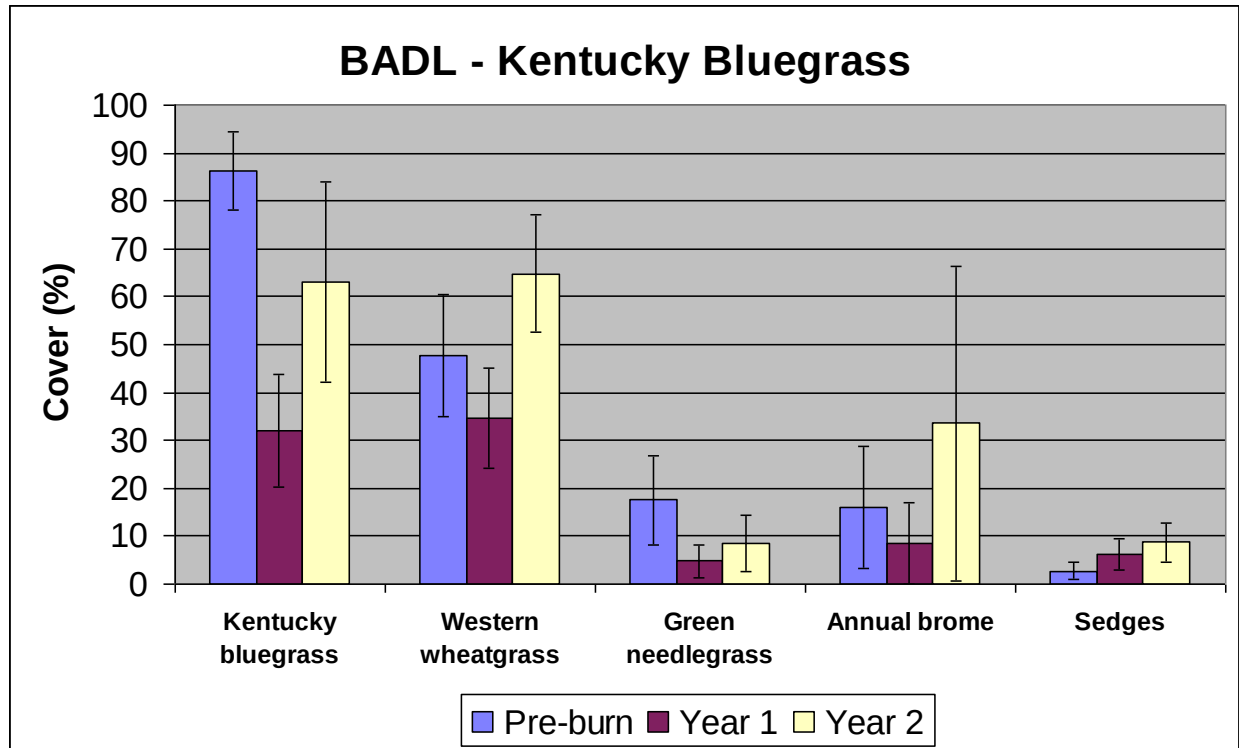
Five Years Post Burn

- Maintain 30% reduction of non-native grass relative cover
- Maintain increase of relative cover of native grass and forbs
- Limit reduction of native cool-season grasses to less than 20% of the pre-burn level

Five Kentucky bluegrass plots have been installed at BADL in three burn units. One of the plots has converted to prairie dog town and has not burned, while the four remaining plots have been visited two years post-fire.



KENTUCKY BLUEGRASS			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	1.3	2.0	60%
<i>Native Forb</i>	16.3	26.3	62%
<i>Non-native Grass</i>	102.3	96.5	-6%
<i>Native Grass</i>	66.3	85.0	28%
<i>Sedges</i>	2.8	8.8	218%



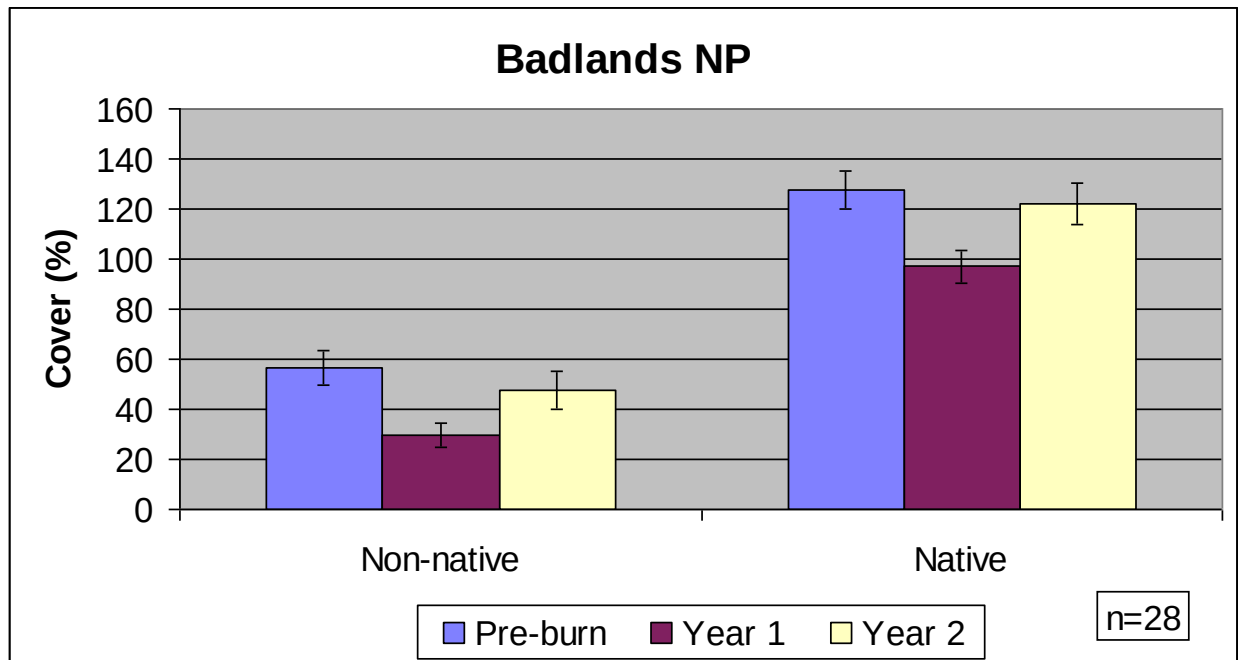
KENTUCKY BLUEGRASS			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Kentucky bluegrass</i>	86.3	63.0	-27%
<i>Western wheatgrass</i>	47.8	64.8	36%
<i>Green needlegrass</i>	17.5	8.5	-51%
<i>Annual brome</i>	16.0	33.5	109%
<i>Sedges</i>	2.8	8.8	218%

Japanese Brome Grassland

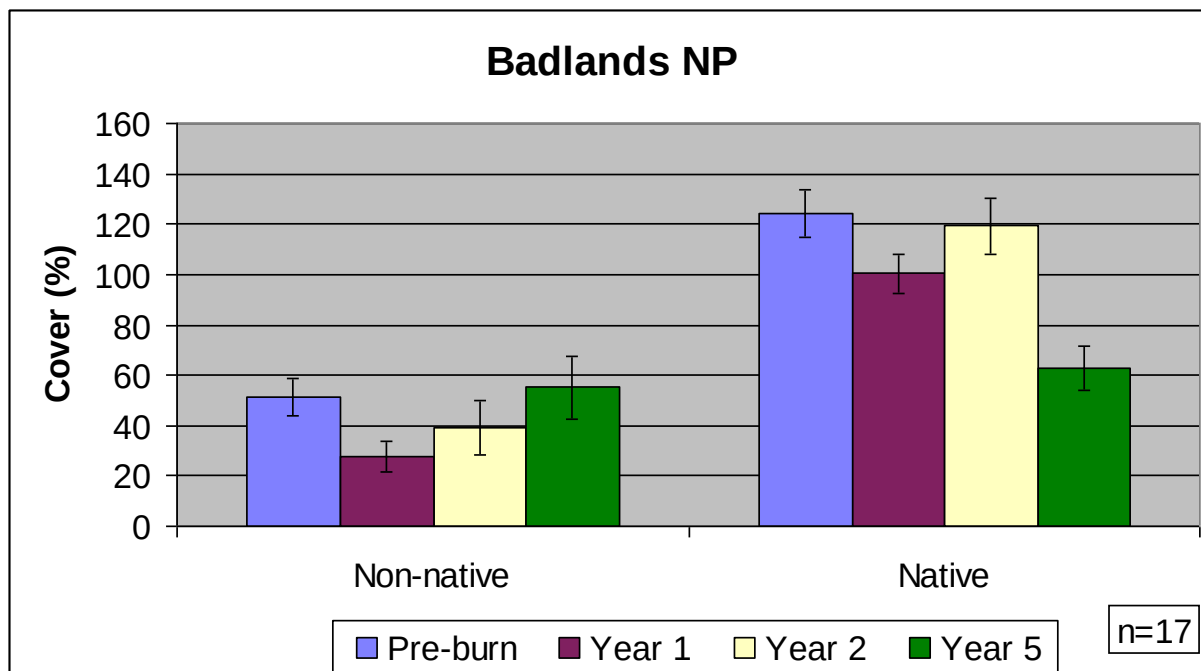
Only one plot has been installed in this monitoring type and it has not burned.

Park-wide Summary

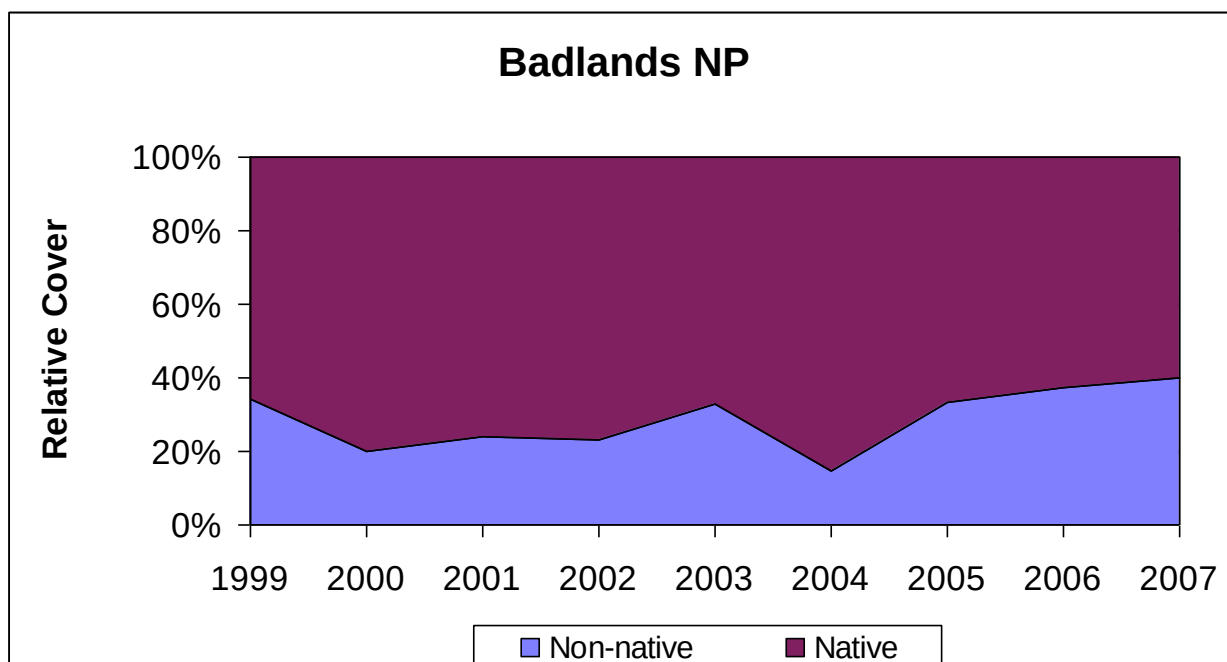
Twenty eight plots at BADL have been visited two years post-fire and seventeen plots have been visited five years post-fire. A summary of these plots can be found in the next two figures. There appears to be an undesirable trend in native and non-native cover. We suspect that this trend is more an effect of the ongoing drought than the effect of fire. The third figure includes relative cover of non-native and native species by year. One note of caution, the sample size changes year-to-year because the same number of plots was not visited each year. Sample size varies from 8 to 17.



BADLANDS NP			
	Pre-burn Cover	Yr 2 Cover	Change
Non-native	56.5	47.6	-16%
Native	127.5	122.1	-4%

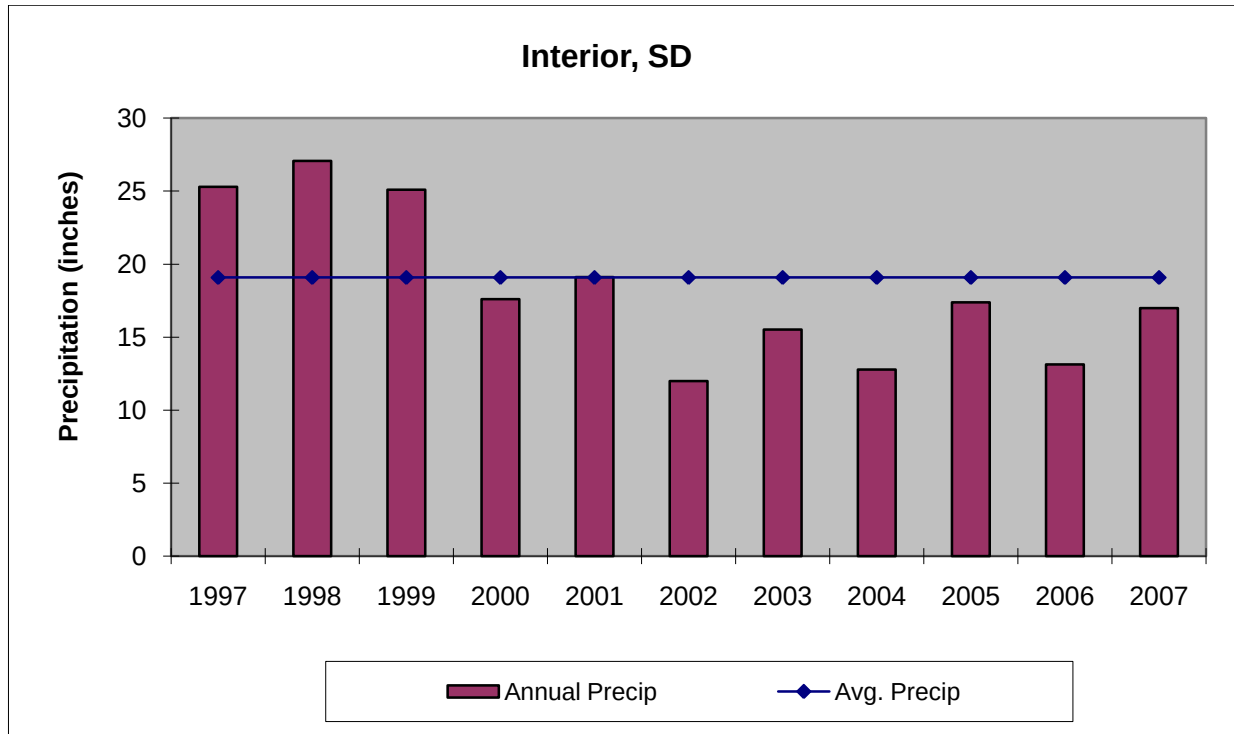


BADLANDS NP					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native</i>	51.4	38.9	-24%	55.1	7%
Native	124.2	119.2	-4%	62.8	-49%



PRECIPITATION

Precipitation data from the National Weather Service weather station at Interior, SD (<http://www.hprcc.unl.edu/data/historical/>). Average precipitation for the period 1956-2008.



DEVILS TOWER NATIONAL MONUMENT

MONITORING UNITS

Non-native grass prairie – Kentucky bluegrass (POPR)

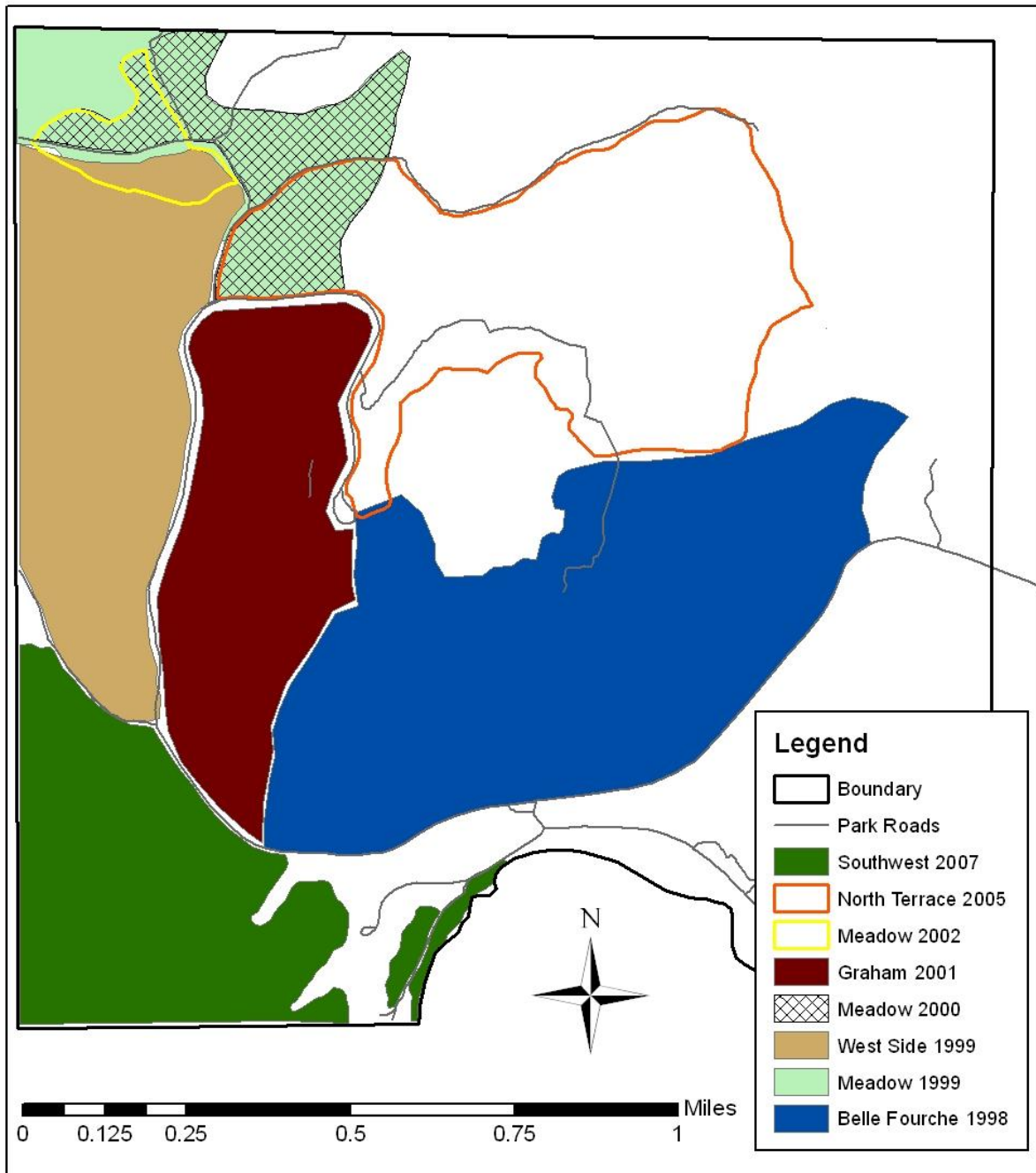
Stands typically have moderate herbaceous cover, ranging from 40-90% and have dense ground litter. Areas tend to be dominated by non-native cool season grasses, primarily Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*). Native grasses occurring include green needle grass (*Nassella viridula*), side-oats grama (*Bouteloua curtipendula*), western wheatgrass (*Pascopyrum smithii*), needle-and-thread (*Hesperostipa comata*), and sedges (*Carex* spp.). Shrubs include wild rose (*Rosa* spp.), and western snowberry (*Symphoricarpos occidentalis*). Native forbs such as showy milkweed (*Asclepias speciosa*), scurfpea (*Pedimelum* & *Psoraleidum* spp.), goldenrod (*Solidago* spp.), and common yarrow (*Achillea millefolium*) are common. Non-native forbs found at the monument include yellow sweet clover (*Melilotus officinalis*) and leafy spurge (*Euphorbia esula*).

Ponderosa pine forest (PIPO)

Overstory dominated by ponderosa pine (*Pinus ponderosa*). Understory trees include bur oak (*Quercus macrocarpa*), chokecherry (*Prunus virginiana*), and American plum (*Prunus americana*). Shrubs include Oregon grape (*Mahonia repens*), common juniper (*Juniperus communis*), western red current (*Ribes cereum*). Dominant grasses are poverty oat grass (*Danthonia spicata*), needle-and-thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), and non-native Kentucky bluegrass (*Poa pratensis*). Native forbs such as common yarrow (*Achillea millefolium*), milkvetch (*Astragalus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), bedstraw (*Galium* spp.), scurfpea (*Pedimelum* & *Psoraleidum* spp.), and goldenpea (*Thermopsis rhombifolia*) are common. Non-native forbs found in this monitoring type include yellow sweetclover (*Melilotus officinalis*), Canada thistle (*Cirsium arvense*), hound's tongue (*Cynoglossum officinale*), and leafy spurge (*Euphorbia esula*).

PRESCRIBED FIRES

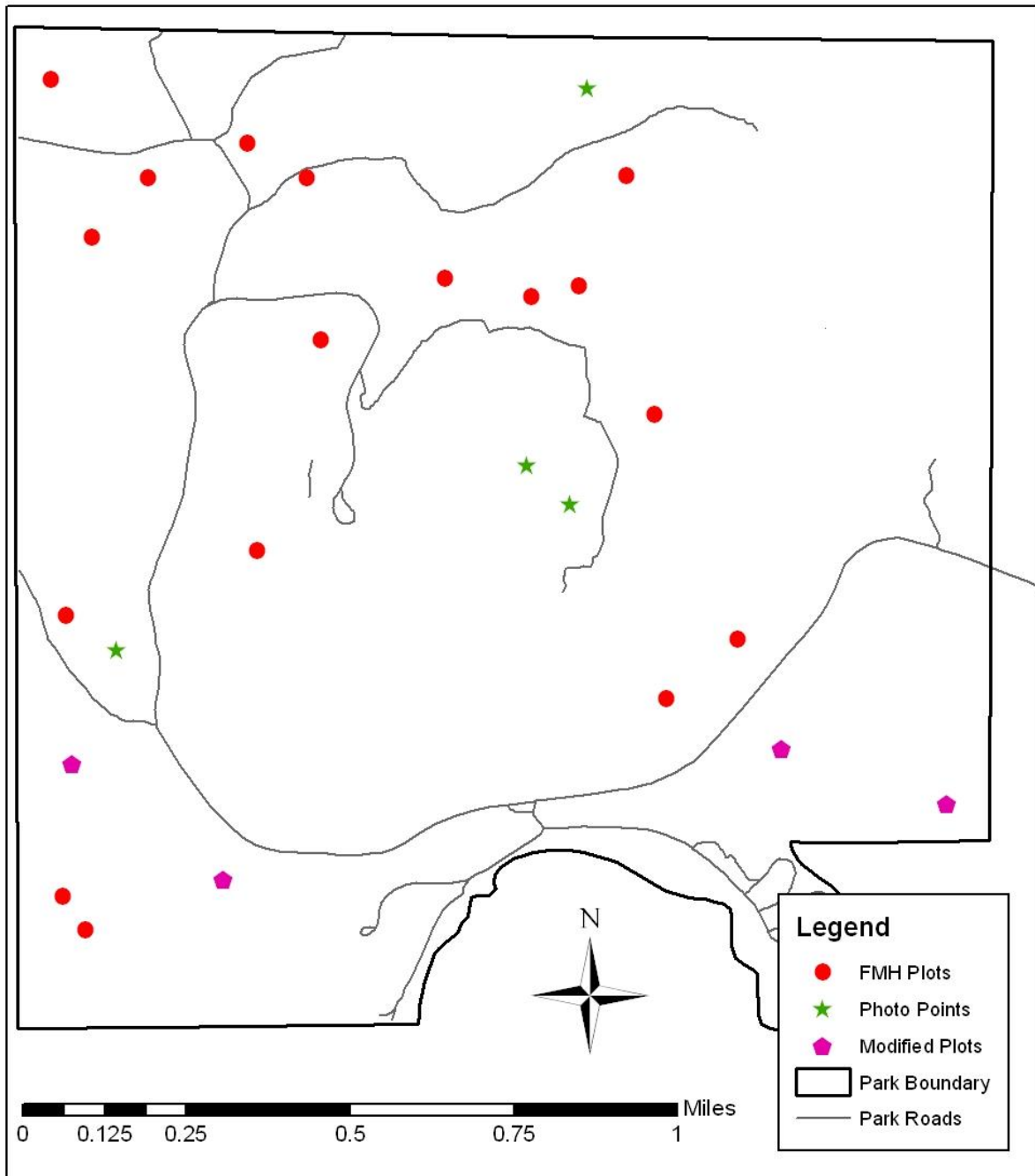
Burn Unit	Date(s)	Season	Size
Belle Fourche	4/29/98	Spring	286
Meadow	5/7/99	Spring	73
Westside	10/21/99	Fall	137
Meadow	5/3/00	Spring	55
Graham	11/15/01	Fall	108
Northside (thinning)	n/a	n/a	203
Meadow	5/10/02	Spring	20
North Terrace	9/22 & 9/23/05	Fall	202
Southwest	10/4/07	Fall	115



MONITORING PLOTS

Burn Unit	Monitoring Type	Plot ID	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belle Fourche	Ponderosa Pine	PIPO_02-01	V		B/V	V	V			V				
Belle Fourche	Ponderosa Pine	PIPO_02-02	V		B/V	V	V			V				
Graham	Ponderosa Pine	PIPO_02-03		V				X						
Graham	Ponderosa Pine	PIPO_02-09						V/B	V	V			V	
Graham	Ponderosa Pine	PIPO_09-02		V		V		V/B	V	V			V	
Graham	Photo Point	PP1						V/B	V	V			V	
Meadow	Ponderosa Pine	PIPO_02-05			V	B/V	V	V			V			
Meadow	Kentucky bluegrass	POPR-01			V	B/V	B/V	V			V			
Meadow	Kentucky bluegrass	POPR-02			V	B/V	B/V	V			V	B/V	V	V
Meadow	Kentucky bluegrass	POPR-03			V	B/V	V	V	B/V	V		V		
Northside	Ponderosa Pine	PIPO_02-04		V				V/M	V	V		B/V	V	V
Northside	Ponderosa Pine	PIPO_02-08						V/M	V	V		B/V	V	V
Northside	Ponderosa Pine	PIPO_09-01	V		V			V/M	V	V		B/V	V	V
Northside	Ponderosa Pine	PIPO_09-03						V/M	V	V		B/V	V	V
Northside	Ponderosa Pine	PIPO_09-05						V/M	V	V		B/V	V	V
Northside	Photo Point	PP2								V			V	V
Northside	Photo Point	PP3								V			V	V
Southwest	Kentucky bluegrass	POPR-04					V							X
Southwest	Kentucky bluegrass	POPR-05					V							X
Southwest	Ponderosa Pine	PIPO_09-06										V	V	V/B
Southwest	Ponderosa Pine	PIPO_09-07										V	V	V/B
Westside	Ponderosa Pine	PIPO_02-06				V/B	V	V			V			
Westside	Ponderosa Pine	PIPO_02-07				V/B	V	V			V			

V = Plot visit; B = Burned; X = Plot removed; M = Mechanical treatment

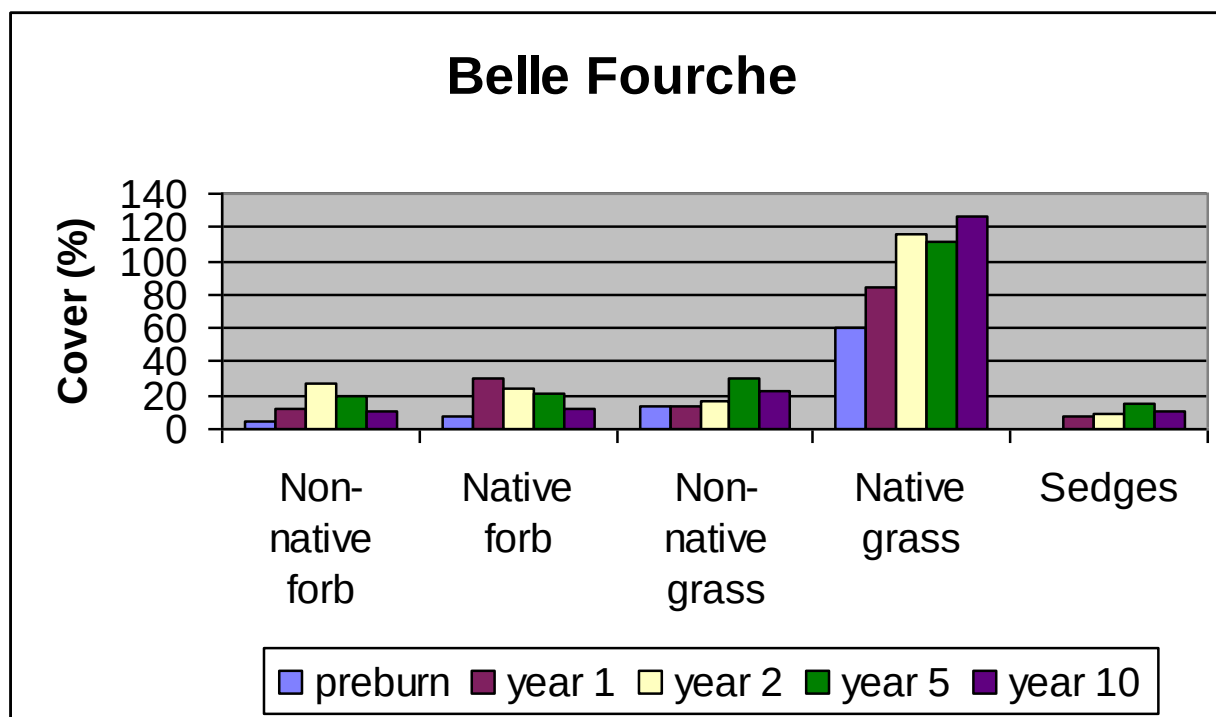


MONITORING RESULTS

Prescribed Fire Units

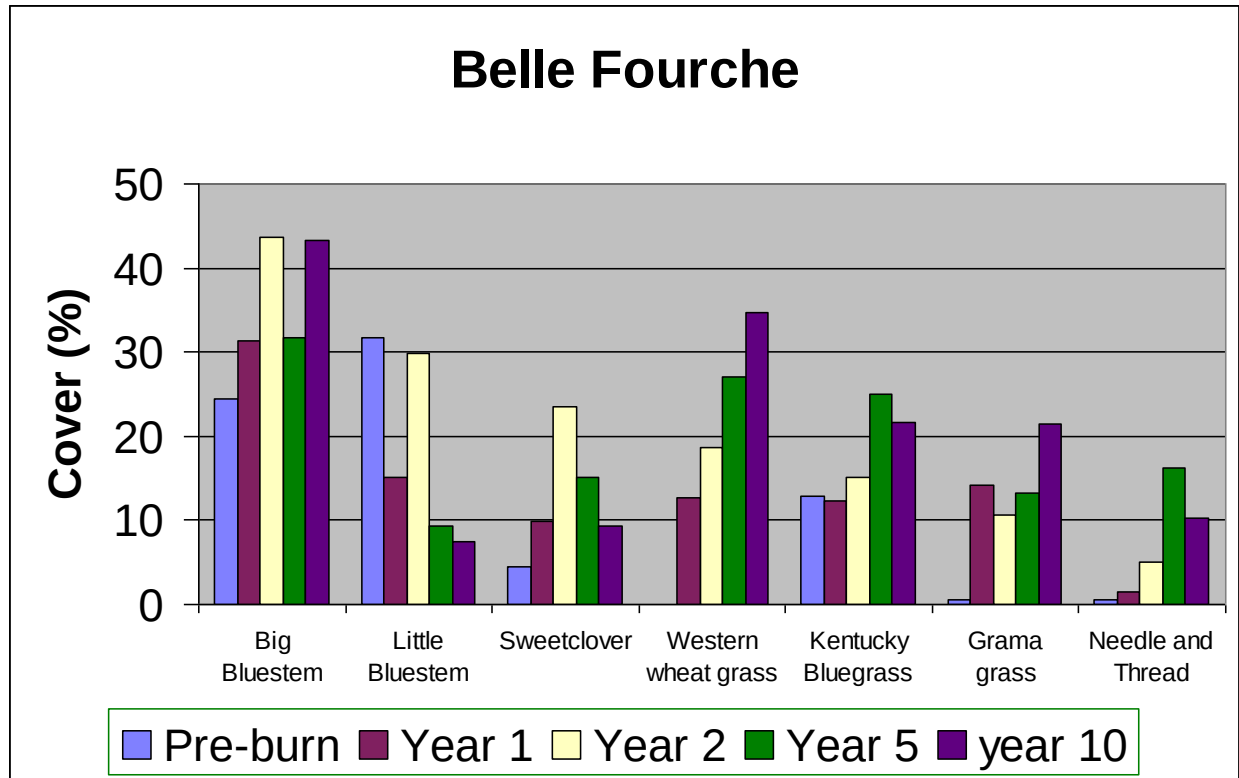
Belle Fourche

Two ponderosa pine plots were installed in Belle Fourche. Standard error bars are not included because of the small sample size.



The table below shows change in cover two, five, and ten years after a prescribed burn event. Non-native lifeforms are italicized.

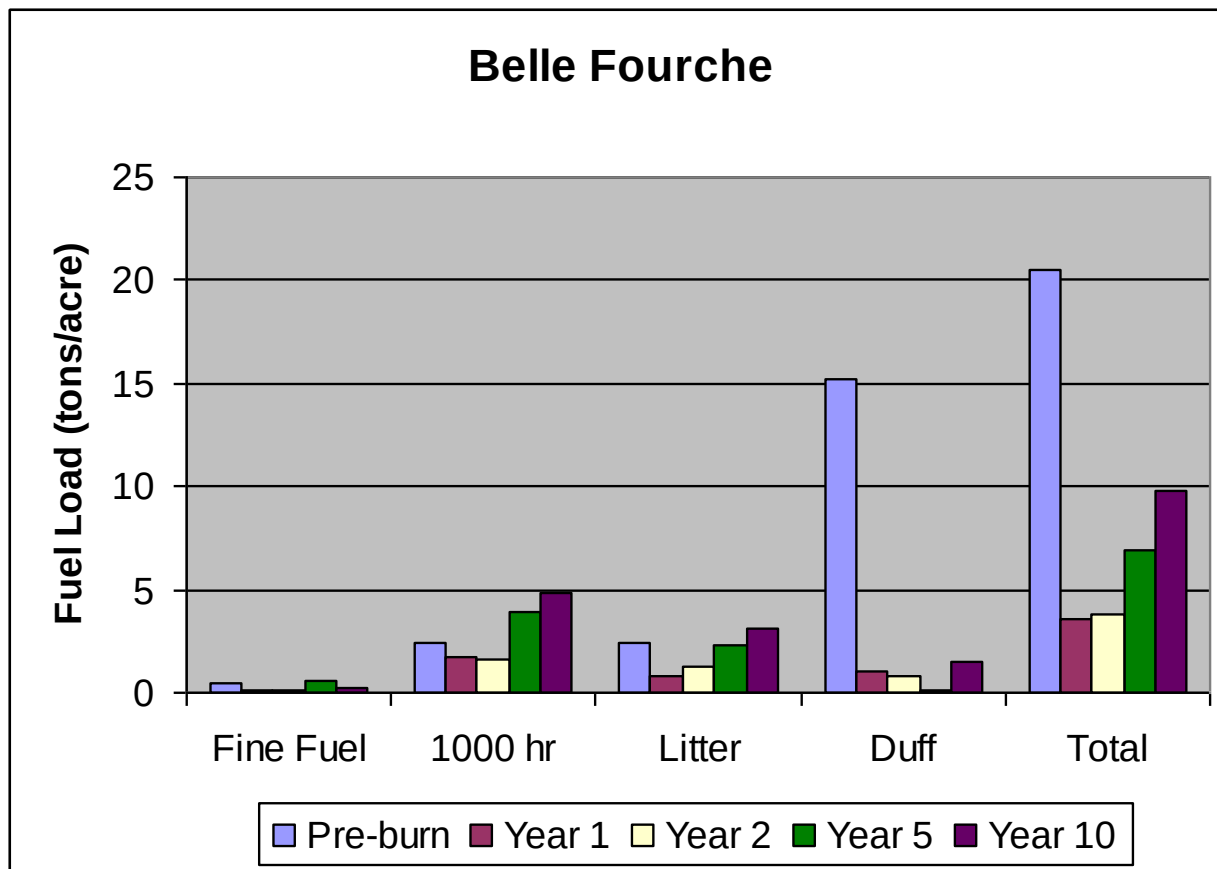
BELLE FOURCHE							
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
<i>Non-native Forb</i>	4.5	26.5	487%	19.9	340%	10.5	133%
Native Forb	7.2	24.4	238%	21.4	196%	12.0	66%
<i>Non-native Grass</i>	14.2	16.9	19%	30.4	115%	22.0	55%
Native Grass	59.6	115.7	94%	112.0	88%	126.2	112%
Sedges	0	9.6	++	15.1	++	10.2	++



The table below presents change in cover from pre-burn conditions for the seven most common genera. *Italicized rows indicates non-native genera.*

BELLE FOURCHE							
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
Big bluestem	24.4	43.7	79%	31.6	30%	43.4	78%
Little bluestem	31.6	29.8	-6%	9.3	-70%	7.5	-76%
<i>Yellow sweetclover</i>	4.5	23.5	420%	15.1	233%	9.3	107%
Western wheatgrass	0.0	18.7	++	27.1	++	34.6	++
<i>Kentucky bluegrass</i>	13.0	15.1	16%	25.0	93%	21.7	67%
Grama grass	0.6	10.5	1651%	13.3	2101%	21.4	3452%
Needle-and-thread	0.6	5.1	750%	16.3	2600%	10.2	1600%





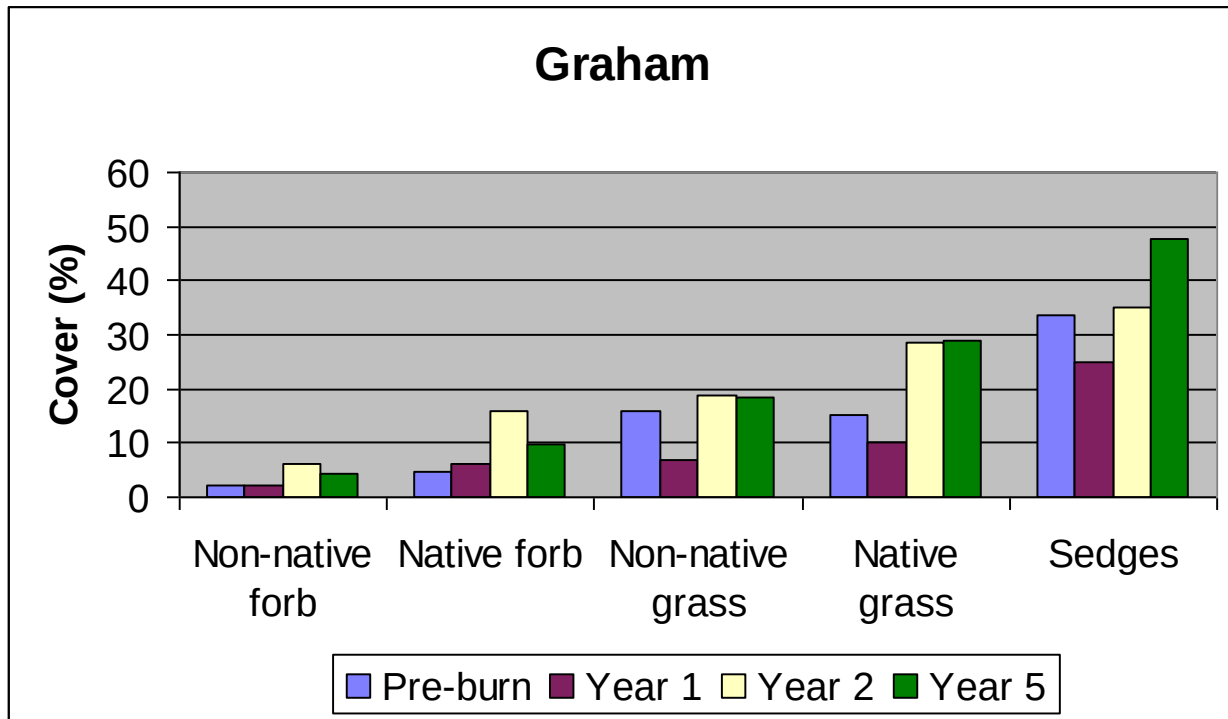
BELLE FOURCHE							
tons/acre	Pre-burn fuel load	Yr 1 fuel load	Change	Yr 5 fuel load	Change	Yr 10 fuel load	Change
Woody Fuels	2.8	1.8	-36%	4.6	64%	5.2	86%
Litter & Duff	17.7	1.9	-89%	2.4	-86%	4.6	-74%
Total	20.5	3.6	-82%	7.0	-66%	9.8	-52%

One hundred percent mortality was observed for pole trees two years post-treatment. Overstory tree density was reduced 50% two years following the burn.

BELLE FOURCHE							
stems/acre	Pre-burn density	Yr 2 density	Change	Yr 5 density	Change	Yr 10 density	Change
Poles	145.7	0.0	-100%	0.0	-100%	0.0	-100%
Overstory	64.7	32.4	-49.9%	32.4	-49.9%	30.4	-53%

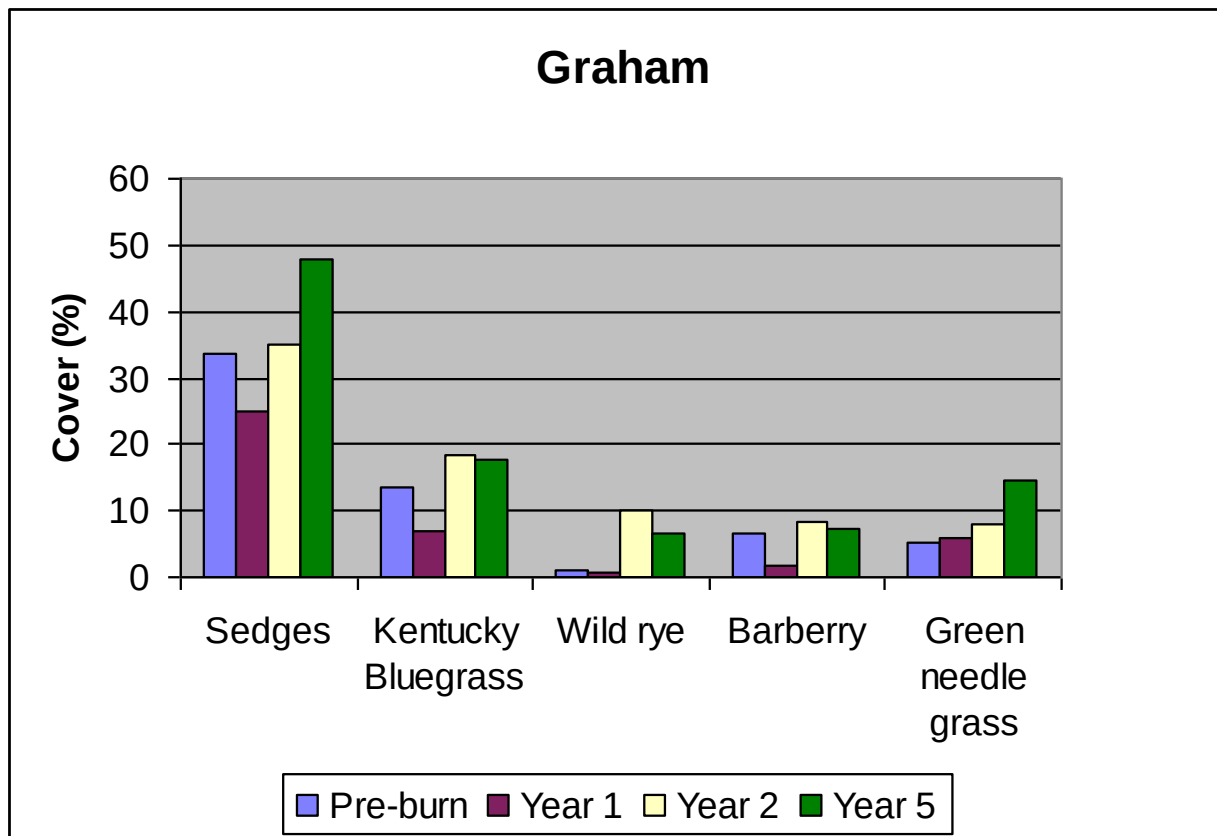
Graham

Two ponderosa pine plots were installed in Graham. Standard error bars are not included because of the small sample size.



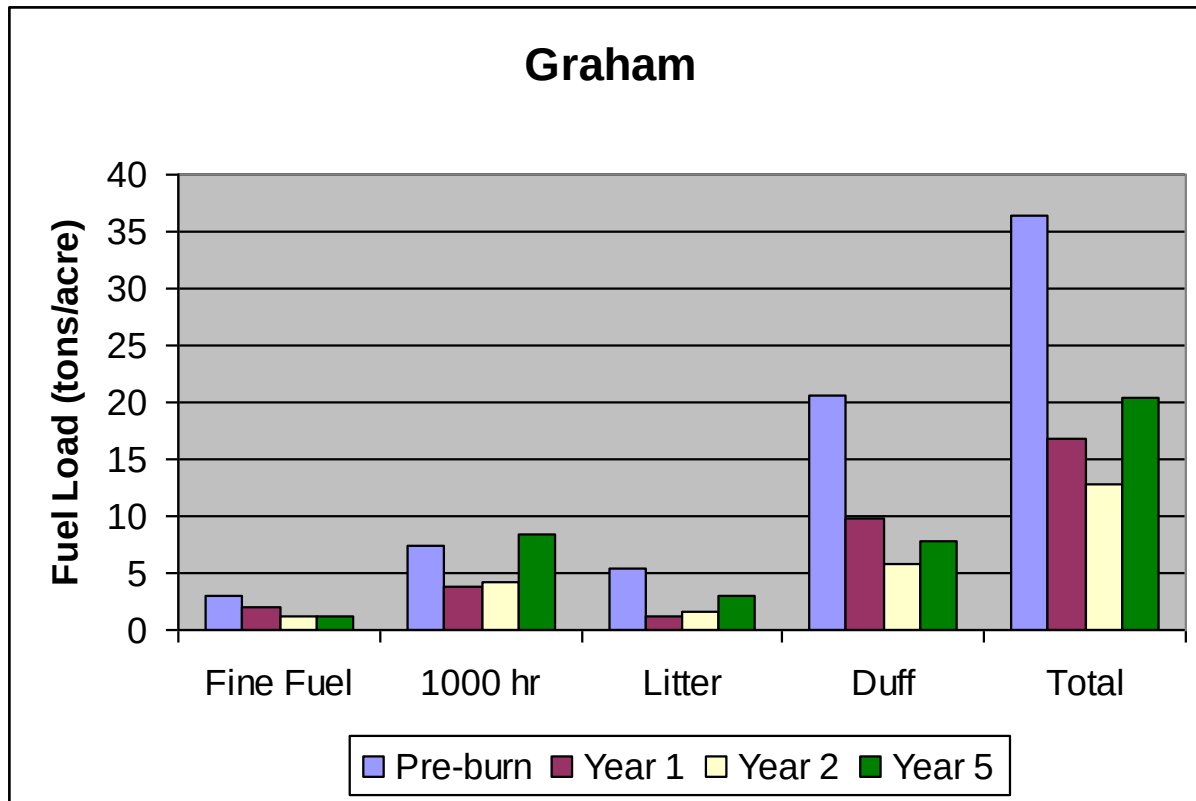
The table below shows change in cover two and five years after a prescribed fire. Non-native lifeforms are italicized.

	GRAHAM				
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	2.1	6.0	186%	4.2	100%
Native Forb	4.8	16.0	231%	9.9	106%
<i>Non-native Grass</i>	16.0	18.7	17%	18.4	15%
Native Grass	15.1	28.6	90%	28.9	92%
Sedges	33.7	34.9	4%	47.9	42%



The table below presents change in cover from pre-burn conditions for the five most common genera. *Italicized rows indicates non-native genera.*

GRAHAM					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Sedges	33.7	34.9	4%	47.9	42%
<i>Kentucky bluegrass</i>	13.6	18.4	36%	17.8	31%
Wildrye	0.9	9.9	1000%	6.6	633%
Barberry	6.6	8.4	27%	7.2	9%
Green needlegrass	5.1	7.8	53%	14.5	182%
Sedges	33.7	34.9	4%	47.9	42%



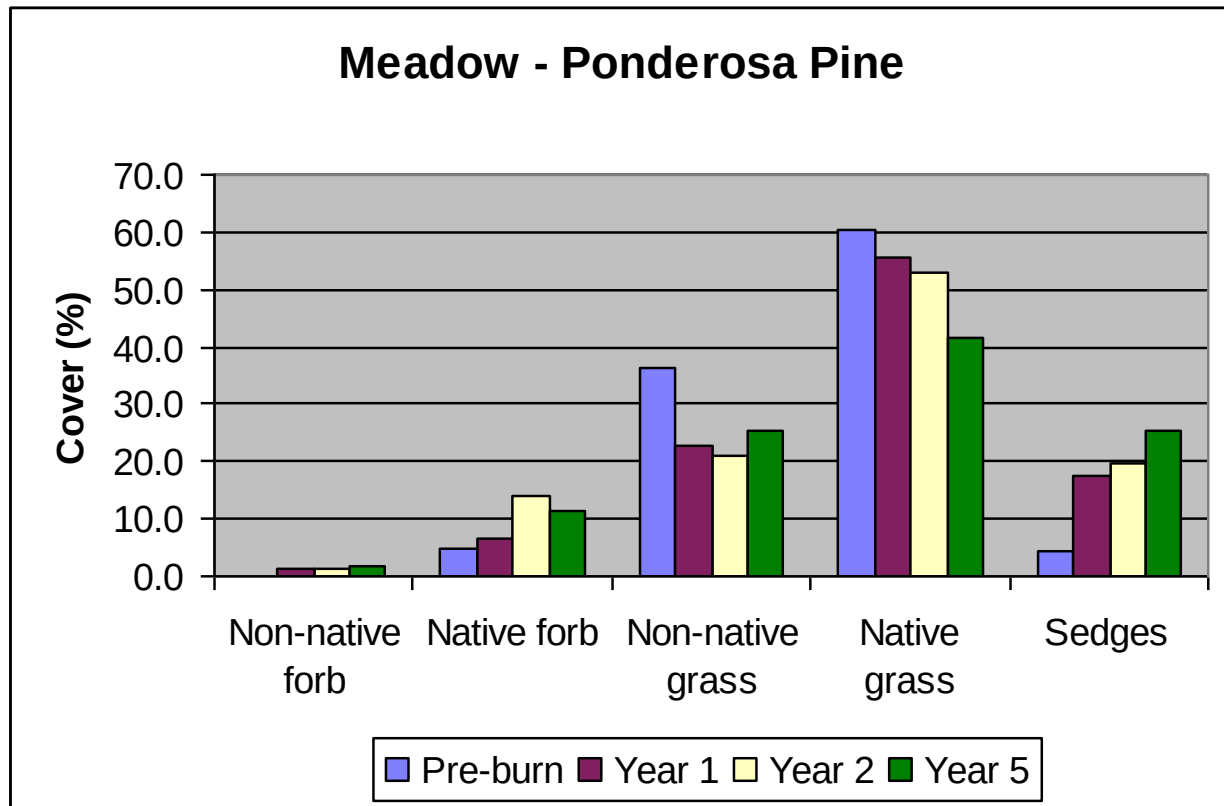
GRAHAM					
tons/acre	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	10.5	5.8	-45%	9.6	-9%
Litter & Duff	25.9	11.0	-58%	10.9	-58%
Total	36.4	16.8	-54%	20.4	-44%

There was approximately 60% mortality in the ponderosa pine poles two years after the prescribed fire with overstory mortality reaching 17% five years post-burn. Approximately 33% of the juniper and bur oak pole trees died two years after the fire with over 60% mortality in the overstory five years post-burn.

GRAHAM					
stems/acre	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Ponderosa Pine Poles	226.7	97.1	-57.1%	89.0	-60.7%
Ponderosa Pine Overstory	155.8	147.7	-5.2%	129.5	-16.9%
Juniper & Oak Poles	72.9	48.6	-33.3%	48.6	-33.3%
Juniper & Oak Overstory	16.2	10.1	-37.5%	6.1	-62.5%

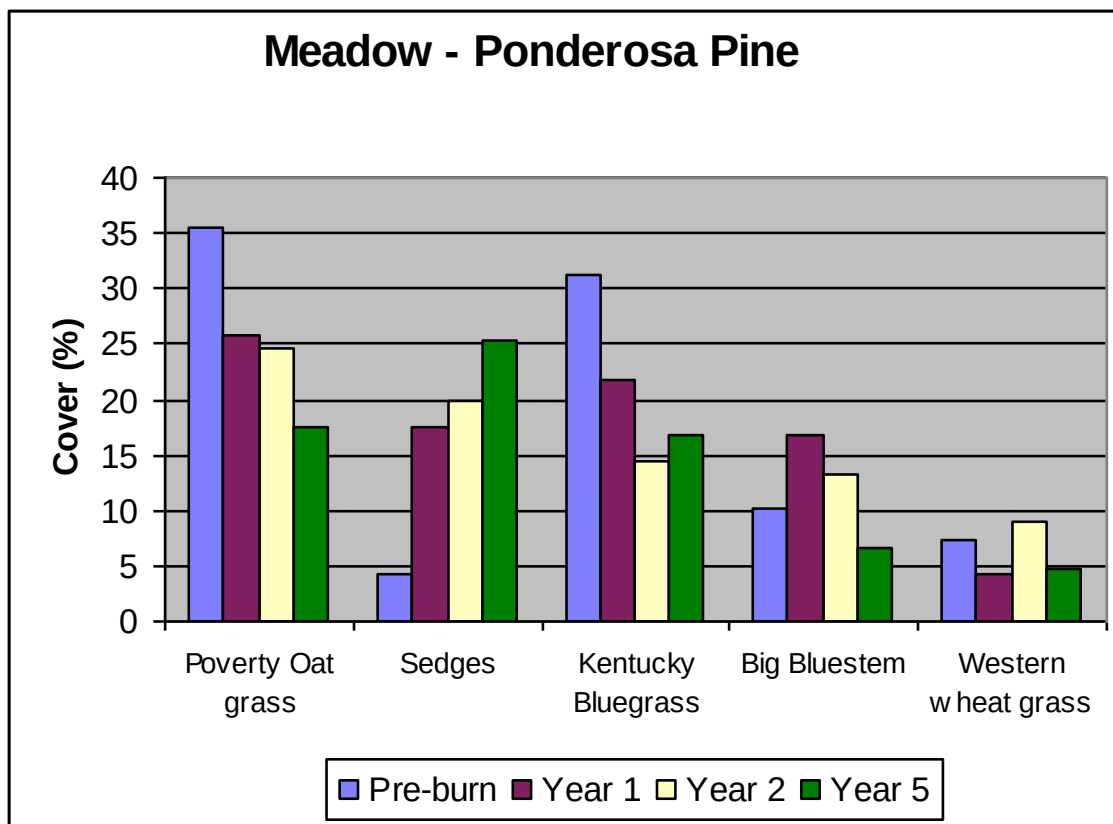
Meadow

One ponderosa pine plot was installed in Meadow. Standard error bars are not included because of the small sample size.



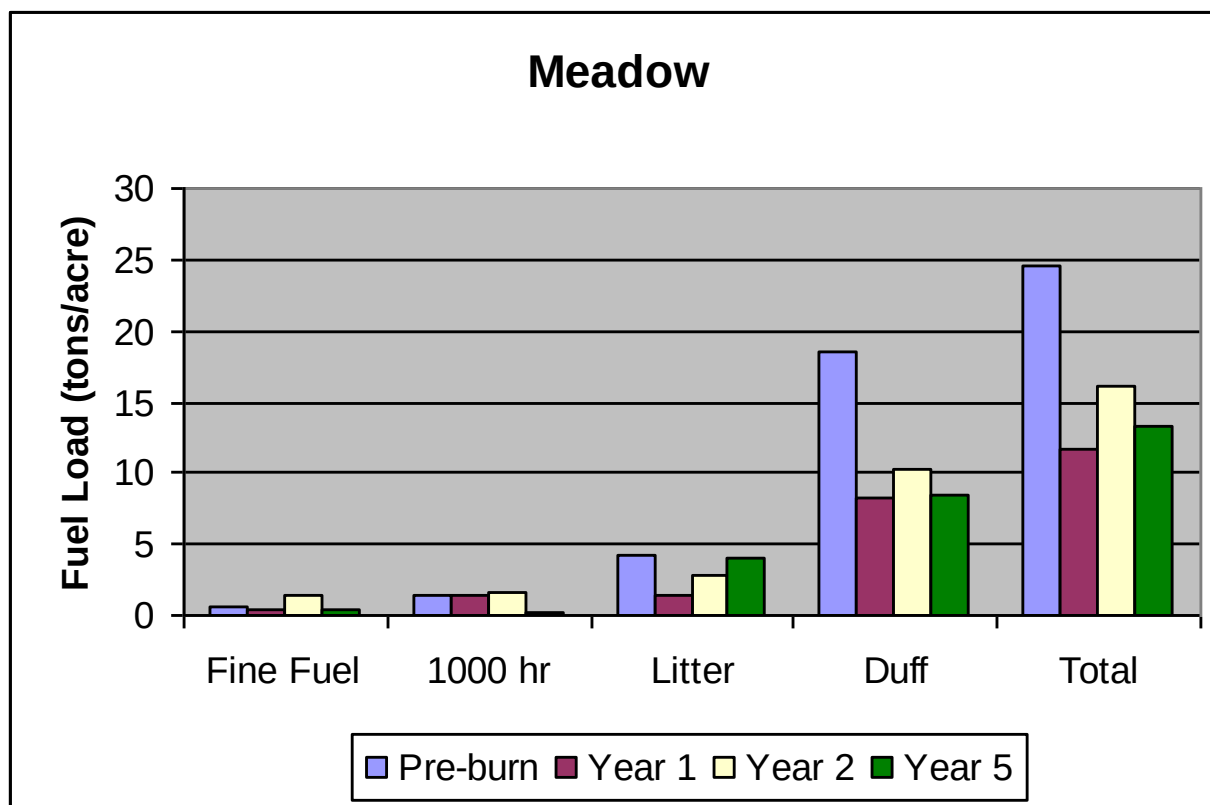
The table below shows change in cover two and five years after a prescribed fire. Non-native lifeforms are italicized.

	MEADOW				
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	0.0	1.2	+++	1.8	+++
Native Forb	4.8	13.9	188%	11.4	137%
<i>Non-native Grass</i>	36.1	21.1	-42%	25.3	-30%
Native Grass	60.2	53.0	-12%	41.6	-31%
Sedges	4.2	19.9	371%	25.3	500%



The table below presents change in cover from pre-burn conditions for the five most common genera. *Italicized rows indicates non-native genera.*

	MEADOW				
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Poverty oatgrass	35.5	24.7	-31%	17.5	-51%
Sedges	4.2	19.9	371%	25.3	500%
<i>Kentucky bluegrass</i>	31.3	14.5	-54%	16.9	-46%
Big bluestem	10.2	13.5	29%	6.6	-35%
Western wheatgrass	7.2	9.0	25%	4.8	-33%



tons/acre	MEADOW				
	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	1.9	1.9	---	0.7	-63%
Litter & Duff	22.6	9.7	-57%	12.6	-44%
Total	24.5	11.7	-52%	13.3	-46%

Pole density increased and overstory density remained unchanged following one prescribed fire.

stems/acre	MEADOW				
	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Poles	0	16.2	++	16.2	++
Overstory	68.8	68.8	---	68.8	---

Three non-native grass prairie plots were installed in Meadow.

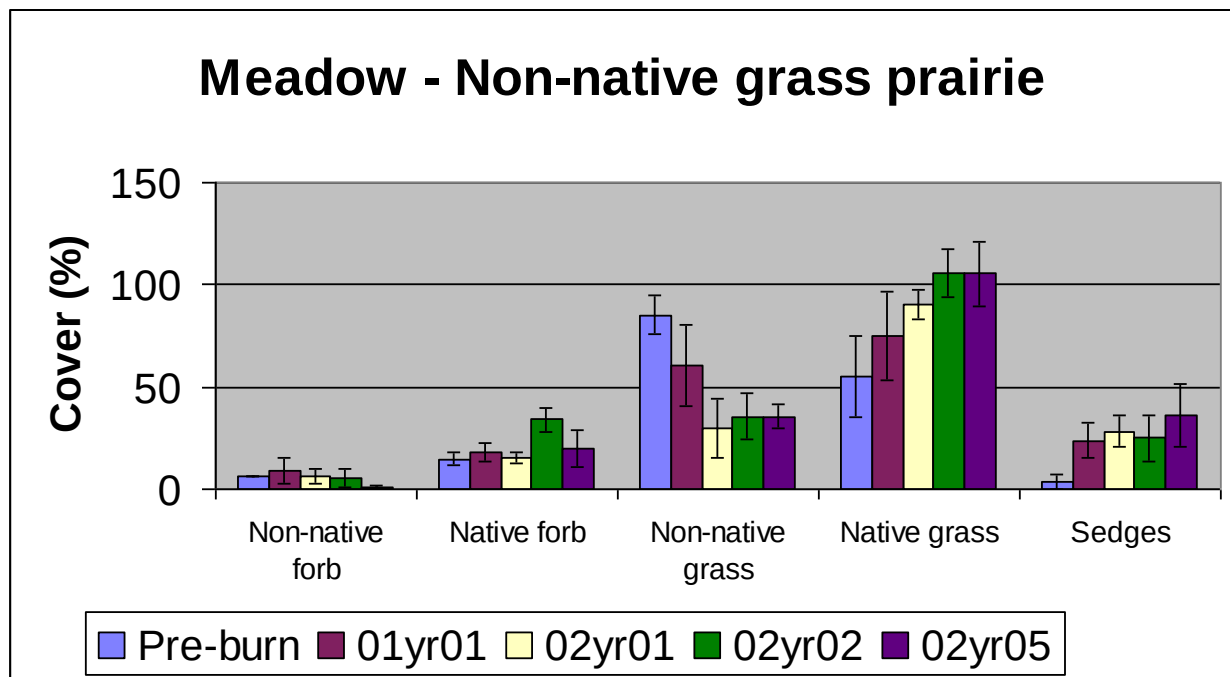
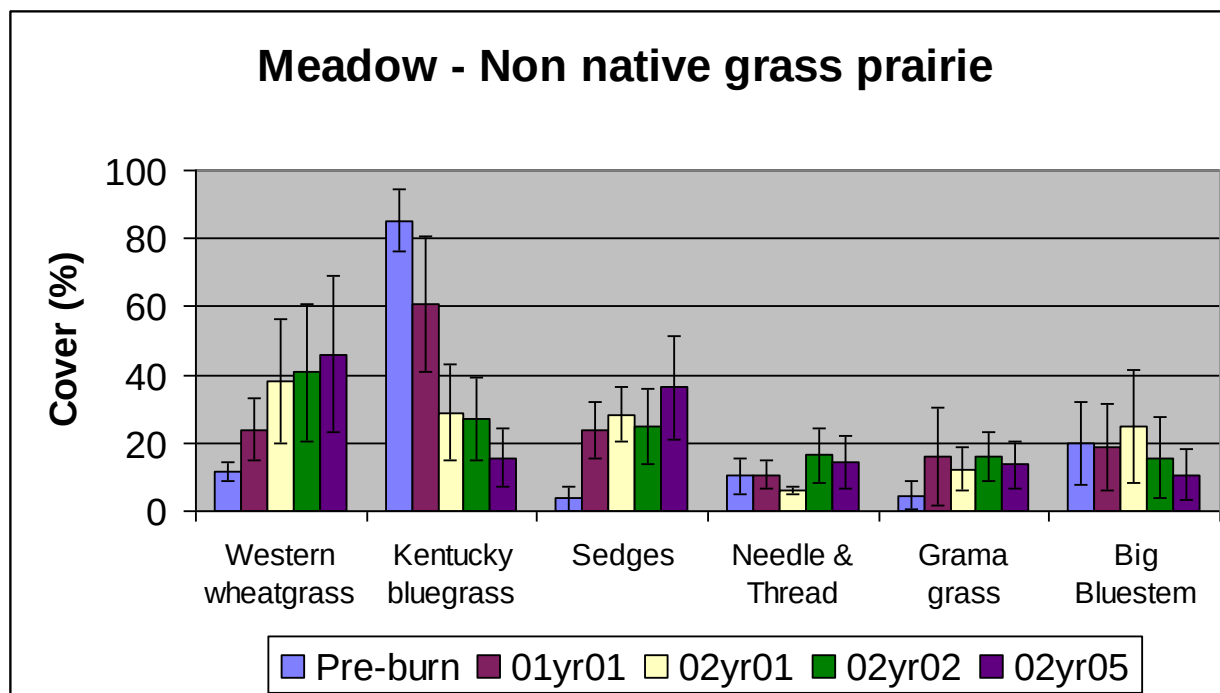


Table below shows the relative change in cover two and five growing seasons after two prescribed burn events.

MEADOW – NON-NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	6.0	5.3	-11%	1.0	-83%
Native Forb	14.7	34.0	132%	19.7	34%
<i>Non-native Grass</i>	85.3	35.3	-59%	35.7	-58%
Native Grass	55.3	105.7	91%	105.3	90%
Sedges	3.7	25.0	582%	36.3	891%



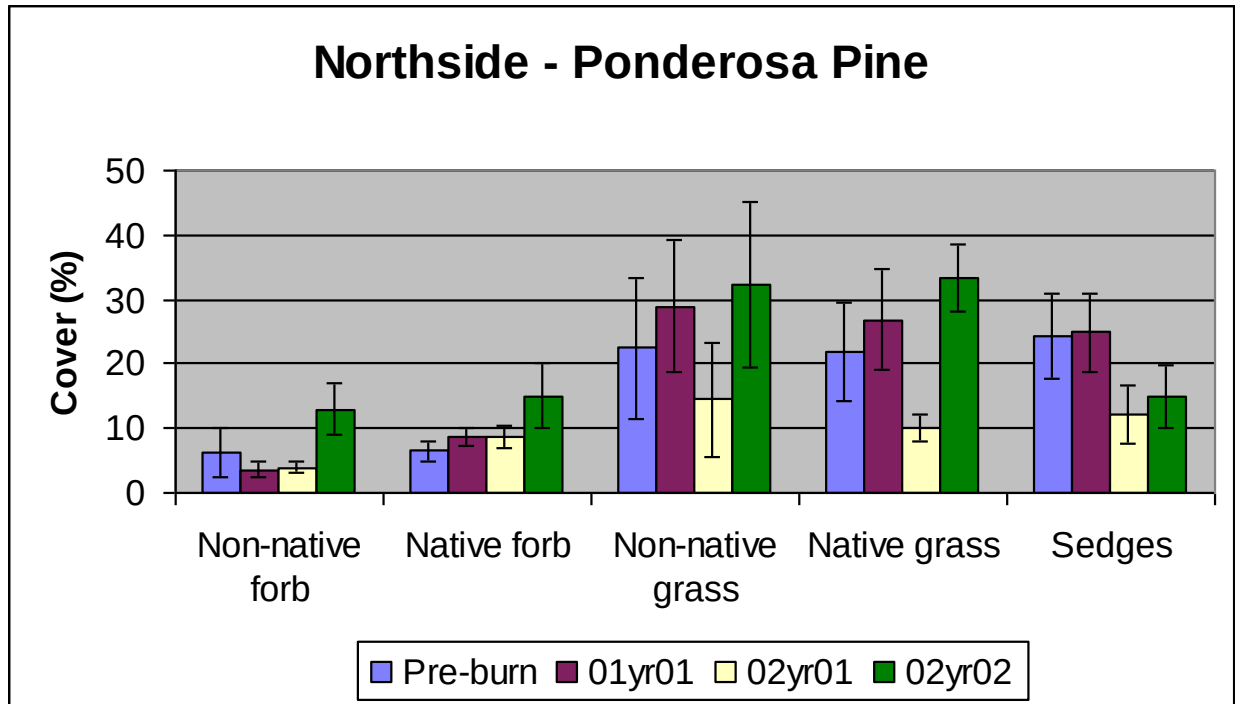


The table below presents change in cover from pre-burn conditions for the six most common genera. *Italicized rows indicates non-native genera.*

MEADOW – NON-NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	11.7	40.7	249%	46.0	294%
<i>Kentucky bluegrass</i>	85.3	27.3	-68%	15.7	-82%
Sedges	3.7	25.0	582%	36.3	891%
Needle-and-thread	10.3	16.3	58%	14.3	39%
Grama grass	4.7	16.0	243%	13.7	193%
Big bluestem	19.7	15.7	-20%	10.7	-46%

Northside

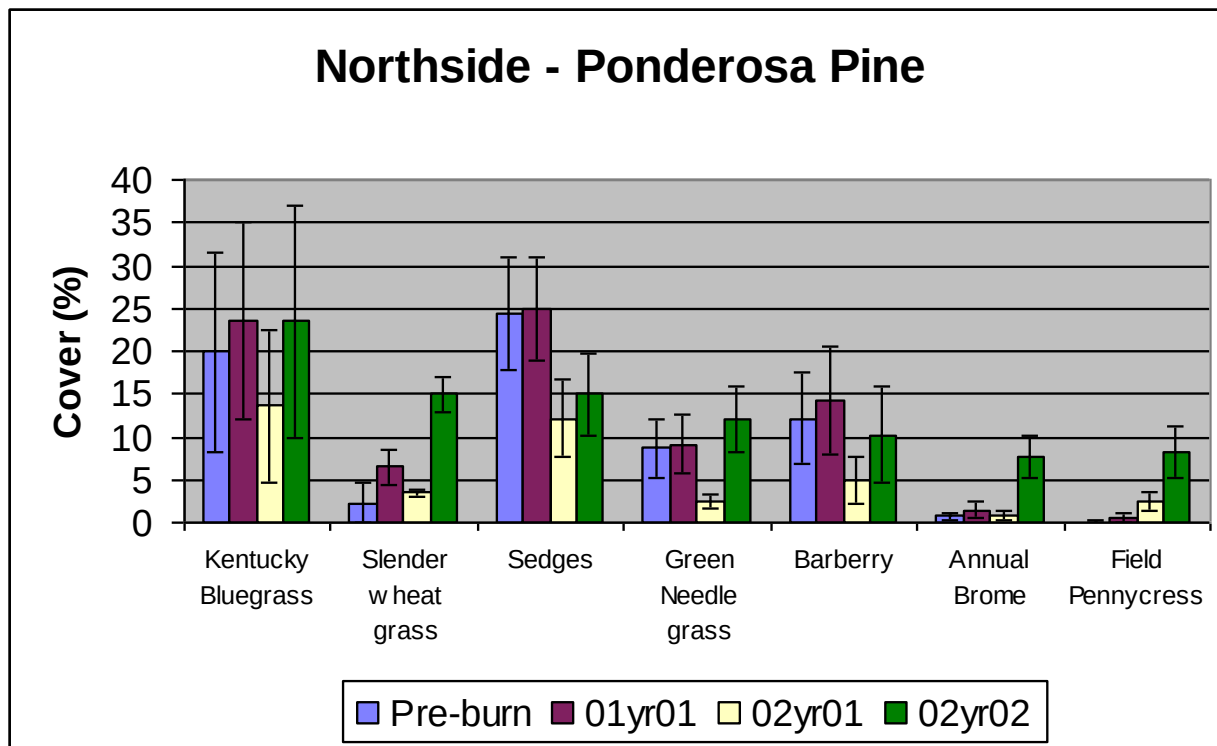
Five ponderosa pine plots were installed in Northside. The first of two fuels treatments involved thinning the density of pole size ponderosa pine (1-6" dbh) by at least 80% within the project area. Four years following this treatment a prescribed burn was implemented to reduce overstory density, fuel load, and non-native herbaceous cover.



The table below presents change in cover two growing seasons after the prescribed fire.

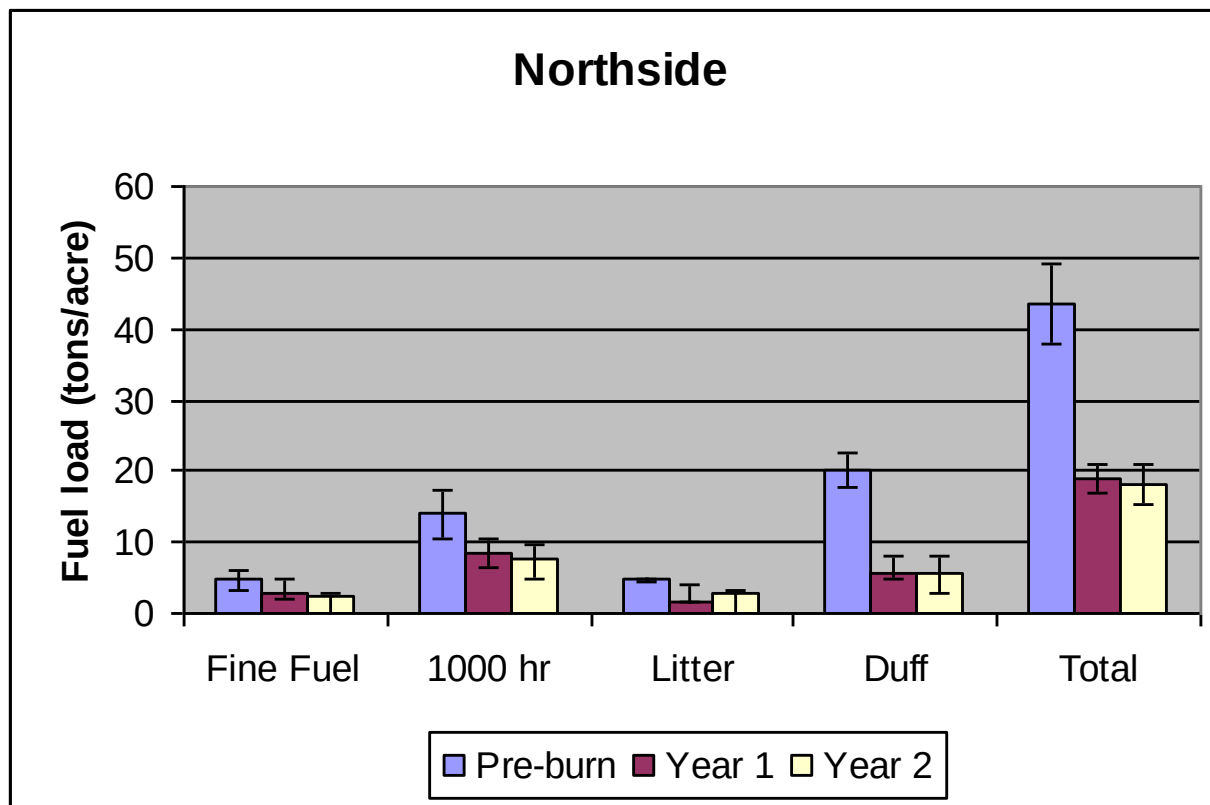
NORTHSIDE			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	6.1	12.9	110%
Native Forb	6.5	15.1	132%
<i>Non-native Grass</i>	22.5	32.3	43%
Native Grass	21.9	33.4	52%
Sedges	24.3	14.9	-39%





The table below presents change in cover from pre-burn conditions to two growing seasons after the second prescribed burn for the seven most common genera. Italicized rows indicate non-native genera.

NORTHSIDE			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Kentucky Bluegrass</i>	19.9	23.5	18%
<i>Slender wheatgrass</i>	2.3	14.9	553%
<i>Sedges</i>	24.3	14.9	-39%
<i>Green Needlegrass</i>	8.7	12.0	39%
<i>Barberry</i>	12.2	10.2	-16%
<i>Annual brome</i>	0.7	7.7	967%
<i>Field pennycress</i>	0.1	8.2	6705%



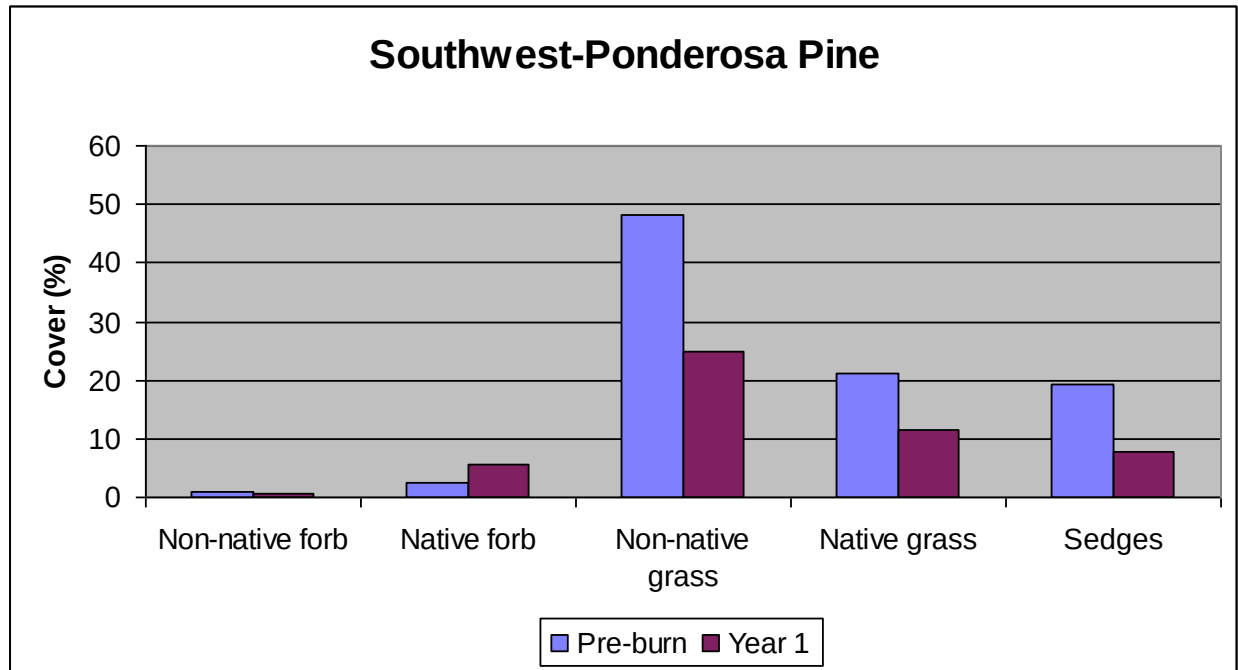
tons/acre	NORTHSIDE		
	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	18.7	11.2	-40%
Litter & Duff	24.8	7.6	-69%
Total	43.5	18.8	-57%

Pole density was reduced over 97% following one thinning treatment and further reduced after a prescribed burn. Overstory density was insignificantly changed following the thinning treatment but reduced almost 20% following the burn.

stems/acre	NORTHSIDE				
	Pretreatment Density	Post-thin Density	Change	Post-burn Density	Change
Poles	427.4	9.7	-97.7%	6.5	-98.5%
Overstory	150.5	147.3	-2.2%	121.4	-19.4%

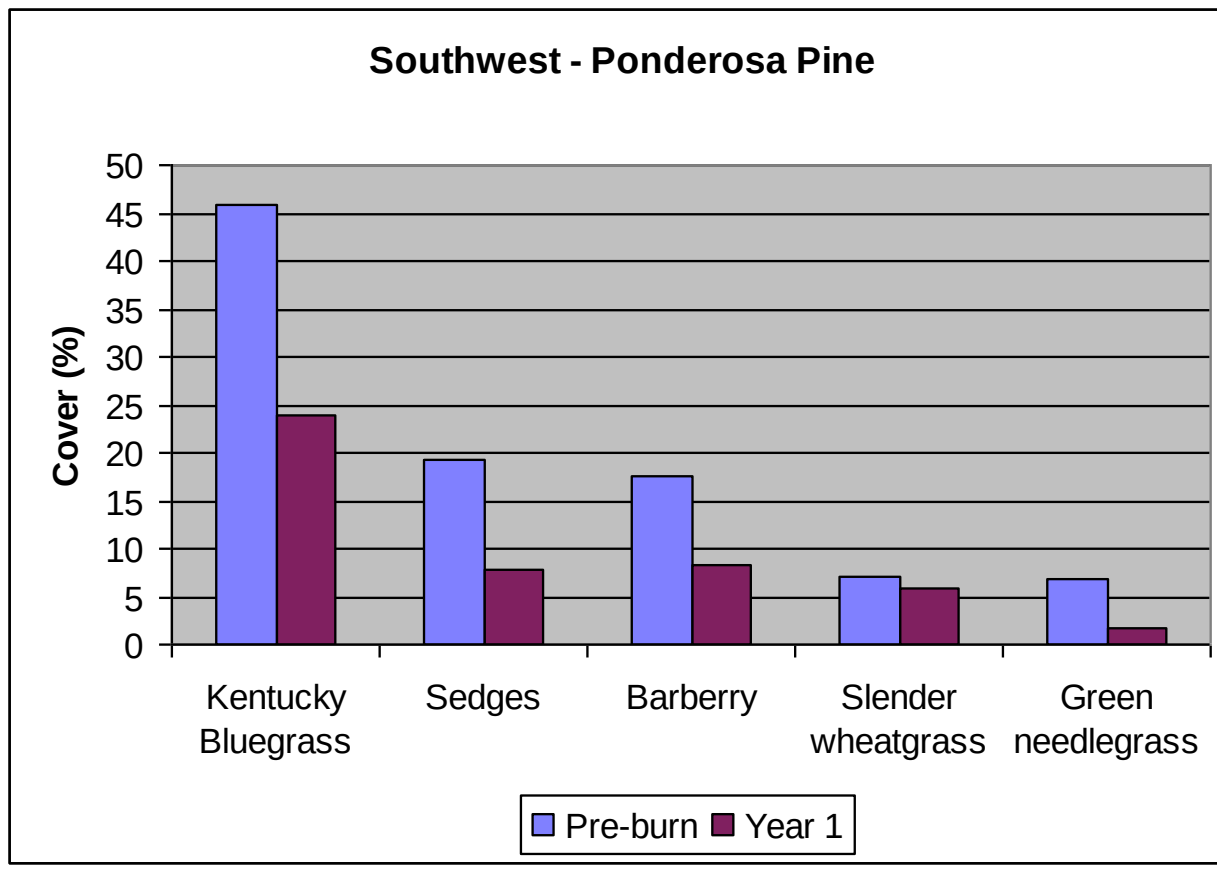
Southwest

Two ponderosa pine plots were installed in Southwest. Standard error bars are not included due to the small sample size.



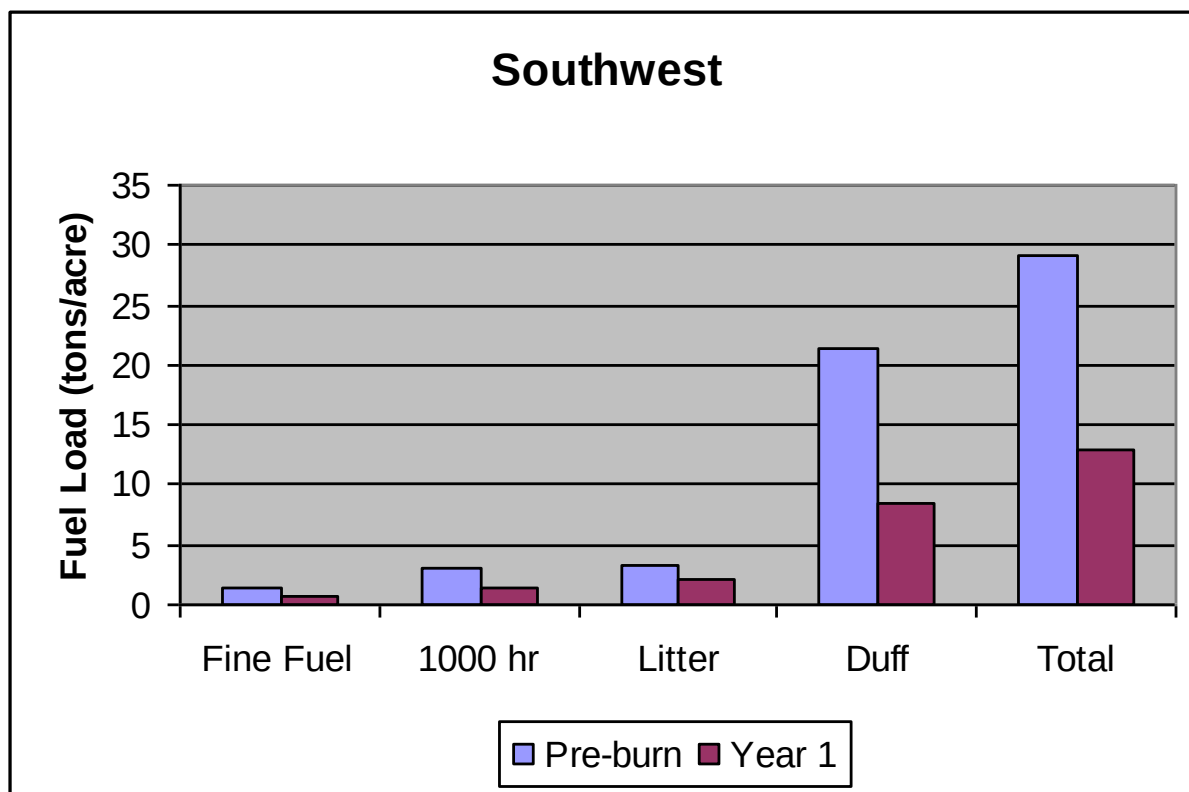
The table below presents changes in cover one year following a prescribed burn treatment. Non-native lifeforms are italicized.

SOUTHWEST			
	Pre-burn Cover	Yr 1 Cover	Change
<i>Non-native Forb</i>	1.0	0.8	-25%
Native Forb	2.5	5.8	130%
<i>Non-native Grass</i>	48.3	25.0	-48%
Native Grass	21.0	11.5	-45%
Sedges	19.3	7.8	-60%



The table below presents change in cover from pre-burn conditions for the five most common genera. *Italicized rows indicate non-native genera.*

SOUTHWEST			
	Pre-burn Cover	Yr 1 Cover	Change
<i>Kentucky bluegrass</i>	45.8	24.0	-48%
<i>Sedges</i>	19.3	7.8	-60%
<i>Barberry</i>	17.5	8.3	-53%
<i>Slender wheatgrass</i>	7.0	5.8	-18%
<i>Green needlegrass</i>	6.8	1.8	-74%



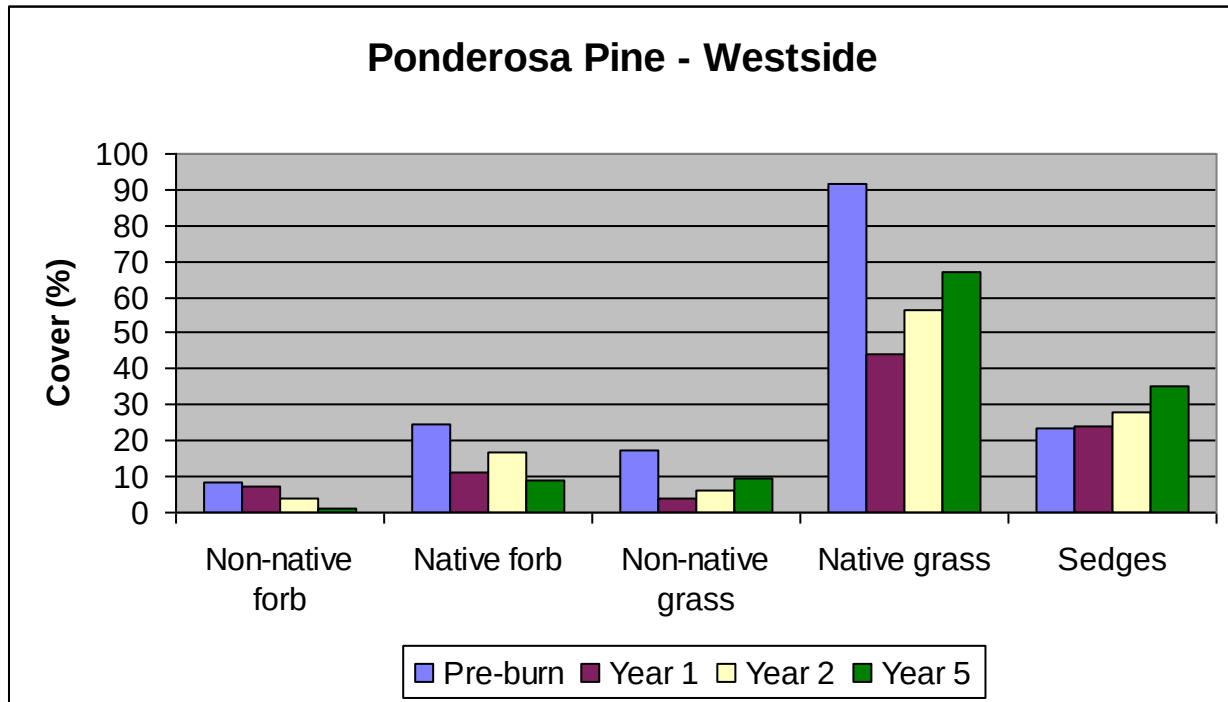
SOUTHWEST			
tons/acre	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	4.6	2.3	-50%
Litter & Duff	24.6	10.6	-57%
Total	29.2	13.0	-55%

Pole density was reduced almost 50% and overstory density 10% one year following a prescribed burn treatment.

SOUTHWEST			
stems/acre	Pre-burn Density	Year 1 Density	Change
Poles	267	146	-45%
Overstory	180	160	-11%

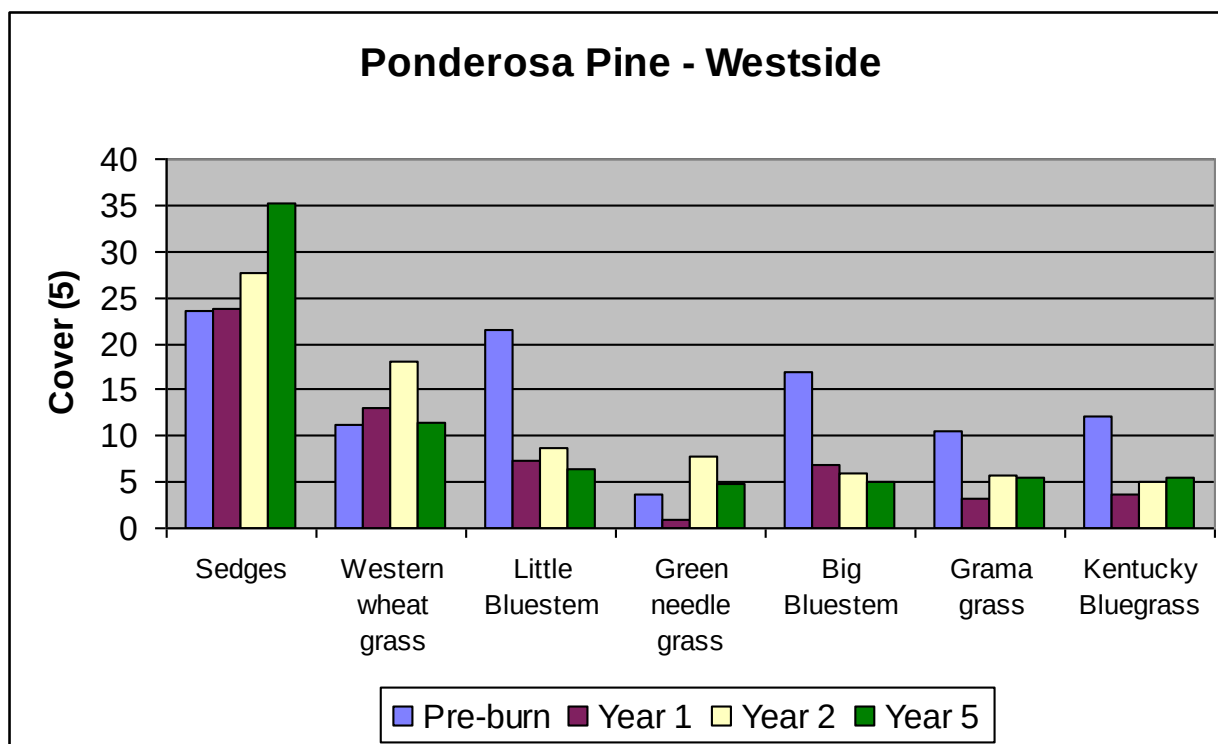
Westside

Two ponderosa pine plots were installed in Westside.



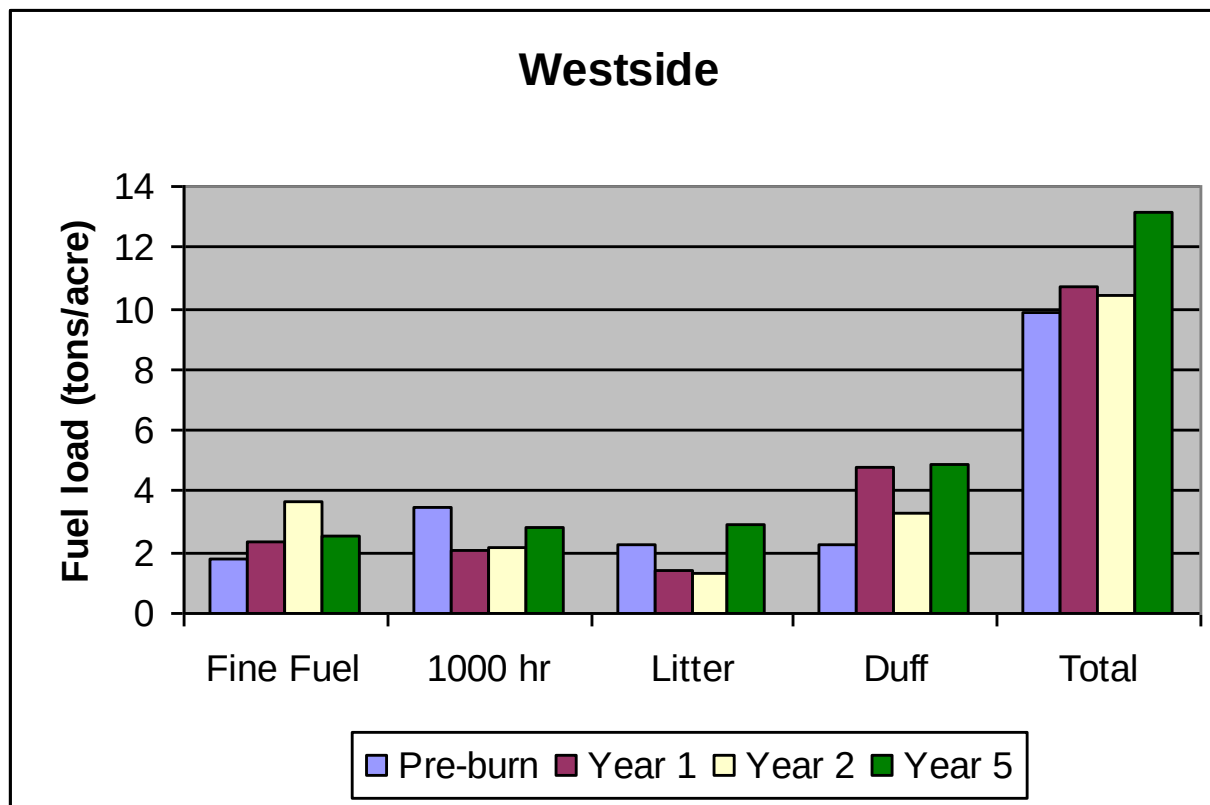
The table below shows changes in cover two and five years following a prescribed burn treatment. Non-native lifeforms are italicized.

WESTSIDE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	8.1	3.9	-52%	0.9	-89%
Native Forb	24.7	16.9	-32%	9.0	-63%
<i>Non-native Grass</i>	17.2	6.3	-63%	9.6	-44%
Native Grass	91.9	56.3	-39%	67.2	-27%
Sedges	23.5	27.7	18%	35.2	50%



The table below presents change in cover from pre-burn conditions for the seven most common genera. *Italicized rows indicate non-native genera.*

WESTSIDE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Sedges	23.5	27.7	18%	35.2	50%
Western wheat grass	11.1	18.1	62%	11.4	3%
Little bluestem	21.4	8.7	-59%	6.3	-70%
Green needlegrass	3.6	7.8	117%	4.8	33%
Big bluestem	16.9	6.0	-64%	5.1	-70%
Grama grass	10.5	5.7	-46%	5.4	-49%
<i>Kentucky bluegrass</i>	<i>12.0</i>	<i>5.1</i>	<i>-57%</i>	<i>5.4</i>	<i>-55%</i>



WESTSIDE					
tons/acre	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	5.3	4.4	-17%	5.3	---
Litter & Duff	4.5	6.2	38%	7.8	73%
Total	9.8	10.7	9%	13.1	34%

Pole and overstory density was virtually unchanged five years following a prescribed burn.

WESTSIDE					
stems/acre	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Poles	56.7	64.8	14.3%	56.7	---
Overstory	125.5	135.6	8.1%	127.5	1.6%

Monitoring Units

Non-native grass prairie - Kentucky bluegrass

Prescribed Fire Objectives

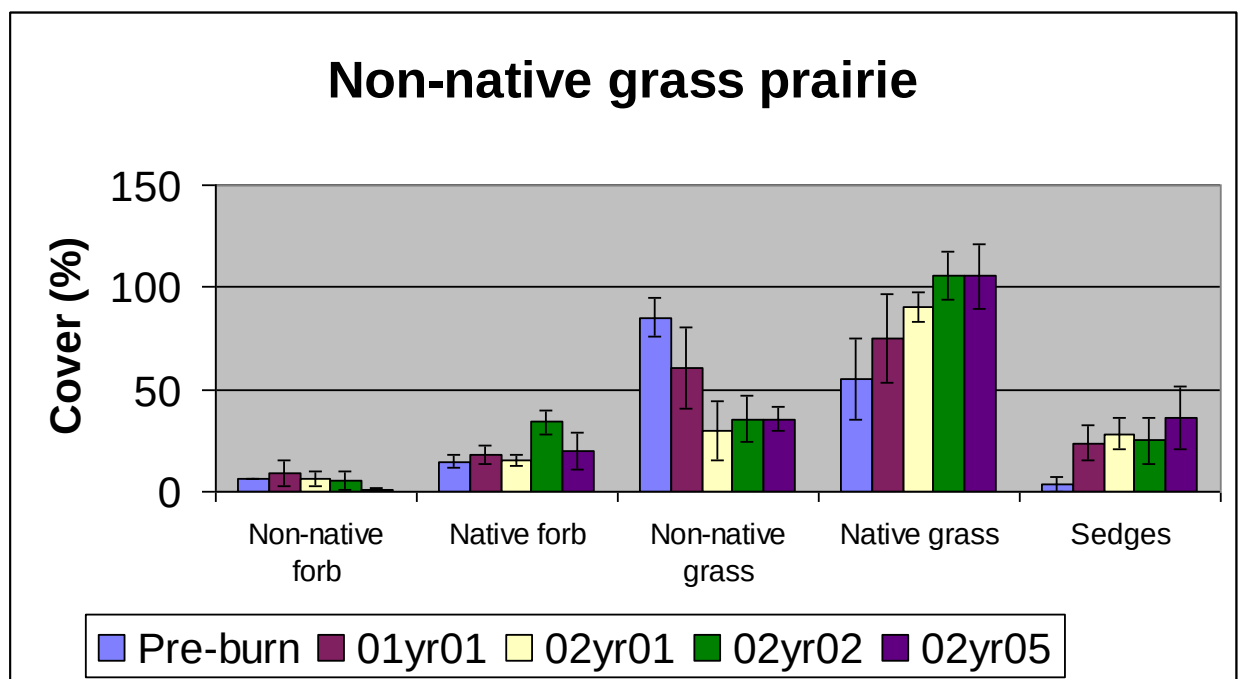
Immediate Post-burn

- Burn at least 60% of the burnable project area.
- Reduce herbaceous fuel loading by at least 30%.

Two Years Post-burn

- Reduce relative cover of non-native grasses by at least 20%.
- Increase relative cover of native grasses by at least 10%.
- Increase relative cover of native forbs by at least 20%.

Three plots have been installed in Kentucky bluegrass dominated grasslands. All of these plots have burned twice and were visited 5 years post-burn. Native grasses and sedges have shown significant increases in cover following two burns while non-native grasses and non-native forbs have significantly decreased. Data from the three plots have been summarized in the following two figures and tables.



NON-NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	6.0	5.3	-11%	1.0	-83%
Native Forb	14.7	34.0	132%	19.7	34%
<i>Non-native Grass</i>	85.3	35.3	-59%	35.7	-58%
Native Grass	55.3	105.7	91%	105.3	90%
Sedges	3.7	25.0	582%	36.3	891%

Ponderosa pine forest

Prescribed Fire Objectives

Immediate Post Burn

- Reduce dead and down fuel loading by 30-70%
- Burn 80-100% of the project area

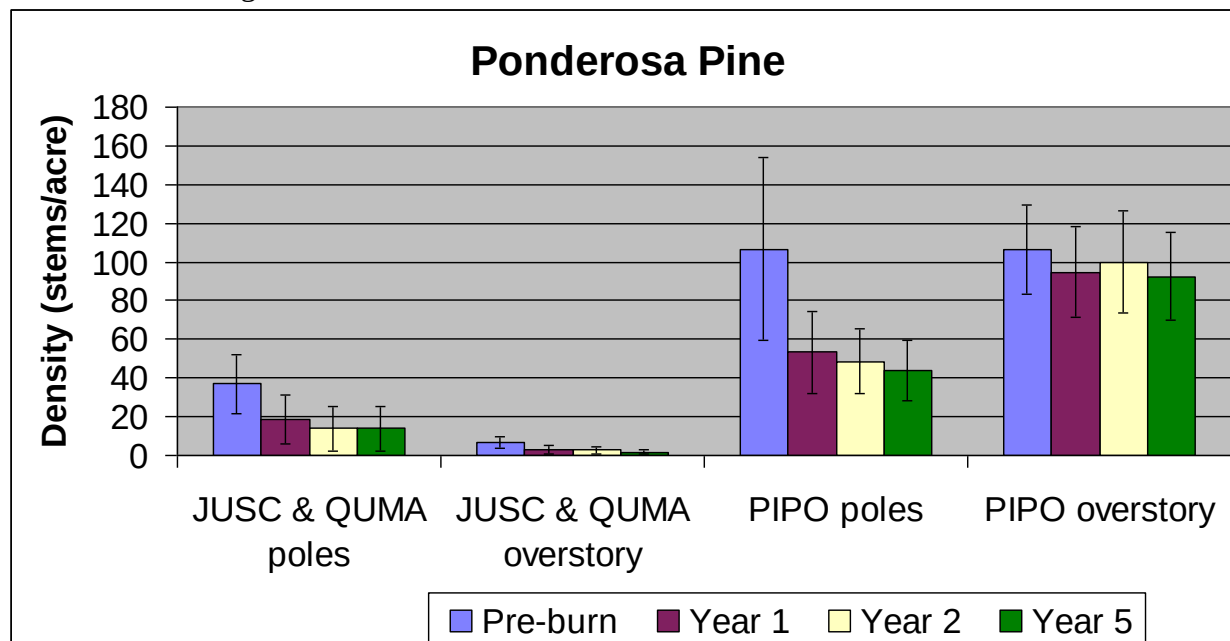
One Year Post Burn

- Reduce cover of non-native grasses by 30 to 50%
- Increase cover of native grasses cover by 10 to 25%
- Increase cover of native forb cover by 10 to 25%

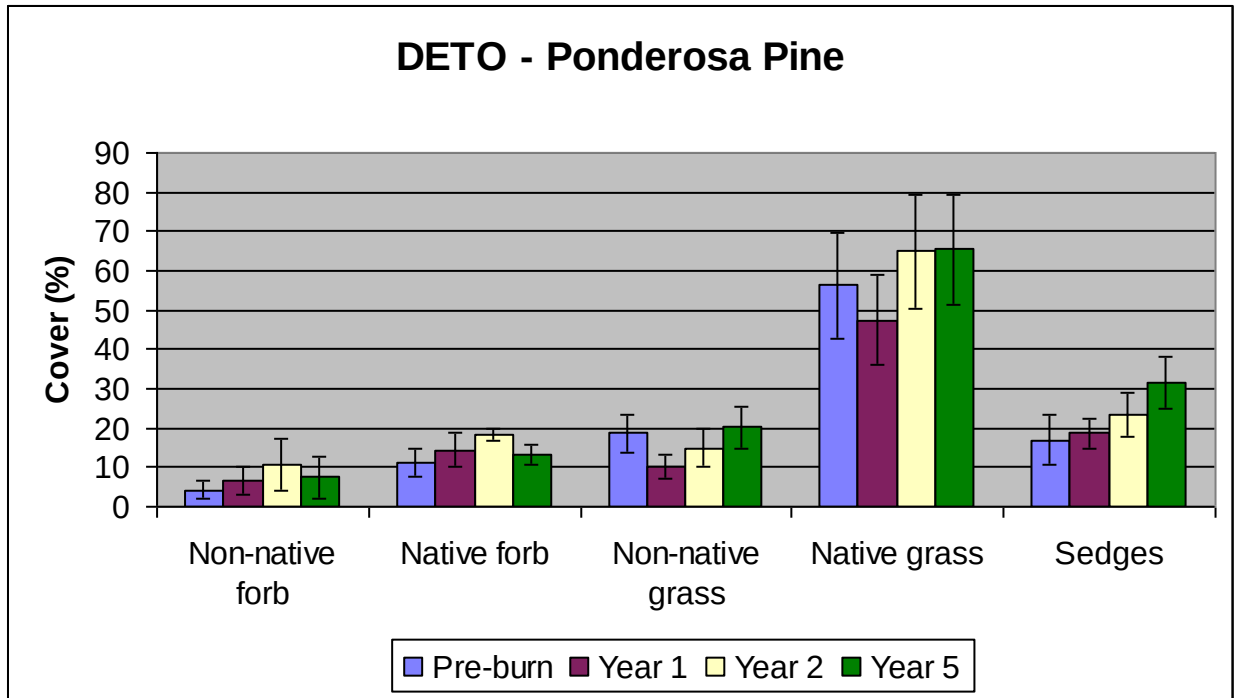
Five Year Post Burn

- Maintain 30% reduction of non-native grass cover.
- Maintain increase cover of native grass and forbs.

Seven FMH tree plots have been installed at DETO and all of these plots have burned in prescribed fires. Data from these plots were used in the summary of overstory trees, poles trees, and herbaceous vegetation.

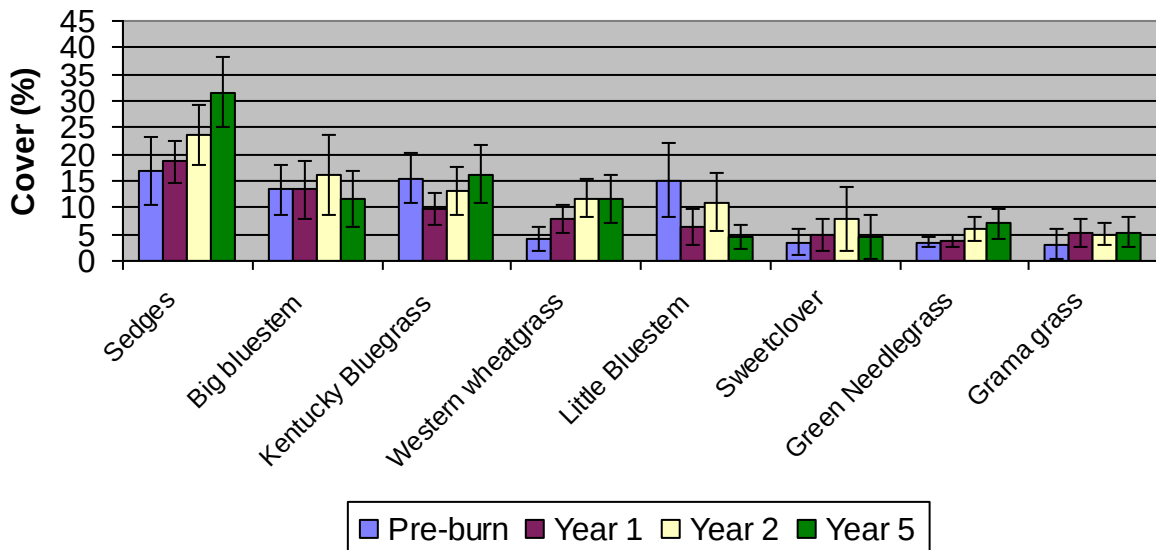


PONDEROSA PINE					
stems/acre	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Ponderosa Pine Poles	106.4	48.6	-54%	43.9	-59%
Ponderosa Pine Overstory	106.4	100.0	-6%	92.5	-13%
Juniper & Oak Poles	37.0	13.9	-63%	13.9	-63%
Juniper & Oak Overstory	6.9	2.9	-58%	1.7	-75%



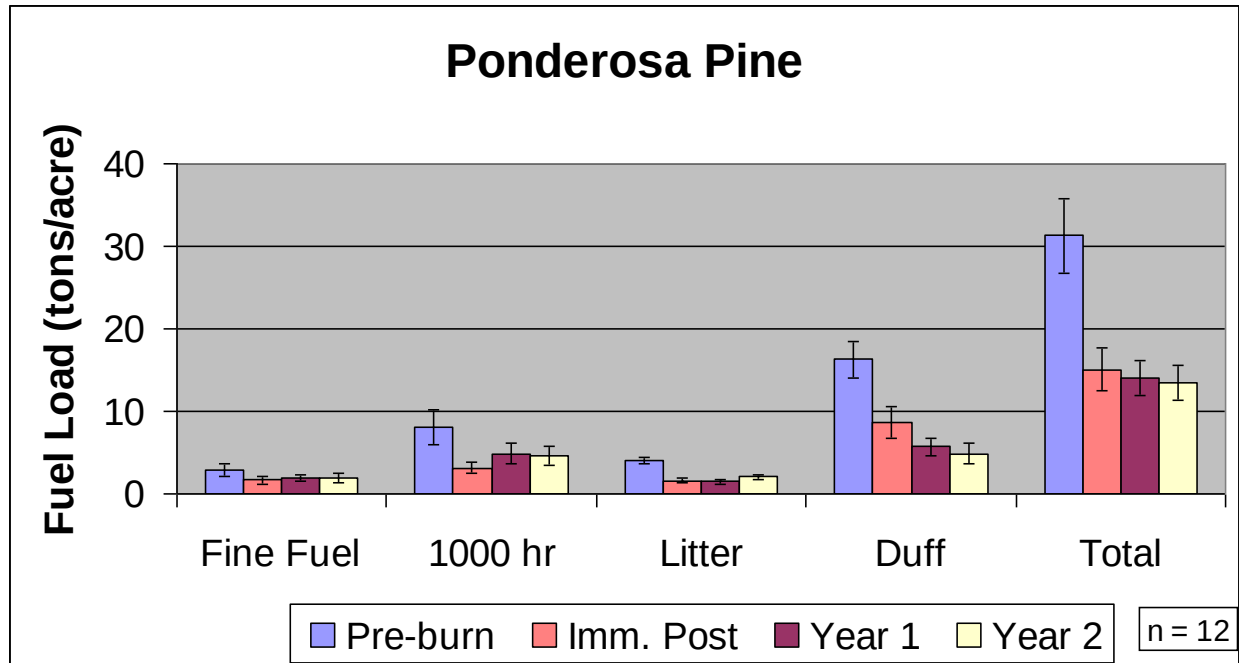
PONDEROSA PINE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	4.2	10.6	151%	7.4	76%
<i>Native Forb</i>	11.2	18.3	64%	13.2	18%
<i>Non-native Grass</i>	18.7	15.0	-20%	20.3	9%
<i>Native Grass</i>	56.2	64.9	15%	65.4	16%
<i>Sedges</i>	17.0	23.5	39%	31.7	87%

DETO- Ponderosa Pine



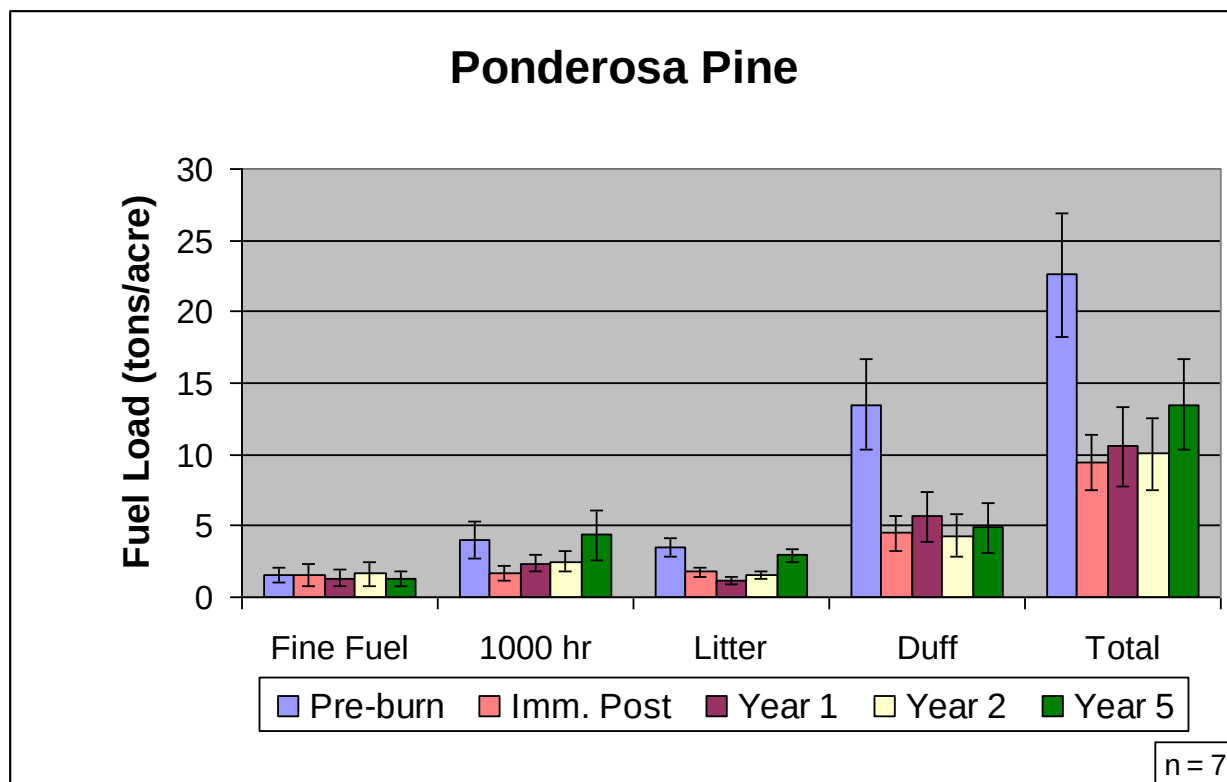
PONDEROSA PINE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Sedges	17.0	23.5	39%	31.7	87%
Big bluestem	13.3	16.1	21%	11.5	-14%
Kentucky bluegrass	15.5	13.1	-16%	16.2	4%
Western wheatgrass	4.2	11.8	180%	11.7	178%
Little bluestem	15.1	11.0	-27%	4.5	-70%
Sweetclover	3.5	7.7	120%	4.5	27%
Green needlegrass	3.5	6.0	71%	7.0	98%
Grama grass	3.2	5.0	57%	5.4	70%





tons/acre	Ponderosa Pine		
	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	11.0	6.8	-38%
Litter & Duff	20.3	7.2	-65%
Total	31.3	14.0	-55%

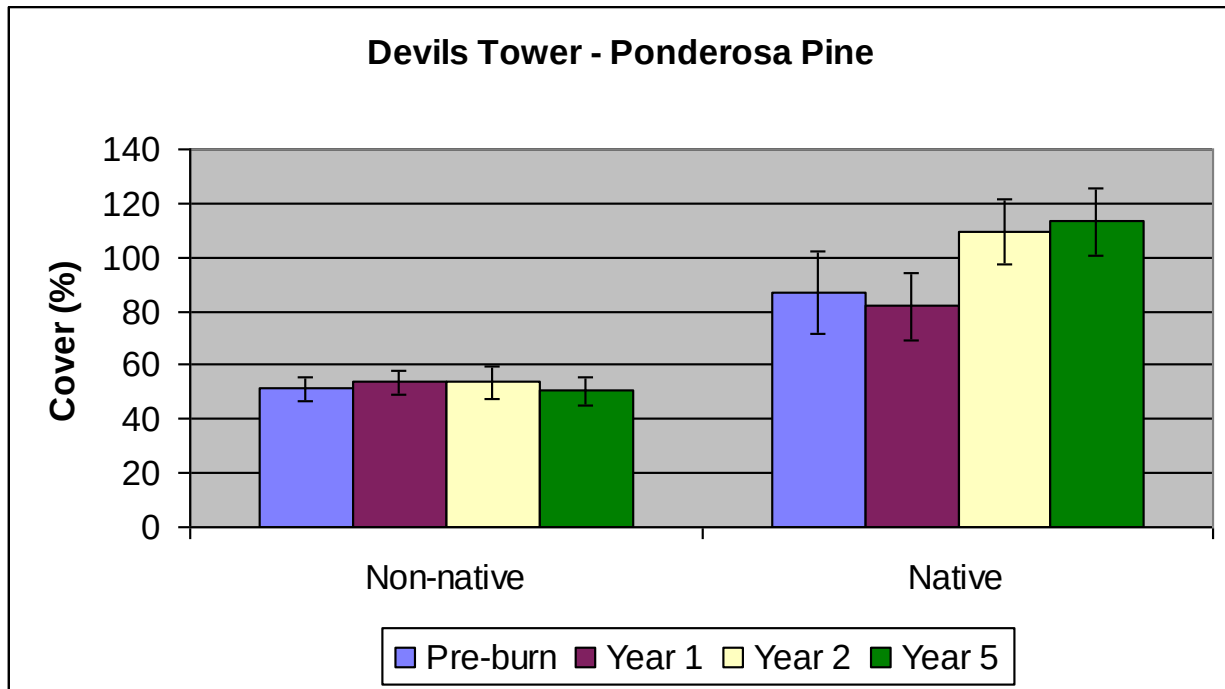




PONDEROSA PINE					
	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	5.6	3.7	-34%	5.7	2%
Litter & Duff	17.0	6.8	-60%	7.8	-54%
Total	22.6	10.5	-54%	13.5	-40%

Park-wide Summary

Twenty-four plots have been installed at DETO with seventeen being FMH. Seven of these plots have been visited five years post-fire.

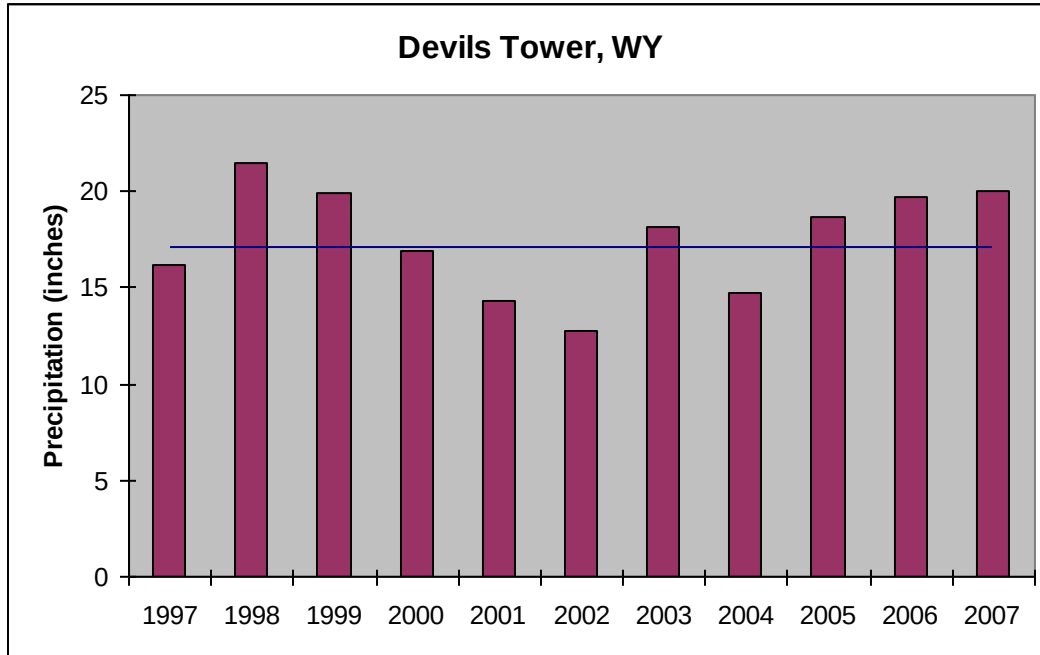


DEVILS TOWER NP					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native</i>	51.1	53.8	5%	50.4	-1%
Native	87.2	109.3	25%	113.1	30%



PRECIPITATION

Precipitation data from Devils Tower Resource Management and the High Plains Regional Climate Center website (<http://www.hprcc.unl.edu/data/historical/>).



KNIFE RIVER INDIAN VILLAGES NATIONAL HISTORIC SITE

MONITORING UNITS

Green ash/boxelder woodland (FRPE)

Woodlands composed of mixed age stands of green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), American elm (*Ulmus americana*), and peach-leaf willow (*Salix amygdaloides*). Herbaceous ground cover dominated by non-native forbs and grasses including stinging nettle (*Urtica dioica*), Virginia wildrye (*Elymus virginicus*), and smooth brome (*Bromus inermis*). Other forbs and grasses include catnip (*Nepeta cataria*), dames rocket (*Hesperis matronalis*), bedstraw (*Galium boreale*), and pellitory (*Parietaria pennsylvanica*).

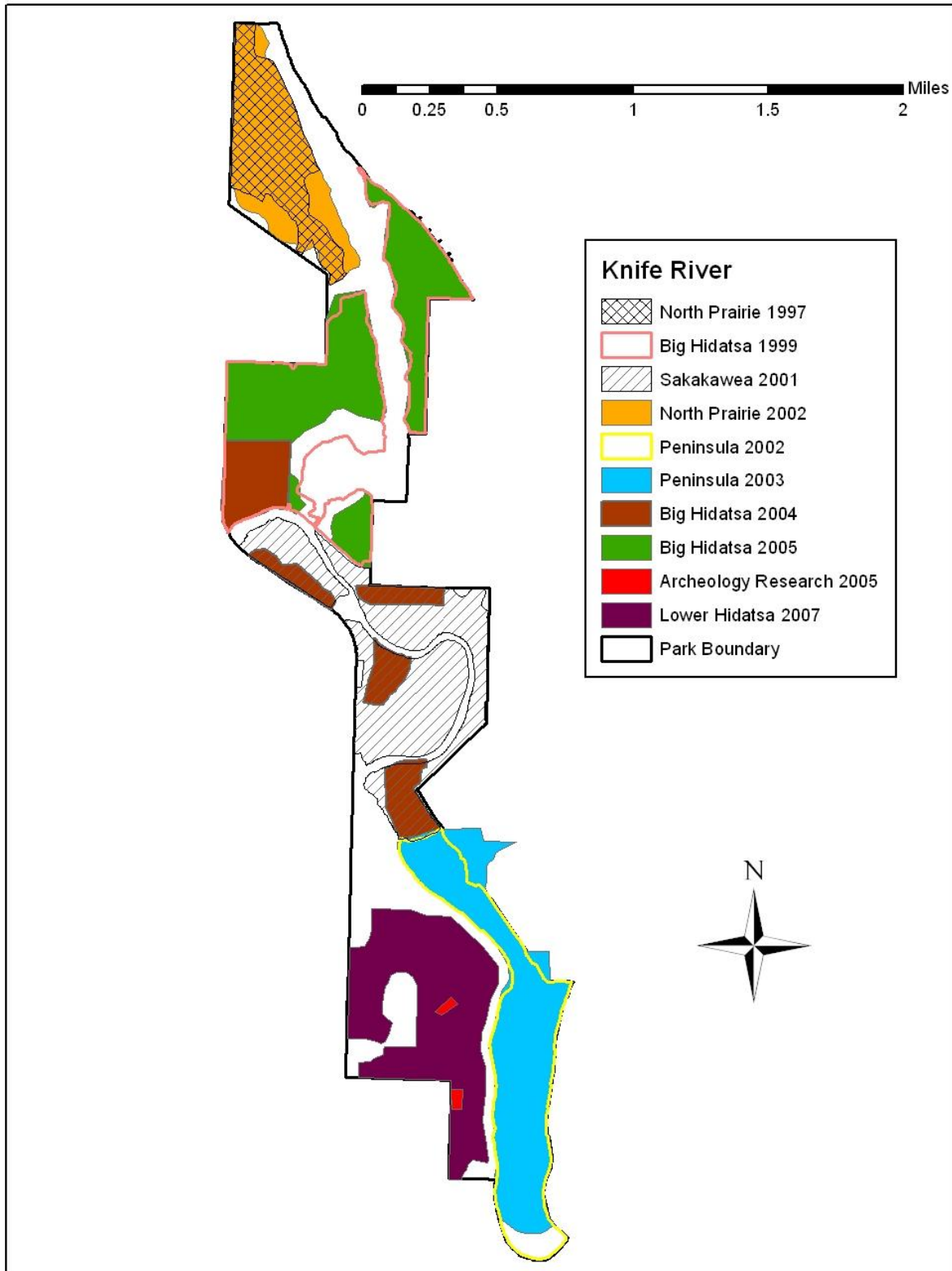
Needle-and-thread/sedge mixed-grass prairie (STCO)

A mixed-grass prairie dominated by needle-and-thread (*Hesperostipa comata*) and threadleaf sedge (*Carex filifolia*). Other common grasses species are blue grama (*Bouteloua gracilis*), and western wheatgrass (*Pascopyrum smithii*). Forbs include fringed sage (*Artemisia frigida*) and yellow owl's-clover (*Orthocarpus luteus*).

PRESCRIBED FIRES

Burn Unit	Date(s)	Season	Size
North Prairie	10/17/97	Fall	106
Big Hidatsa	9/23/99	Fall	406
Sakakawea	10/23/01	Fall	252
North Prairie	9/19/02	Fall	178
Peninsula	5/12/02	Spring	260
Peninsula	4/29/03	Spring	300
Big Hidatsa 04	5/4/04	Spring	116
Big Hidatsa 05	4/28 & 4/29/05	Spring	216
Artifact Research	4/28 & 9/28/05	Both	2
Lower Hidatsa	4/25/07	Spring	250

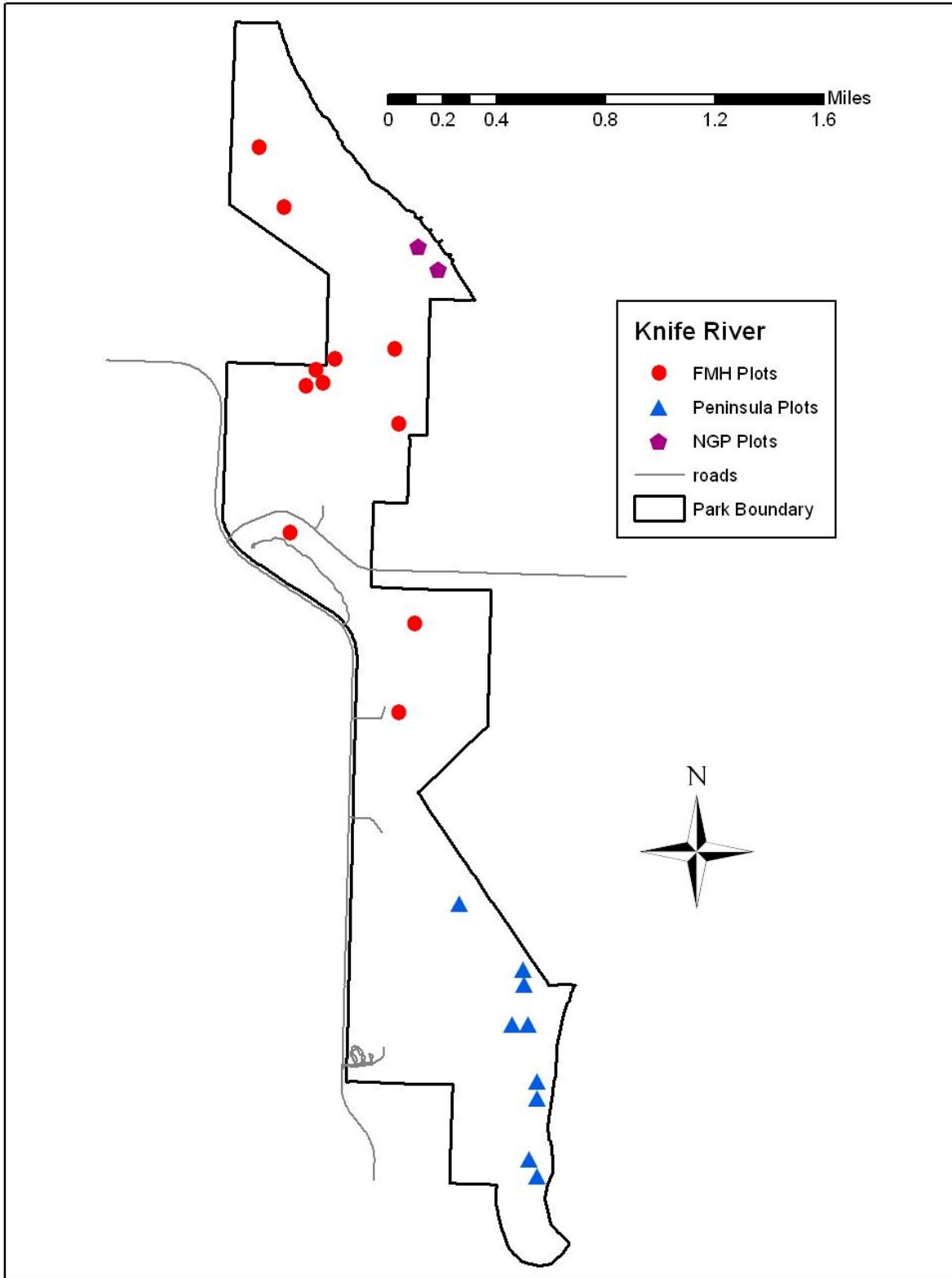




MONITORING PLOTS

Burn Unit	Monitoring Type	Plot ID	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Big Hidatsa	Green Ash	FRPE-01		V									
Sakakawea	Green Ash	FRPE-02			V		V/B	V	V			B/V	V
Big Hidatsa	Green Ash	FRPE-03			V								
Sakakawea	Green Ash	FRPE-04			V		V/B	V	V			V	
Sakakawea	Green Ash	FRPE-05			V		V/B	V	V			V	
Boneyard	Photo Point	PP1							V				
North Prairie	Needlegrass	STCO-01	V		V			V/B	V	V			V
North Prairie	Needlegrass	STCO-02	V/B	V	V			V/B	V	V			V
Big Hidatsa	Needlegrass	STCO-03		V	B/V	V	V			V	B/V	V	
Big Hidatsa	Needlegrass	STCO-04		V	B/V	V	V			V	B/V	V	
Big Hidatsa	Needlegrass	STCO-05		V	B/V	V	V			V	B/V	V	
Big Hidatsa	Needlegrass	STCO-06		V	B/V	V	V			V	B/V	V	
Restoration	restoration grassland										V	V	
Peninsula	Smooth Brome	Rx-01						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-02						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-03						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-04						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-05						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-06						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-07						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-08						B/V	B/V	V			V
Peninsula	Smooth Brome	Rx-09						B/V	B/V	V			V
Lower Hidatsa	Mixed-grass prairie	GFV-1											V
Big Hidatsa East	Mixed-grass prairie	GFV-2											V
Big Hidatsa East	Mixed-grass prairie	GFV-3											V

V = Plot visit; B = Burned

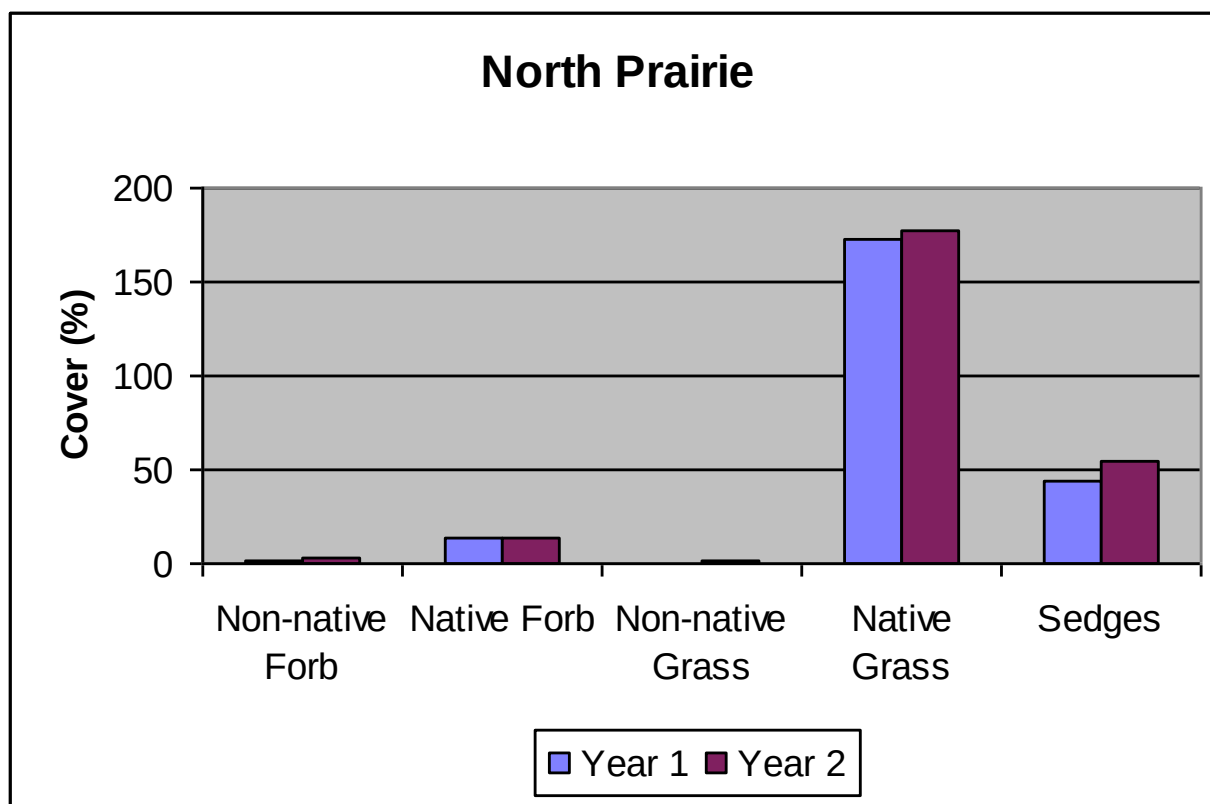


MONITORING RESULTS

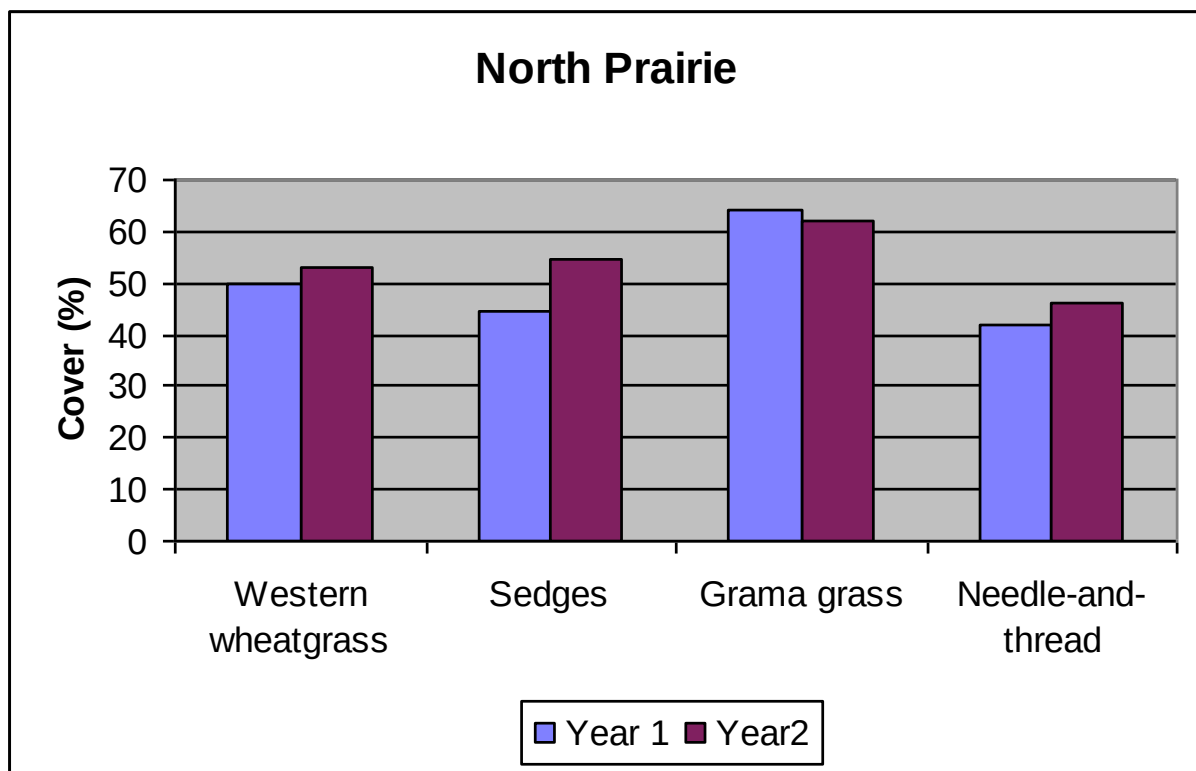
Prescribed Fire Units

North Prairie

Two needle-and-thread/sedge mixed-grass prairie plots were installed in North Prairie. Both plots had data for two growing seasons after the first prescribed burn. Standard error bars are not included because of the small sample size.

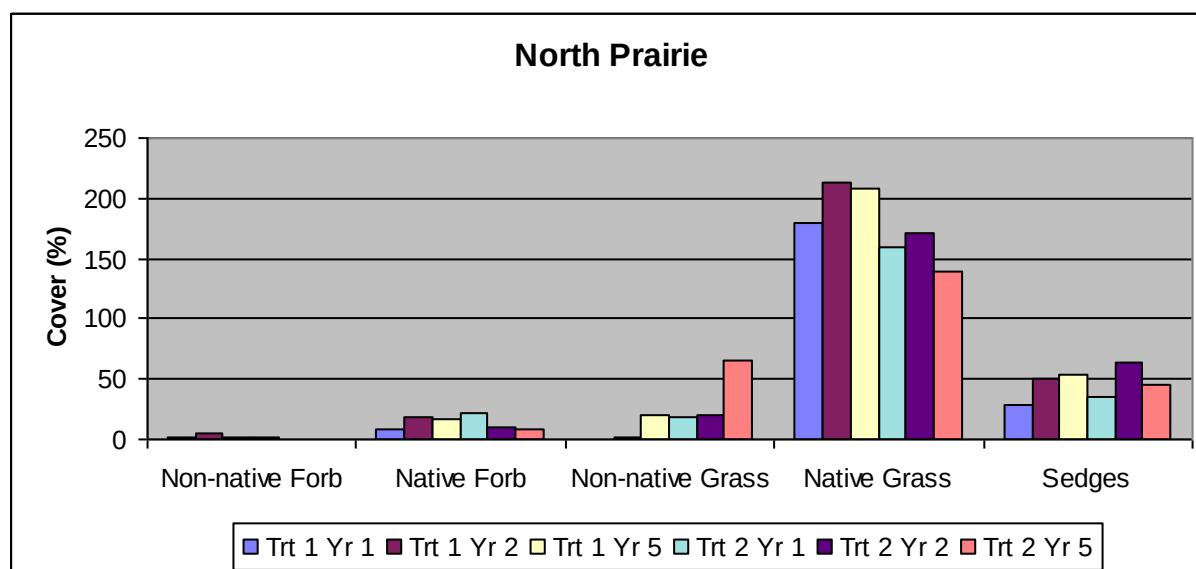


NORTH PRAIRIE			
	Yr 1 Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	1	3	150%
Native Forb	14	14	4%
<i>Non-native Grass</i>	0	1	++
Native Grass	173	178	3%
Sedges	45	55	22%



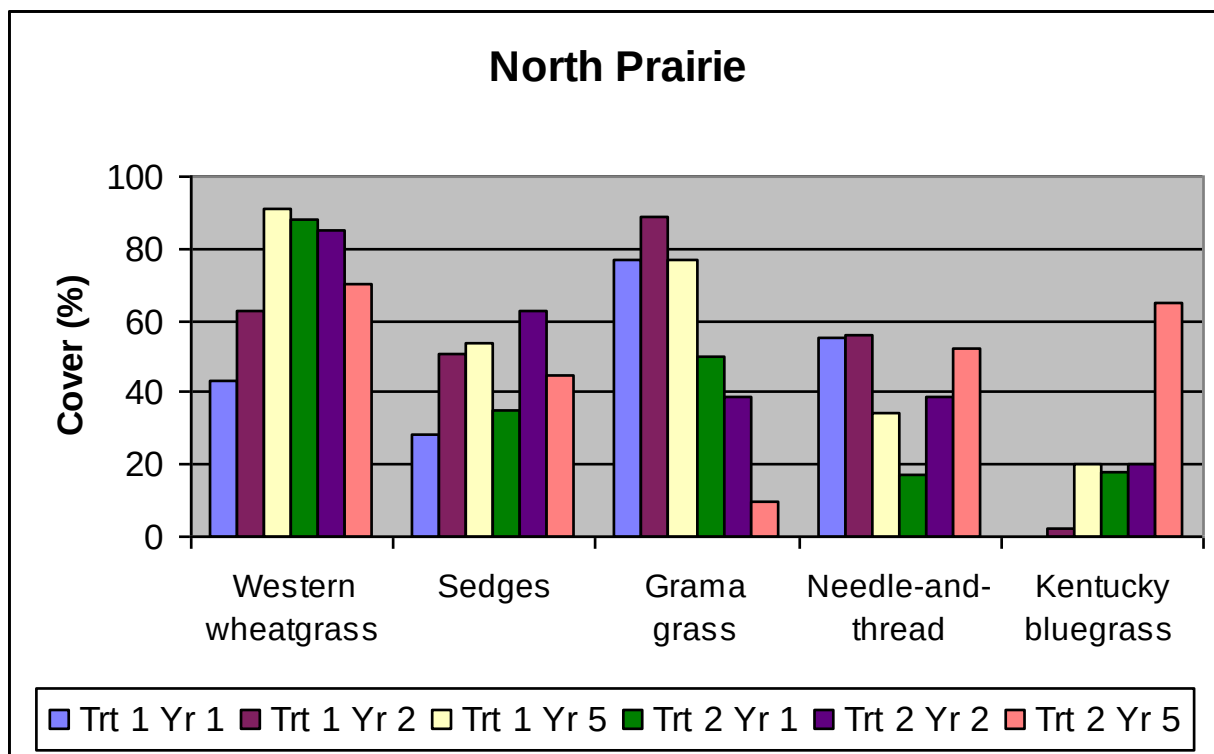
NORTH PRAIRIE			
	Yr 1 Cover	Yr 2 Cover	Change
Western wheatgrass	50	53	6%
Sedges	45	55	22%
Grama grass	64	62	-3%
Needle-and-thread	42	46	10%

One needle-and-thread/sedge mixed-grass prairie plot was read five growing seasons after two prescribed burns. Standard error bars are not included because of the small sample size.



NORTH PRAIRIE					
	Trt 1 Yr 1 Cover	Trt 1Yr 5 Cover	Change	Trt 2Yr 5 Cover	Change
<i>Non-native Forb</i>	1	1	---	0	-100%
Native Forb	9	17	89%	9	---
<i>Non-native Grass</i>	0	20	++	65	++
Native Grass	179	208	16%	140	-22%
Sedges	28	54	93%	45	61%

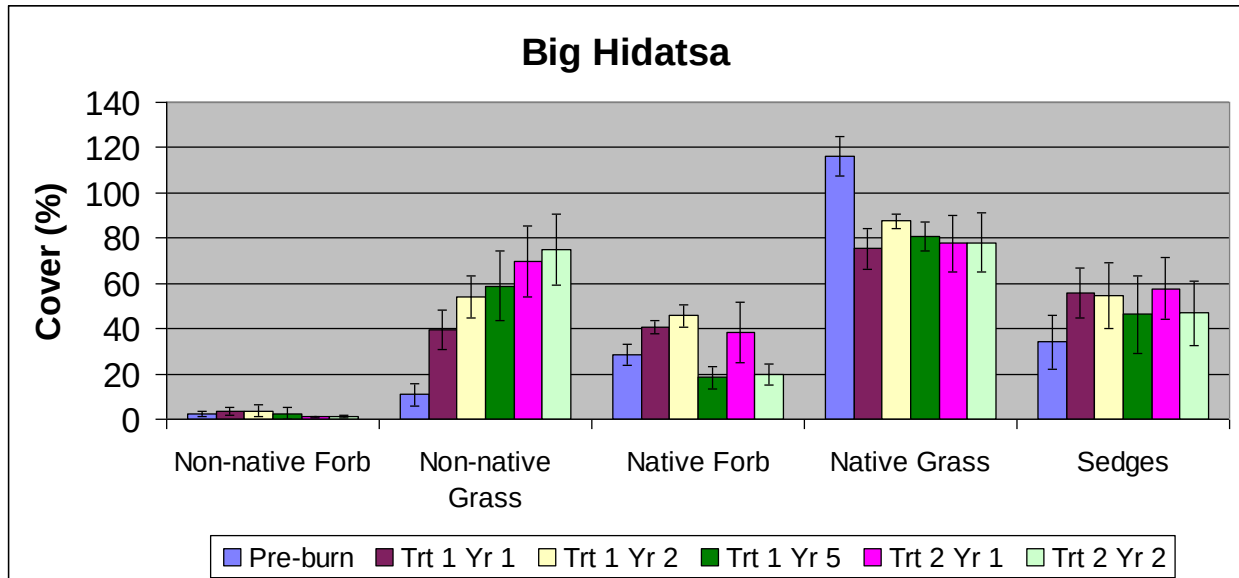




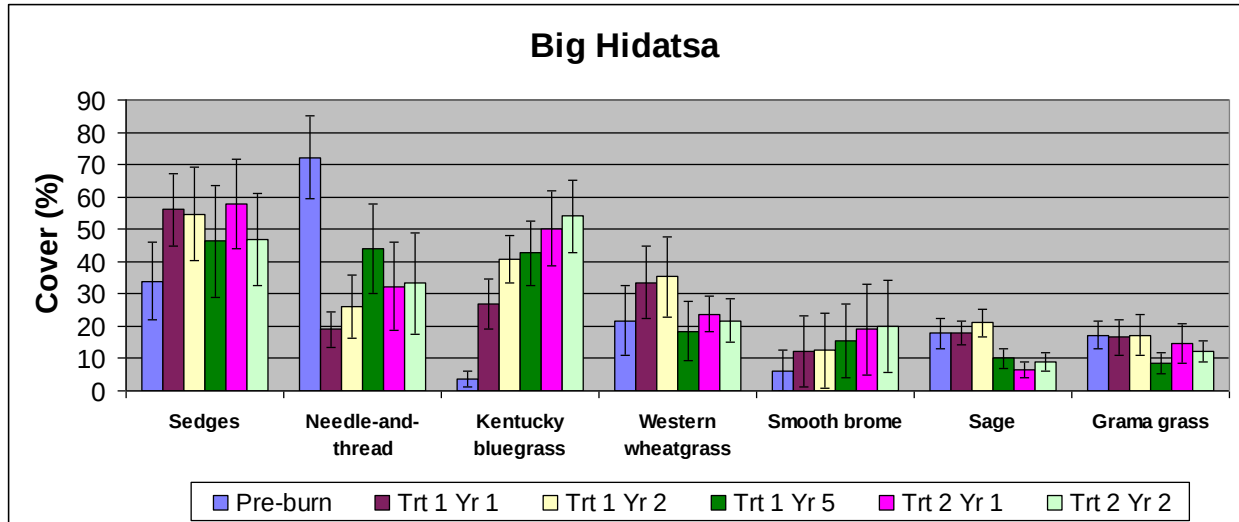
NORTH PRAIRIE					
	Trt 1 Yr 1 Cover	Trt 1Yr 5 Cover	Change	Trt 2Yr 5 Cover	Change
Western wheatgrass	43	91	112%	70	63%
Sedges	28	54	93%	45	61%
Grama grass	77	77	0%	10	-87%
Needle-and-thread	55	34	-38%	52	-5%
Kentucky bluegrass	0	20	++	65	++

Big Hidatsa

Four needle-and-thread/sedge mixed-grass prairie plots were installed in Big Hidatsa. Summary includes data for five growing seasons after two prescribed burns.



BIG HIDATSA					
	Pre-burn Cover	Trt 1Yr 5 Cover	Change	Trt 2Yr 2 Cover	Change
<i>Non-native Forb</i>	2.3	2.5	11%	1.0	-56%
<i>Native Forb</i>	28.5	18.5	-35%	19.5	-32%
<i>Non-native Grass</i>	10.8	58.8	447%	75.0	598%
<i>Native Grass</i>	116.3	81.0	-30%	78.0	-33%
<i>Sedges</i>	34.0	46.3	36%	47.0	38%

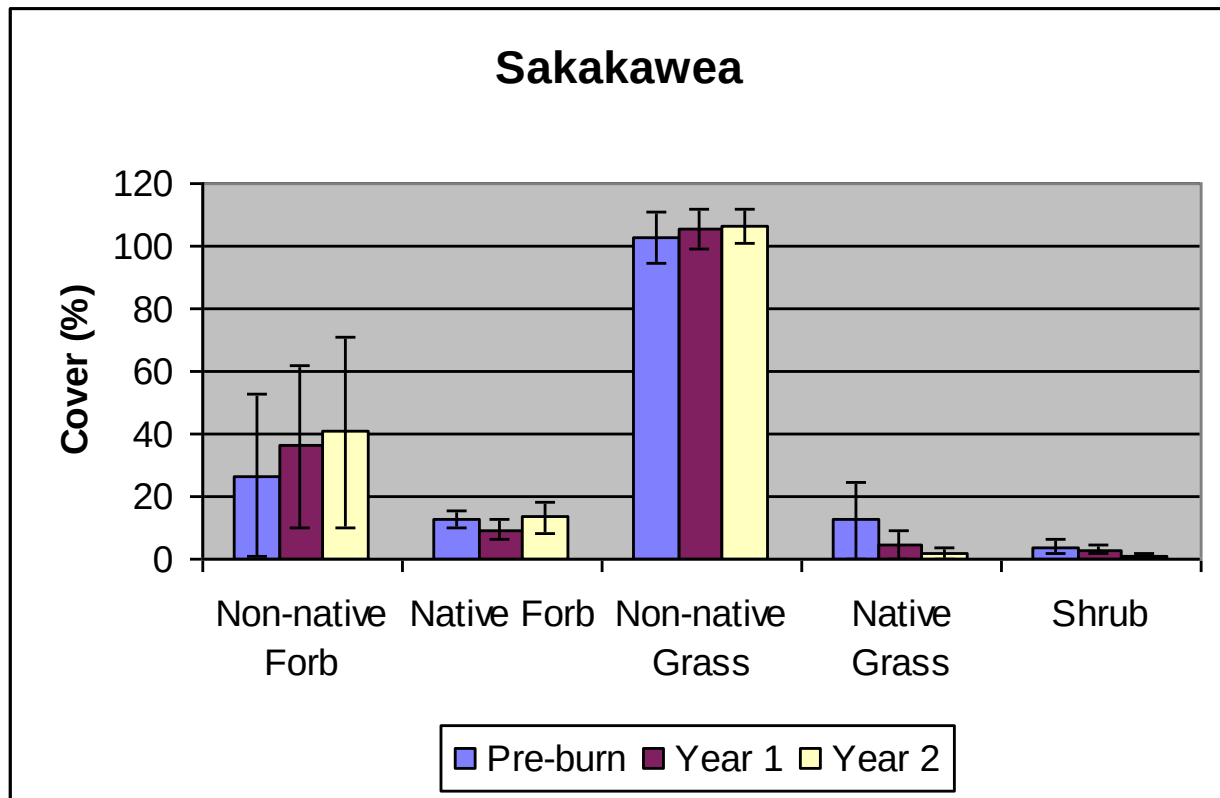


BIG HIDATSA					
	Pre-burn Cover	Trt 1Yr 5 Cover	Change	Trt 2Yr 2 Cover	Change
Sedges	34.0	46.3	36%	47.0	38%
Needle-and-thread	72.3	44.0	-39%	33.3	-54%
Kentucky bluegrass	3.8	42.8	1040%	54.0	1340%
Western wheatgrass	21.8	18.5	-15%	21.8	--
Smooth brome	6.3	15.5	148%	20.0	220%
Sage	17.8	10.0	-44%	9.0	-49%
Grama grass	17.3	8.5	-51%	12.3	-29%

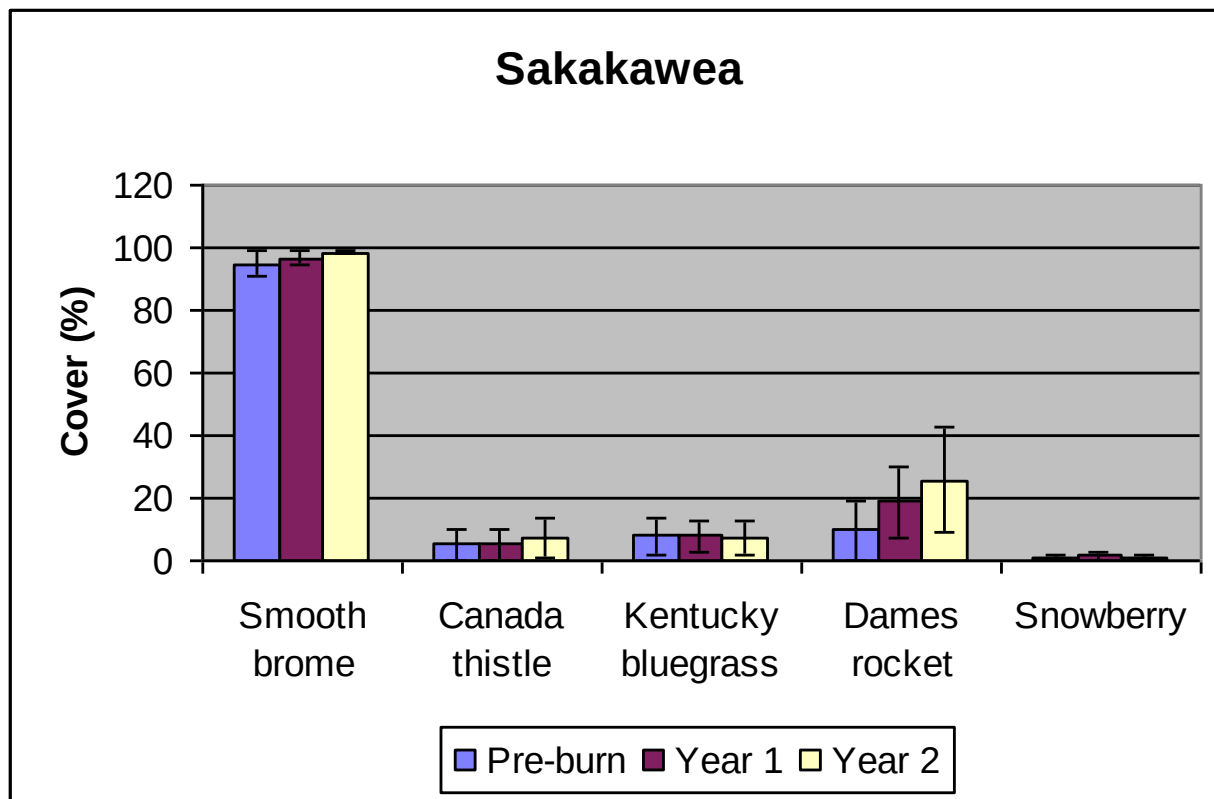


Sakakawea

Three green ash/boxelder woodland plots were installed in Sakakawea. Summary includes data following two growing seasons after one prescribed burn.

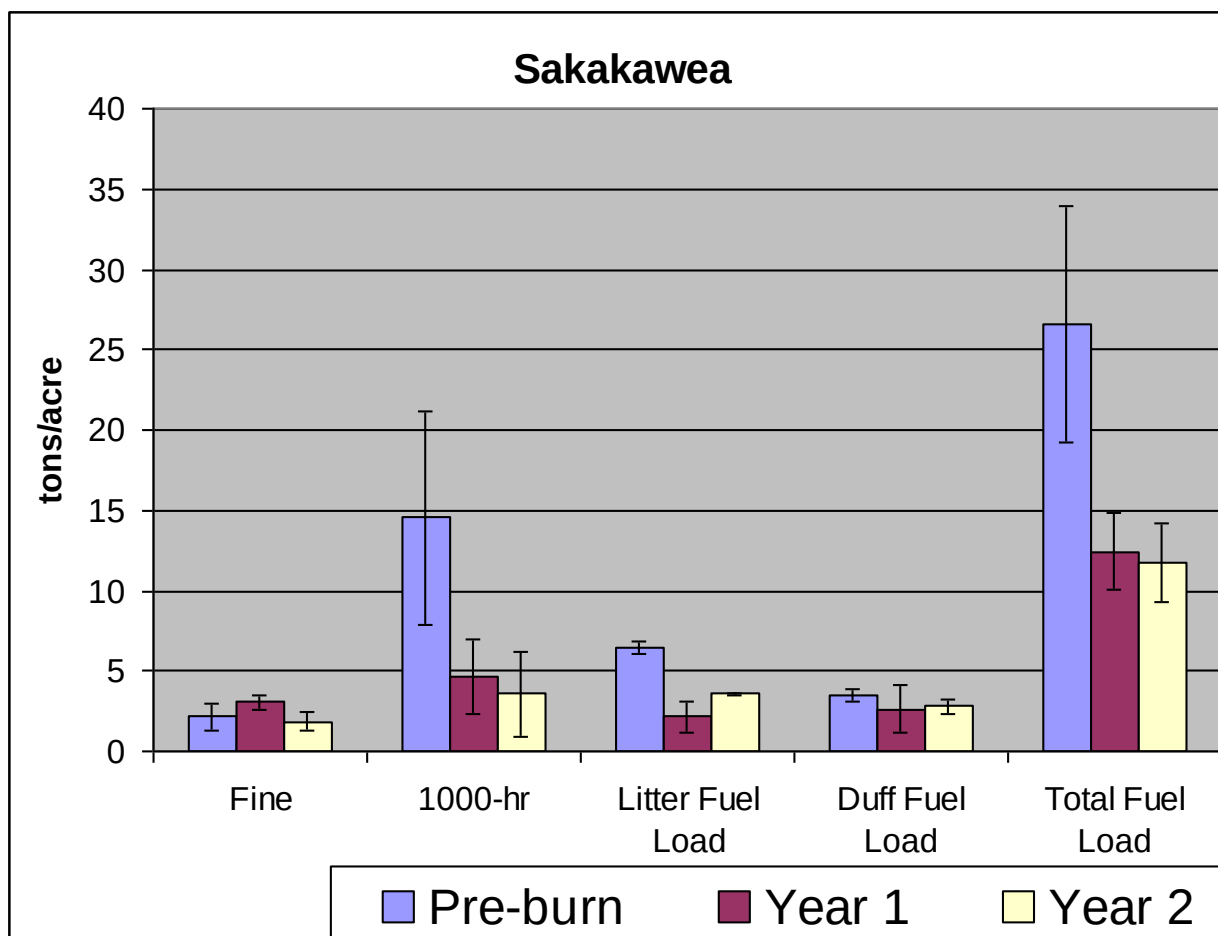


SAKAKAWEA			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	26.5	40.8	54%
Native Forb	12.9	13.3	3%
<i>Non-native Grass</i>	102.8	106.0	3%
Native Grass	12.4	2.0	-84%



SAKAKAWEA			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Smooth brome</i>	94.8	98.6	4%
<i>Canada thistle</i>	5.0	7.2	44%
<i>Kentucky bluegrass</i>	7.8	7.4	-5%
<i>Dames rocket</i>	9.6	25.7	167%
<i>Snowberry</i>	1.2	0.8	-33%





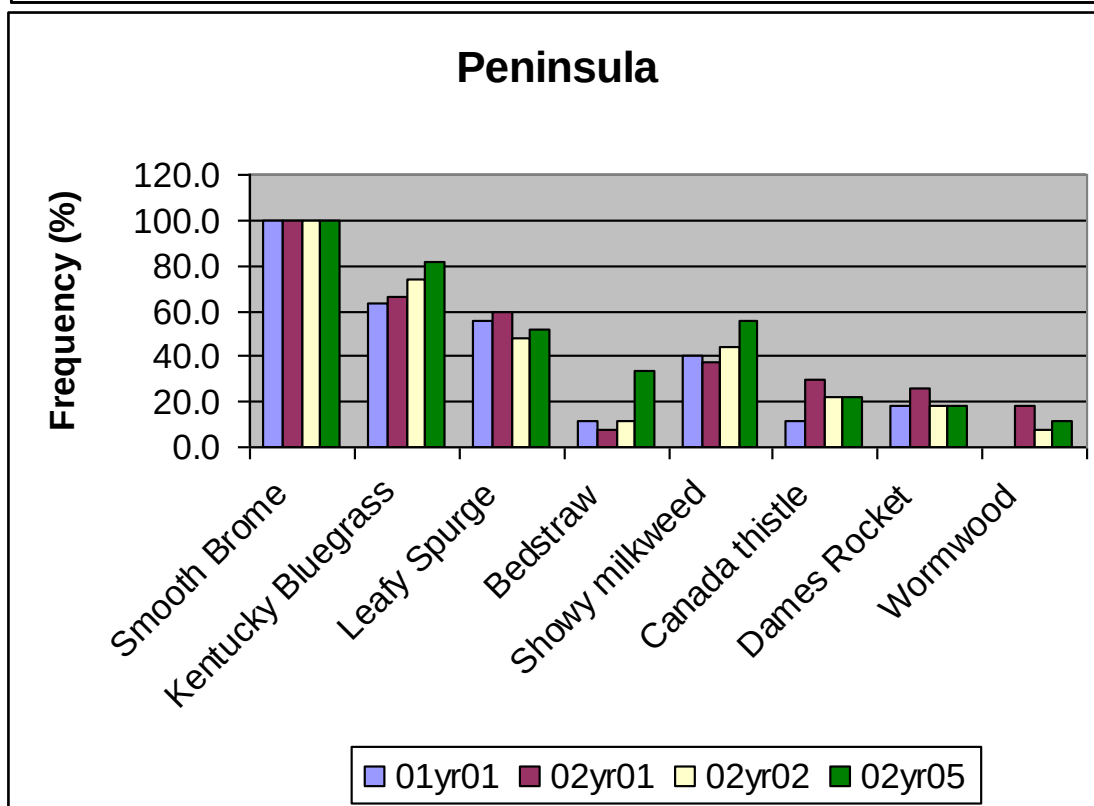
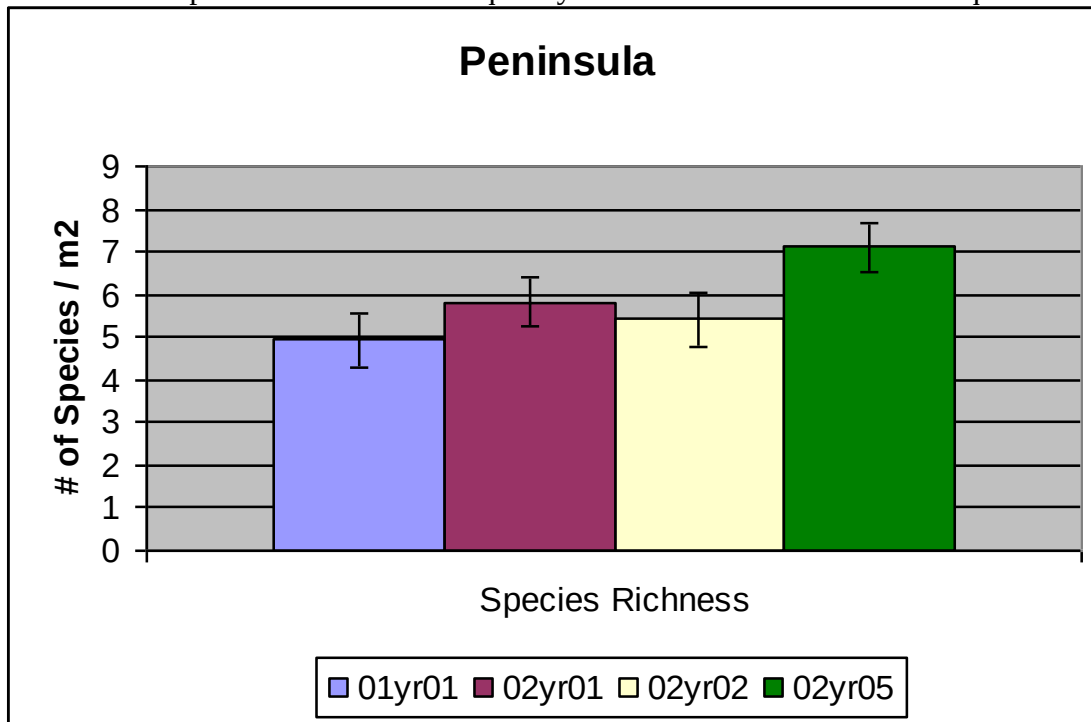
SAKAKAWEA			
tons/acre	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	16.7	7.6	-54%
Litter & Duff	10.0	4.7	-53%
Total	26.6	12.4	-53%

Pole and overstory density decreased two years after one prescribed burn.

SAKAKAWEA			
stems/acre	Pre-burn Density	Year 2 Density	Change
Poles	91.7	27.0	-71%
Overstory	107.2	86.6	-19%

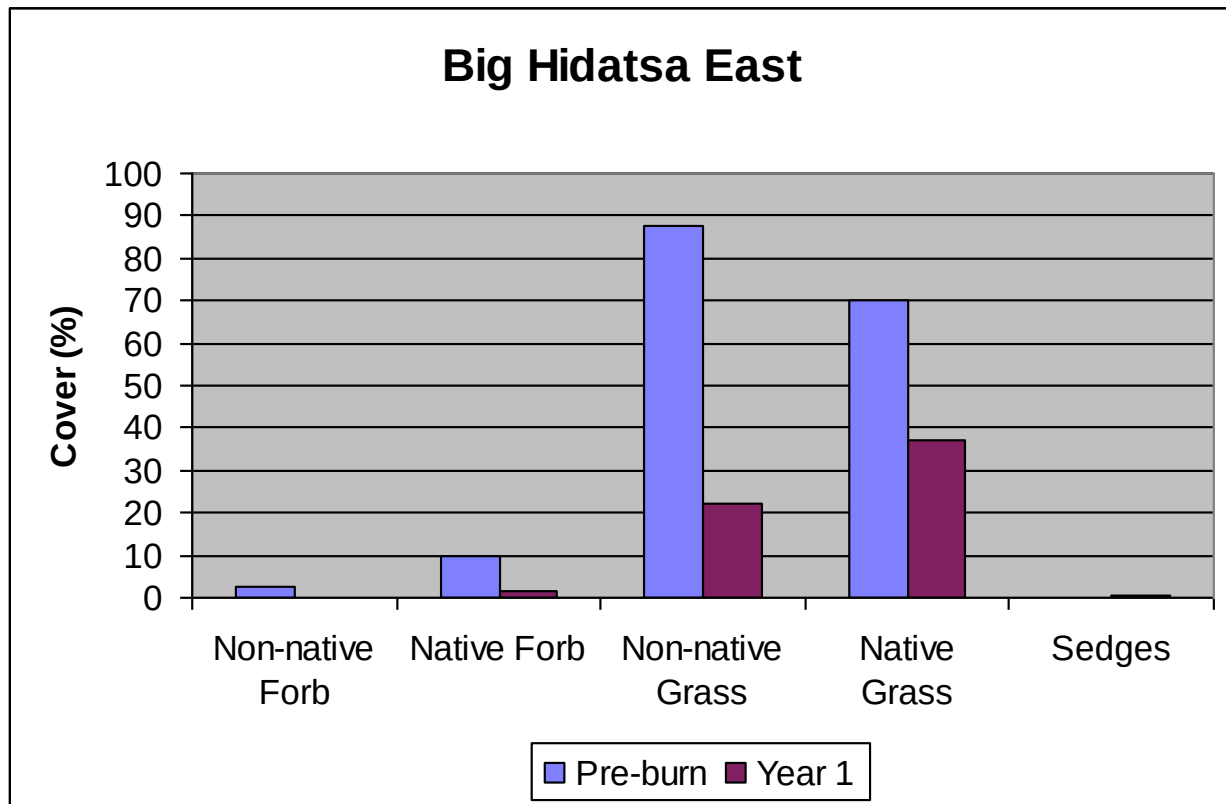
Peninsula

Nine smooth brome nested frequency plots were established within the Peninsula burn unit. Summary data includes one year after first treatment as well as one, two, and five years after second treatment. Species richness and frequency data were used from the 1 m² quadrat.

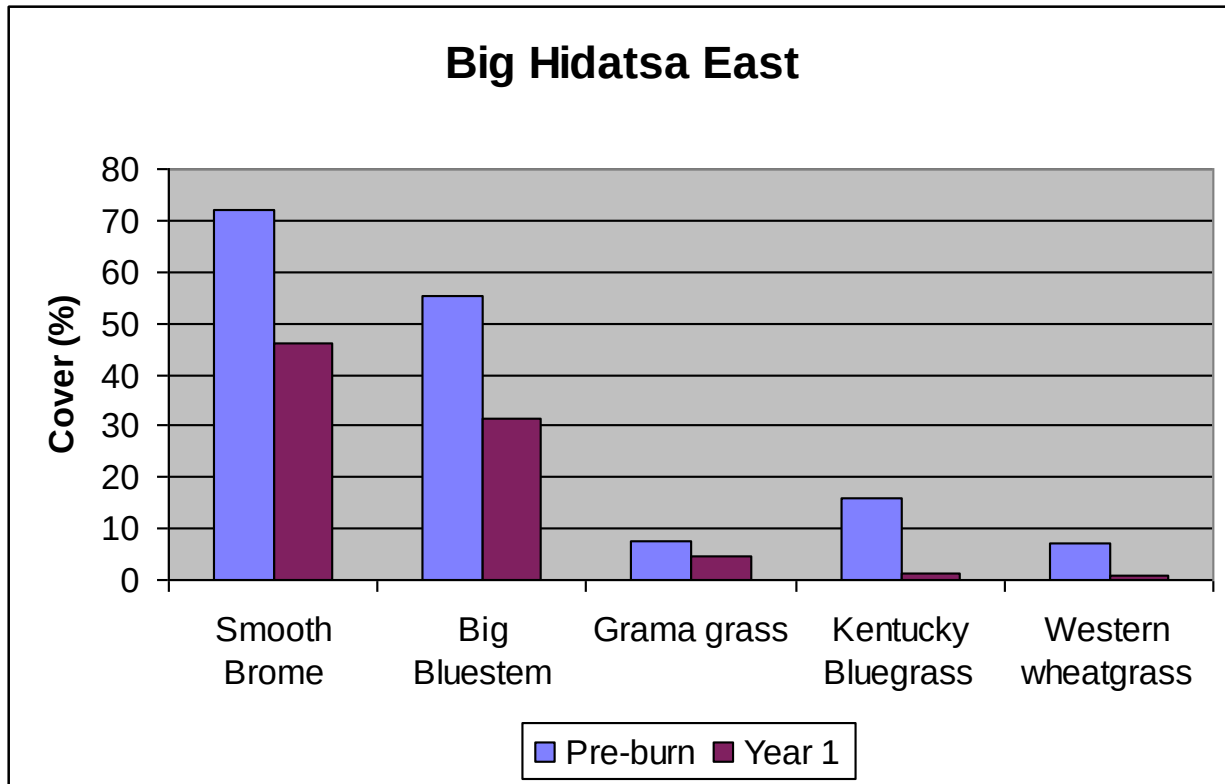


Big Hidatsa East

Two mixed-grass prairie plots were installed in Big Hidatsa East. Summary includes data one growing season after the first prescribed burn.



BIG HIDATSA EAST			
	Pre-burn Cover	Yr 1 Cover	Change
<i>Non-native Forb</i>	2.5	0.0	-100%
Native Forb	10.0	1.5	-85%
<i>Non-native Grass</i>	87.8	22.0	-75%
Native Grass	70.0	37.0	-47%



BIG HIDATSA EAST			
	Pre-burn Cover	Yr 1 Cover	Change
<i>Smooth brome</i>	72.0	46.3	-36%
<i>Big bluestem</i>	55.3	31.3	-43%
<i>Grama grass</i>	7.5	4.8	-37%
<i>Kentucky bluegrass</i>	15.8	1.3	-92%
<i>Western wheatgrass</i>	7.0	1.0	-86%



Monitoring Units

Green ash/boxelder woodland

Prescribed Fire Objectives:

Immediate Post Burn

- Reduce dead and downed woody fuels by 30-50% immediate postburn

Two Years Post Burn

- Limit overstory mortality to 10-20% within 2 years postburn.
- Reduce frequency and relative cover of non-native herbaceous species by 20-30% with each burn cycle.
- Increase the number of seedling and pole-size native deciduous trees.

Five green ash / boxelder plots have been installed in this monitoring type with only three of them having prescribed fire and are located within the Sakakawea burn unit. Graphs and tables of density, fuel loading, and vegetative cover are included on pages 78 – 82 for the Sakakawea burn unit.

Needle-and-thread/sedge mixed-grass prairie

Prescribed Fire Objectives

Immediate Post Burn

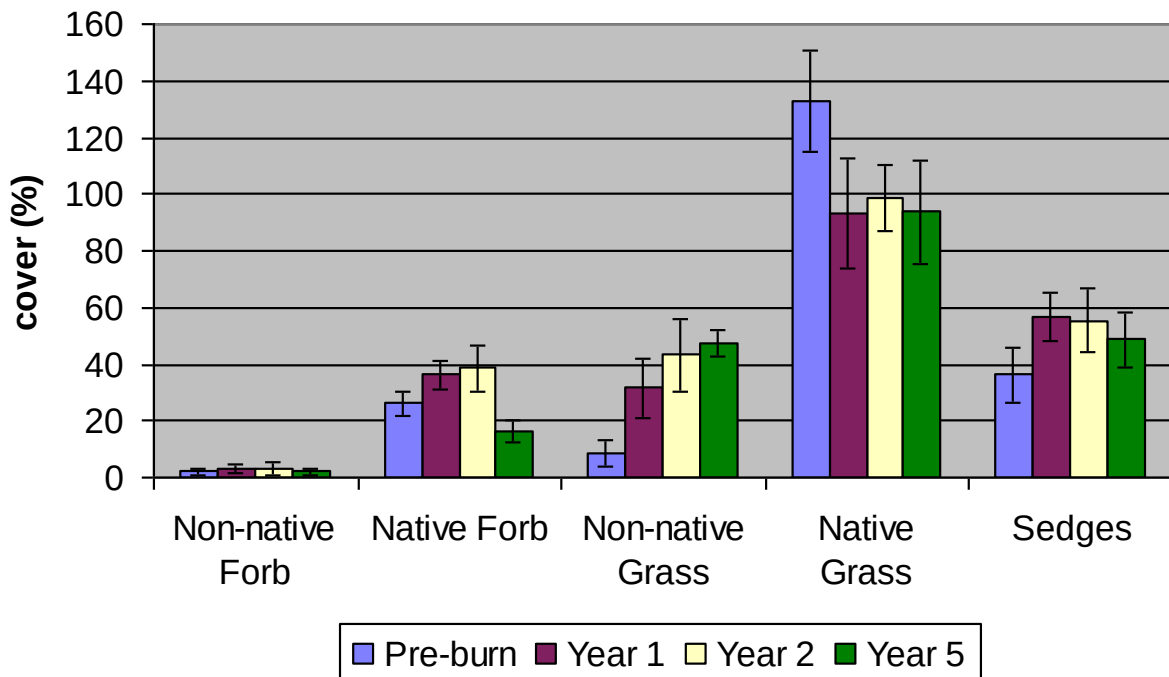
- Reduce thatch and litter layer.
- Reduce total fuel-load by 85%.

Two Year Post Burn

- Increase native perennial grass and forb cover by at least 25%
- Reinvigorate native perennial grasses and forbs.
- Reintroduce fire into the ecosystem

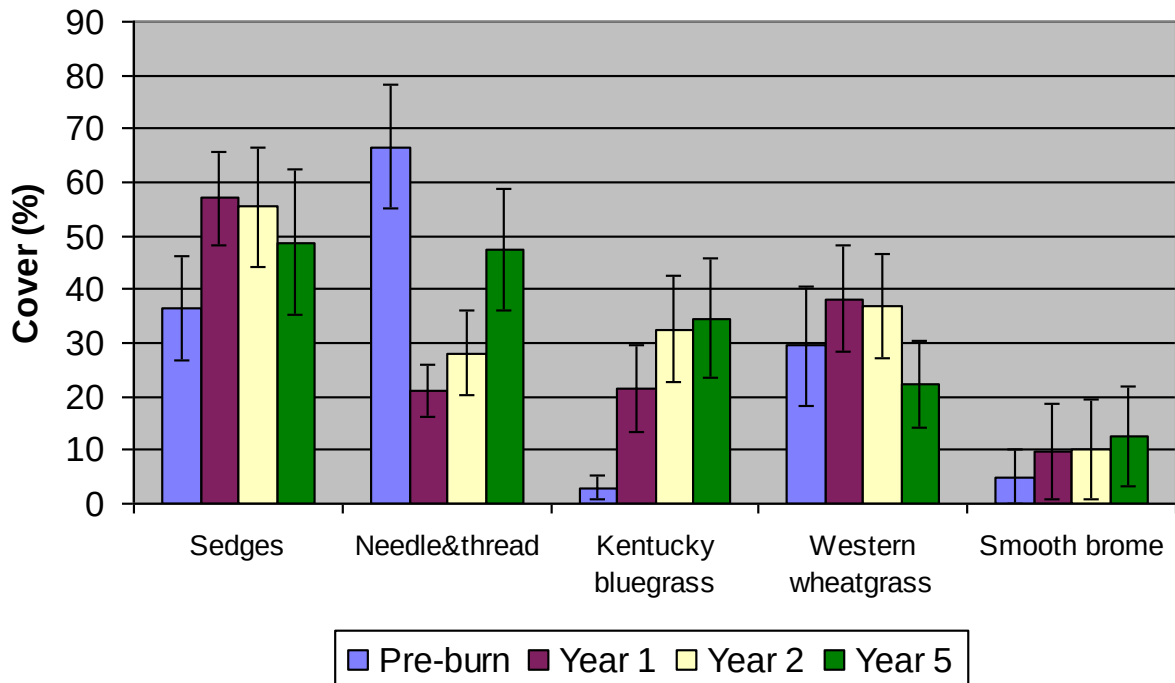
Six needlegrass / sedge mixed-grass prairie FMH plots have been installed at KNRI. Only five of these plots were used in the analysis below since different sampling protocols were used with one of them.

Needlegrass / Sedge Mixed-grass Prairie



NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	2.0	3.0	50%	2.0	--
Native Forb	26.2	38.6	47%	16.4	-37%
<i>Non-native Grass</i>	8.6	43.2	402%	47.4	451%
Native Grass	133.0	98.6	-26%	93.6	-30%
Sedges	36.4	55.4	52%	48.8	34%

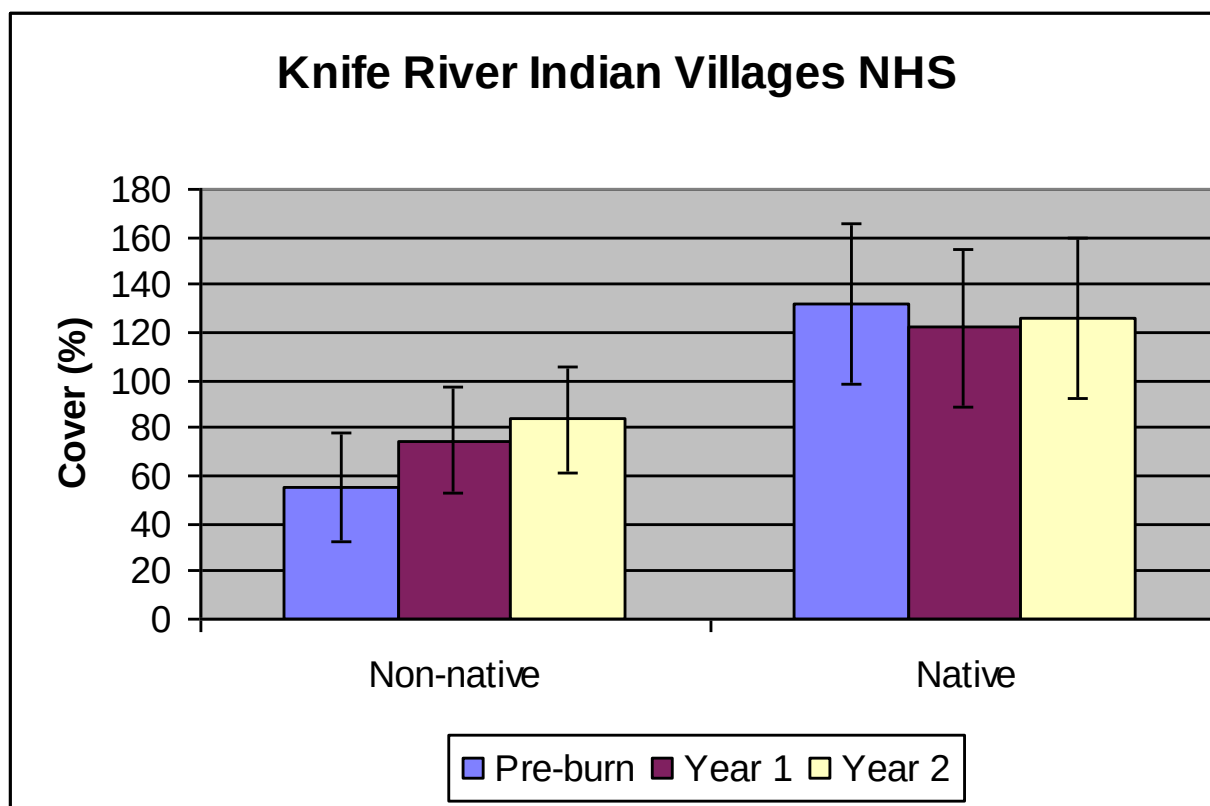
Needlegrass / Sedge Mixed-grass Prairie



NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Sedges	36.4	55.4	52%	48.8	34%
Needle-and-thread	66.6	28.0	-58%	47.4	-29%
Kentucky bluegrass	3.0	32.6	987%	34.6	1053%
Western wheatgrass	29.4	36.8	25%	22.4	-24%
Smooth brome	5.0	10.0	100%	12.4	148%

Park-wide Summary

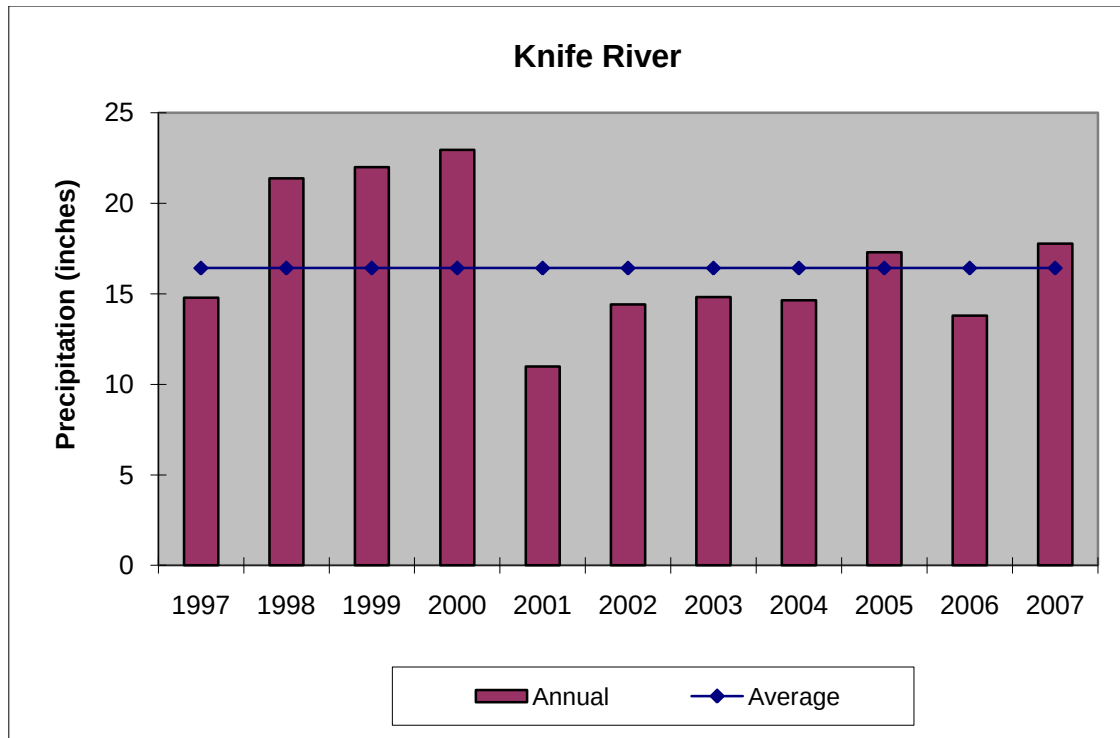
Eleven FMH plots and seventeen non-FMH plots have been installed at Knife River Indian Villages NHS. Of these, twenty have been burned in prescribed fires. Ten of the twenty plots burned in prescribed fires do not have pre-burn data and two plots only have year 1 data so these have been excluded from analysis. Therefore eight plots have been visited two years after fire and the summaries are shown in the figure and table below.



Knife River Indian Villages NHS			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native</i>	55.1	83.9	52%
<i>Native</i>	131.7	126.1	-4%

PRECIPITATION

Data presented is a composite of precipitation amounts from weather stations at Washburn, ND.
Data from the High Plains Regional Climate Center website
(<http://www.hprcc.unl.edu/data/historical/>).





MOUNT RUSHMORE NATIONAL MEMORIAL

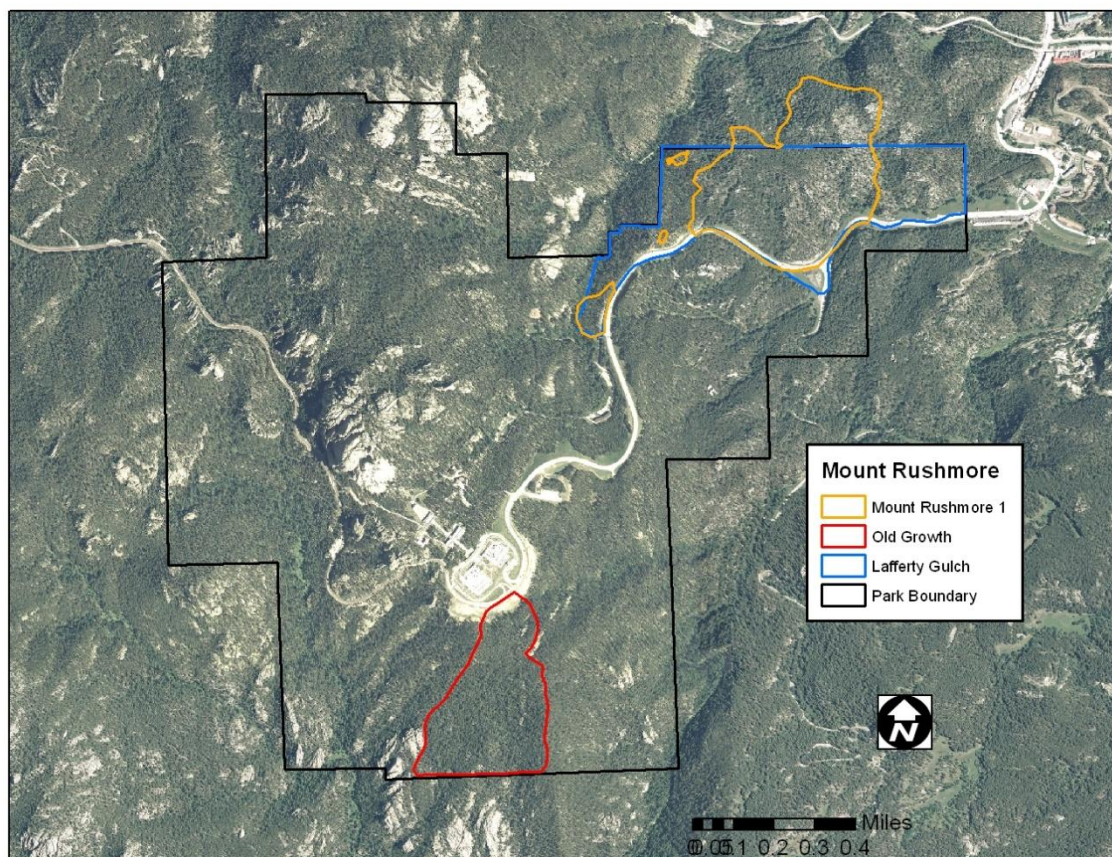
MONITORING UNITS

Ponderosa pine forest (PIPO)

Overstory dominated by ponderosa pine (*Pinus ponderosa*). Other trees include ironwood (*Ostrya virginiana*), bur oak (*Quercus macrocarpa*), paper birch (*Betula papyrifera*), and quaking aspen (*Populus tremuloides*). The most common shrub species is common juniper (*Juniperus communis*), followed by snowberry (*Symphoricarpos occidentalis*), currant (*Ribes* spp.), and chokecherry (*Prunus virginiana*). The understory consists of Kentucky bluegrass (*Poa pratensis*), sedges (*Carex* spp.), Junegrass (*Koeleria macrantha*), rough-leaved ricegrass (*Oryzopsis asperifolia*), bluejoint reedgrass (*Calamagrostis canadensis*), poison ivy (*Toxicodendron radicans*), bearberry (*Arctostaphylos uva-ursi*), harebell (*Campanula rotundifolia*), timothy (*Phleum pratense*), and pinedrops (*Pterospora andromedea*).

TREATMENTS

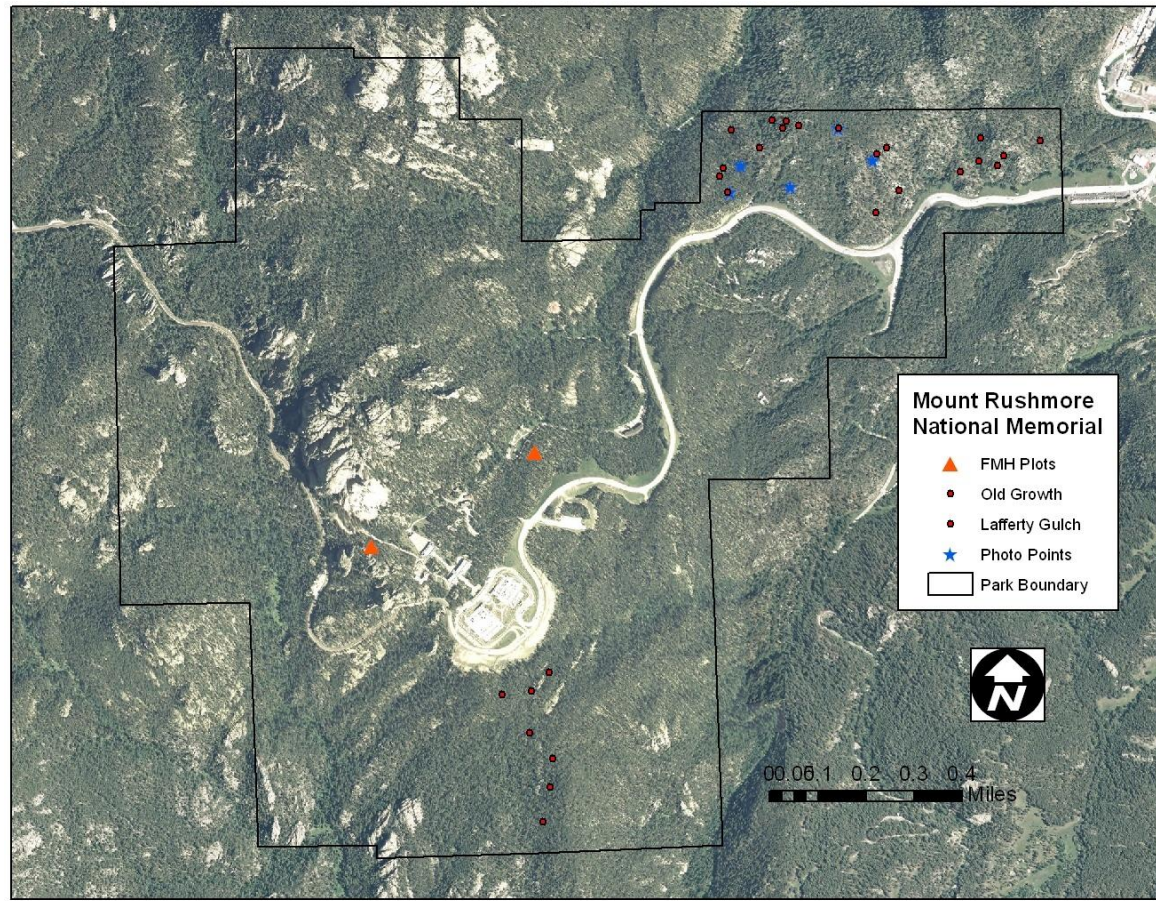
Treatment Unit	Type	Date(s)	Season	Size
Lafferty Gulch	mechanical thin	initiated 2003		115
Mt. Rushmore 1 WF	wildland fire	2/26 to 3/3/2006	Dormant	98
Old Growth	mechanical thin	initiated 2007		30



MONITORING PLOTS

Burn Unit	Monitoring Type	Plot ID	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
no unit	Ponderosa Pine	PIPO_02-01	V		V								
Reardon's Rock	Ponderosa Pine	PIPO_09-01	V							thin	V	V	
Lafferty Gulch	Photo Points	5 Points						V	thin/V			V/B	V
Lafferty Gulch	Ponderosa Pine	20 Plots						V	thin/V			V/B	V
Old Growth	Ponderosa Pine	7 Plots											thin/V

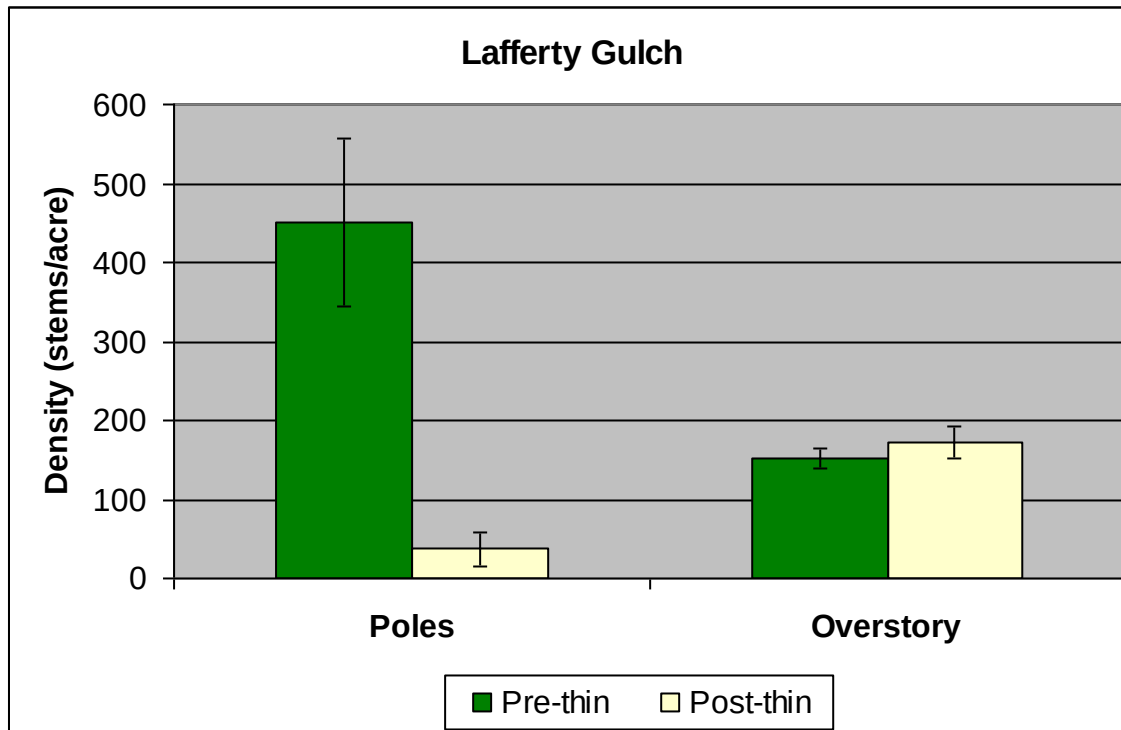
V = Plot visit; B = Burned



MONITORING RESULTS

Lafferty Gulch

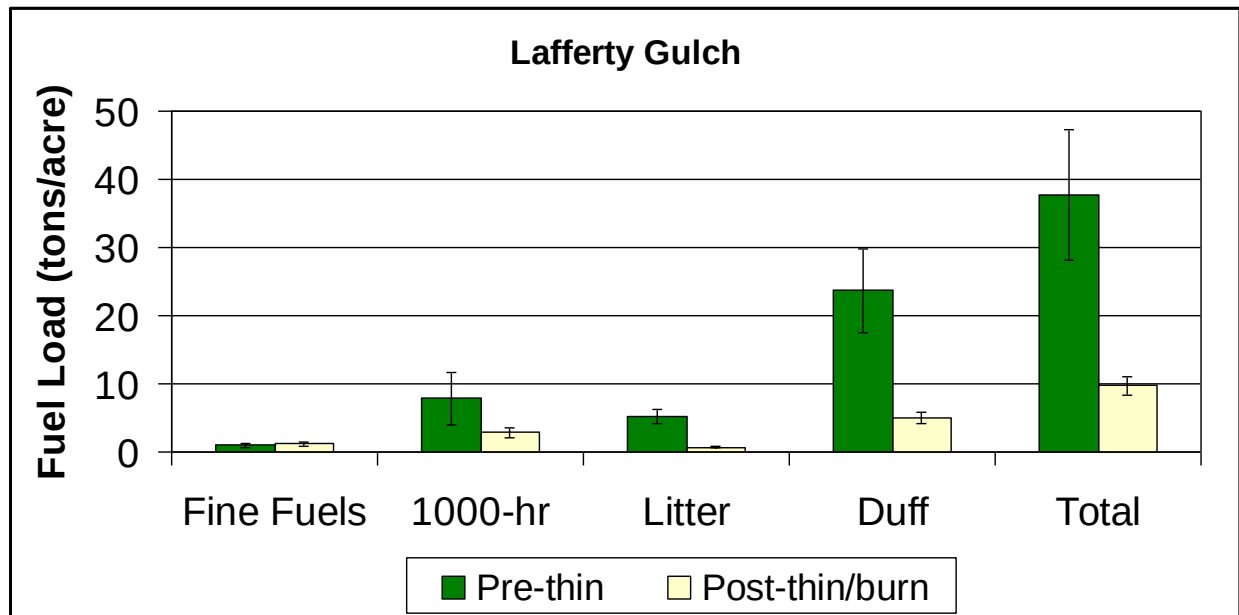
Twenty Forest & Fuels plots were installed before the thinning project began. Some areas were excluded from the project area during the application of the thinning treatment, which resulted in seven plots not receiving the thinning treatment. When we returned to this site for the post-thin visit, we selected seven new plot locations to replace those that had not been thinned. The summary below included data from 20 plots both pre- and post-treatment, but the seven of the plot locations changed between visits.



LAFFERTY GULCH			
stems/acre	Pre-thin	Post-thin	Change
Poles	450	37	-91.8%
Overstory	153	172	12.4%*

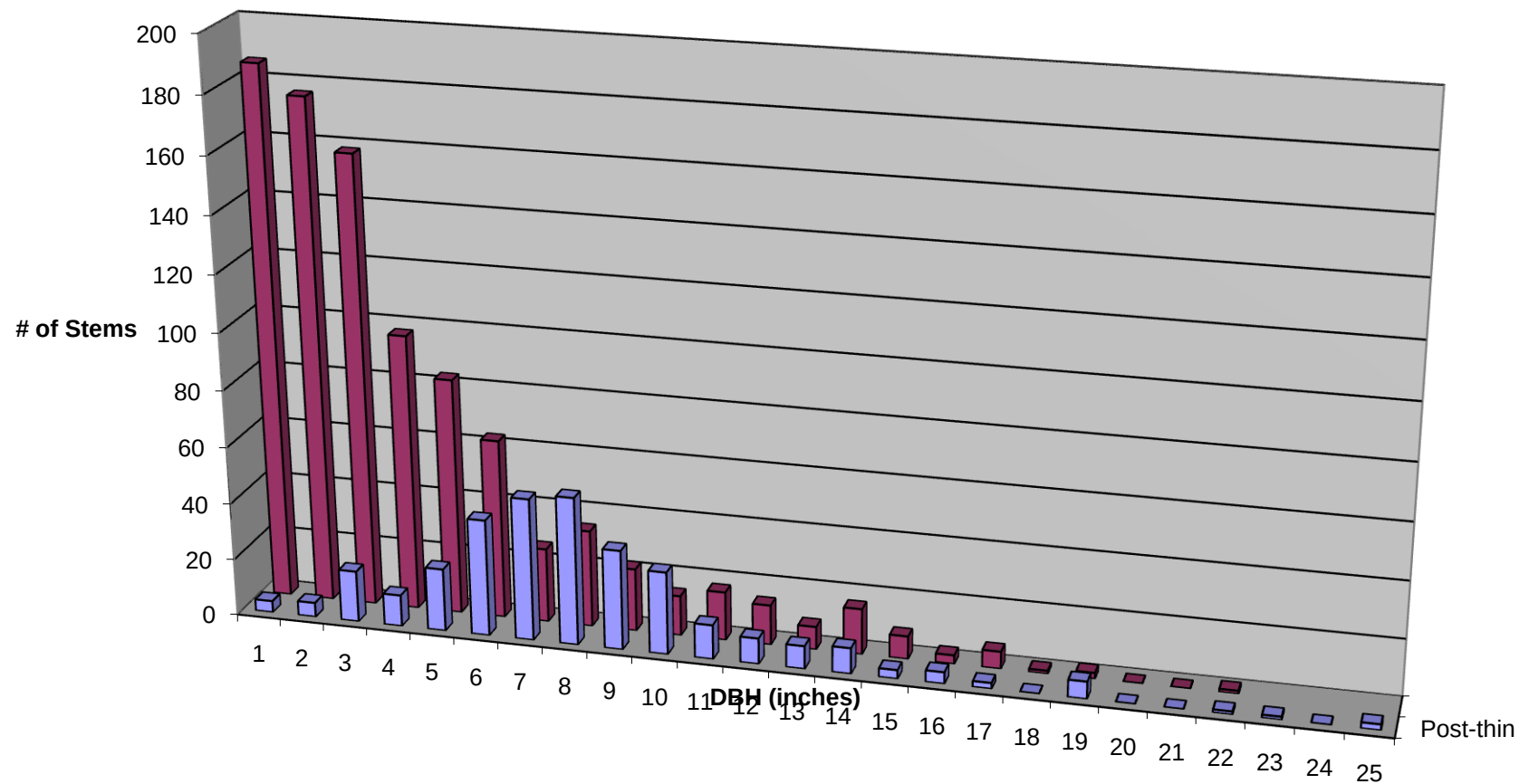
* Increase in overstory density was a result of changes in plot locations.

As a result of the way plot locations were selected and the unplanned nature of the fire that burned through this area, six plots within the burned area had been installed before the thinning project and an additional three plots had been installed in this area after the thinning, but before the fire. Because of this, six plots are included in the summary of fuel load pre-thin while nine plots are included in the summary of fuel load after the fire.



tons/acre	Lafferty Gulch		Change
	Pre-thin Fuel Load	Post-thin/burn Fuel Load	
Woody Fuels	8.8	4.1	-54%
Litter & Duff	28.9	5.7	-80%
Total	37.7	9.7	-74%

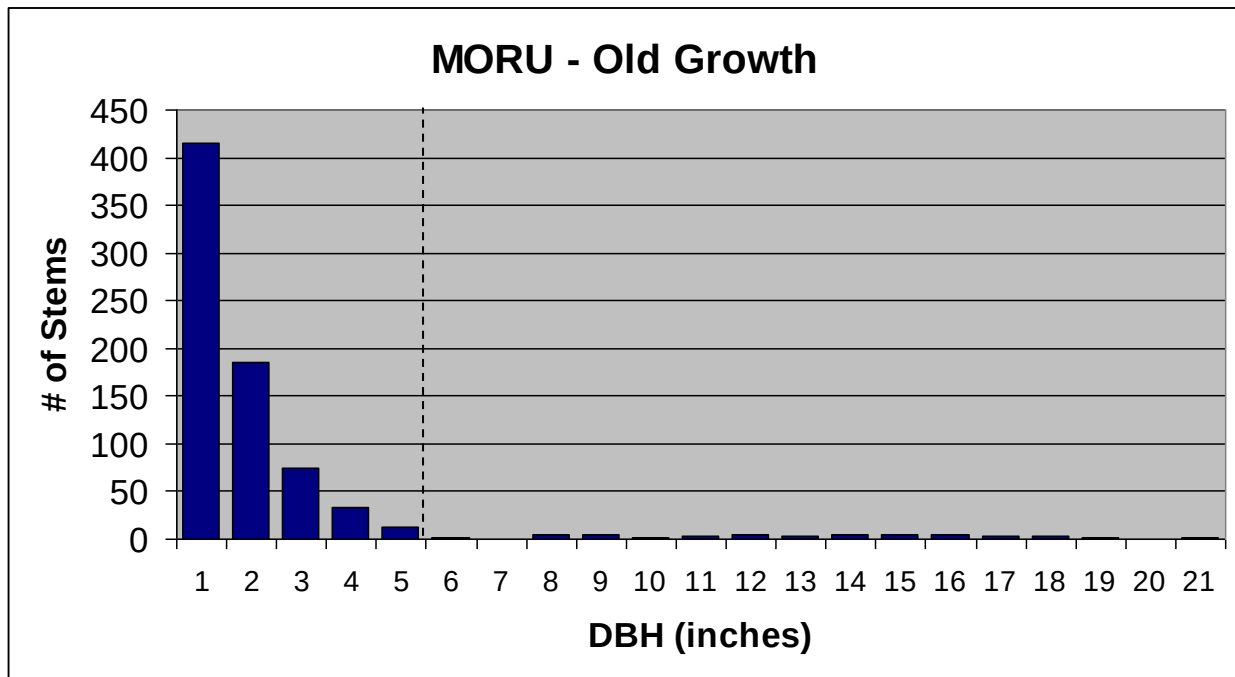
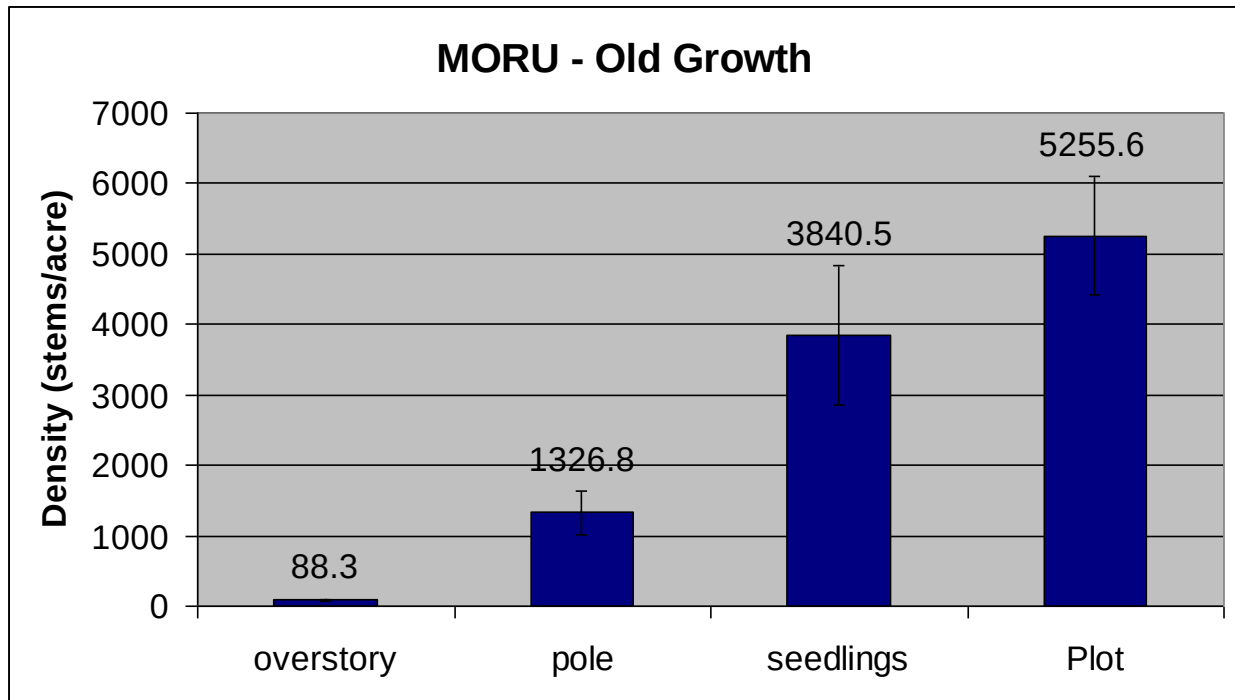




This figure includes a summary of all trees measured in all plots, sorted by diameter class. It displays stand structure across the thinning unit both pre- and post-thinning. The prescription was written to remove trees 6" DBH and smaller. It appears that the treatment was quite successful at reducing the trees in this size class.

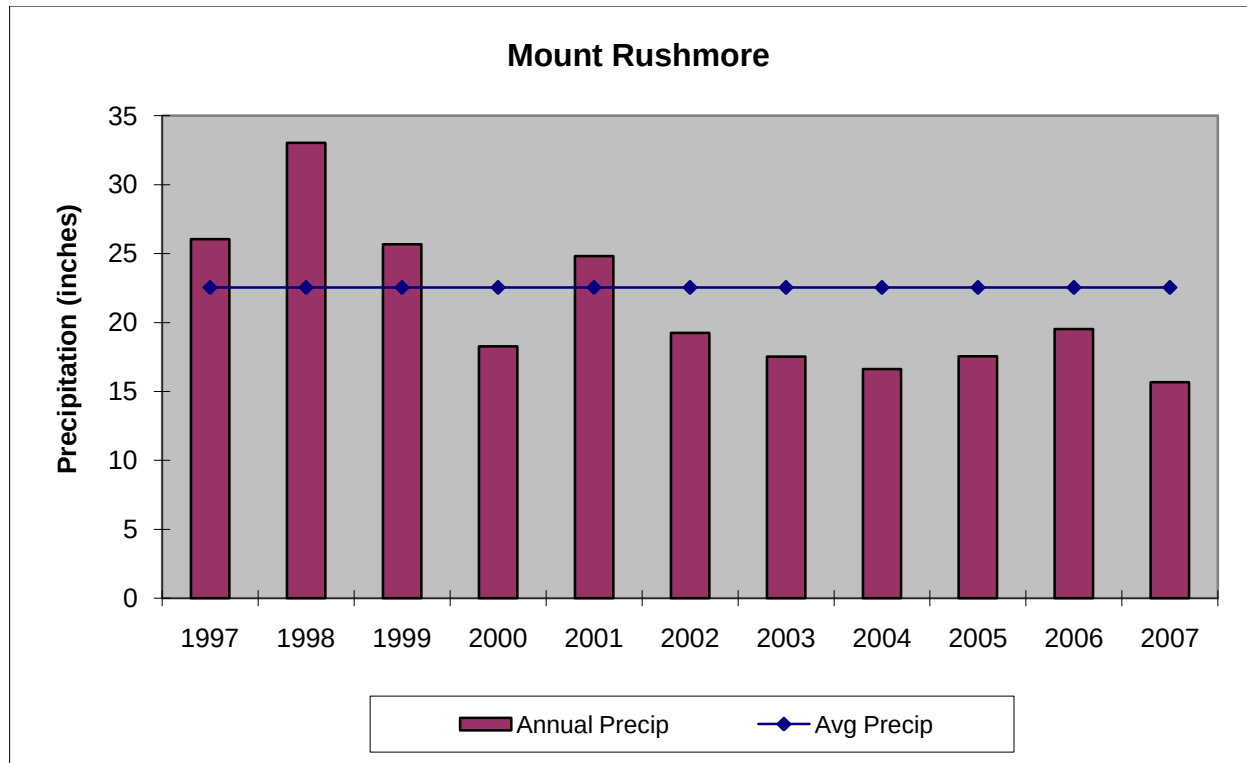
Old Growth

The following two figures display a summary of the pre-treatment stand conditions in the Old Growth unit. The first figure includes tree density by size class and for the entire plot. The second figure is the sum of stems in all plots by stem diameter. The vertical dashed line represents the upper limit of the thinning prescription. Stems with a diameter of 5 inches and smaller were targeted for thinning.



PRECIPITATION

Precipitation data from the manual weather station at MORU. Data downloaded from the High Plains Regional Climate Center website (<http://www.hprcc.unl.edu/data/historical/>). Average precipitation for 1962-2008.





SCOTTS BLUFF NATIONAL MONUMENT

MONITORING UNITS

Juniper woodlands (JUSC)

Overstory dominated by Rocky Mountain juniper (*Juniperus scopulorum*) occurring mainly on steep north aspects of drainages and bluffs accounting for greater than 20% of canopy cover. Understory is predominantly blue grama (*Bouteloua gracilis*) and littleseed ricegrass (*Piptatherum micranthum*) under the juniper canopy and needle-and-thread (*Hesperostipa comata*) and threadleaf sedge (*Carex filifolia*) in the open. Shrubs include western snowberry (*Symphoricarpos occidentalis*), skunkbush sumac (*Rhus aromatica*), Woods' rose (*Rosa woodsii*) and winterfat (*Krascheninnikovia lanata*). Common forbs are milkweed (*Asclepias speciosa*) and spiderwort (*Tradescantia occidentalis*).

Sideoats grama/needlegrass mixed-grass prairie (BOCU)

This monitoring type occurs where native species have been seeded in previously disturbed areas. The areas of disturbance are located on flat to rolling terrain that were used as farmland or as a golf course. These areas are currently dominated by sideoats grama (*Bouteloua curtipendula*) and green needlegrass (*Nassella viridula*). Other graminoids include threadleaf sedge (*Carex filifolia*), needle-and-thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), and prairie sandreed (*Calamovilfa longifolia*). Ponderosa pine (*Pinus ponderosa*), and Rocky Mountain juniper (*Juniperus scopulorum*) occur on the bluff summits, slopes and sheltered ravines. Riparian areas contain plains cottonwoods (*Populus deltoides*), boxelder (*Acer negundo*), and Siberian elm (*Ulmus pumila*). Non-native species include crested wheatgrass (*Agropyron cristatum*), dwarf alyssum (*Alyssum desertorum*), cheatgrass (*Bromus tectorum*), Japanese brome (*B. japonicus*), kochia (*Kochia scoparia*), Russian thistle (*Salsola tragus*), and tumble mustard (*Sisymbrium altissimum*).

Western snowberry shrubland (SYOC)

Shrublands are dominated by western snowberry (*Symphoricarpos occidentalis*), winterfat (*Krascheninnikovia lanata*), skunkbush sumac (*Rhus aromatica*), and lesser amounts of common chokecherry (*Prunus virginiana*), wild rose (*Rosa woodsii*), silver buffaloberry (*Shepherdia argentea*), rubber rabbitbrush (*Chrysothamnus nauseosus*), yucca (*Yucca glauca*), and prickly pear (*Opuntia* spp.). The herbaceous layer consists of western wheatgrass (*Pascopyrum smithii*), sideoats grama (*Bouteloua curtipendula*), smooth brome (*Bromus inermis*), Japanese brome (*B. japonicus*), needle-and-thread (*Hesperostipa comata*), goatsbeard (*Tragopogon dubius*), prickly lettuce (*Lactuca serriola*), sunflower (*Helianthus* spp.), and prairie coneflower (*Ratibida columnifera*).

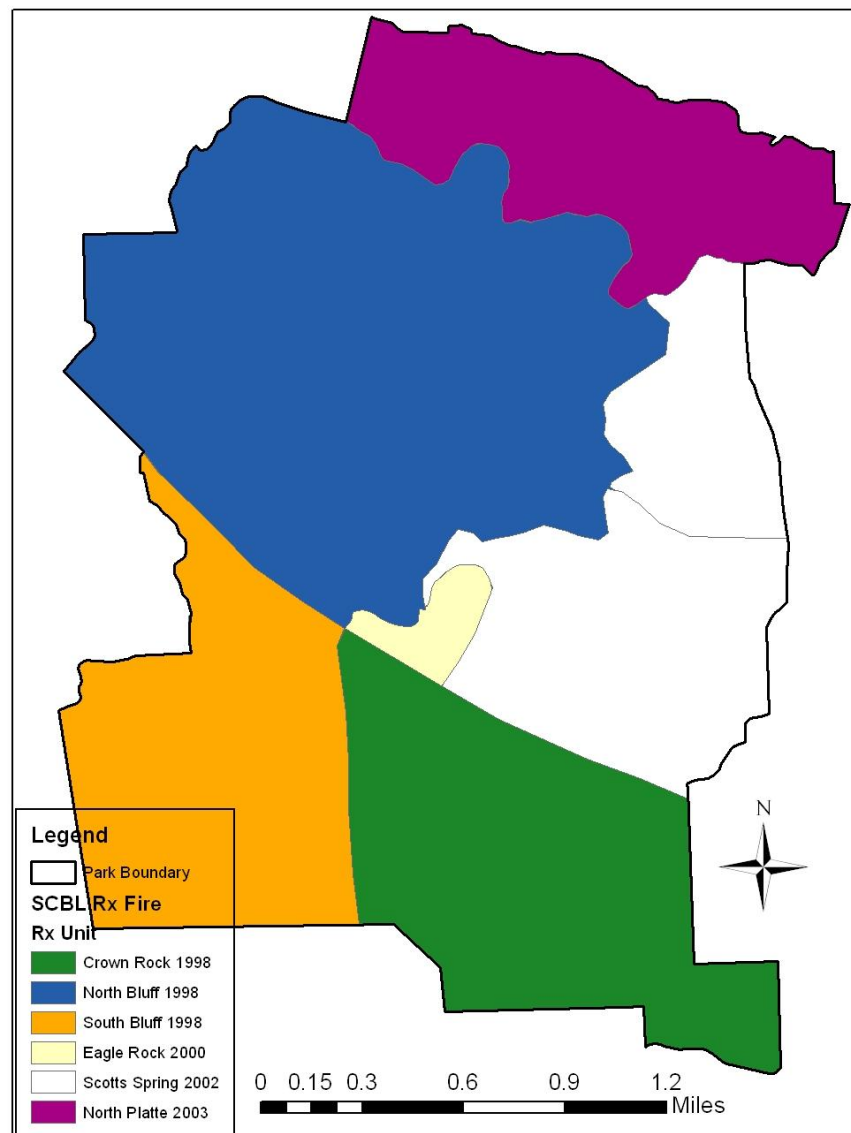
Needlegrass/sedge mixed-grass prairie (STCO)

A mixed-grass prairie dominated by threadleaf sedge (*Carex filifolia*) and needle-and-thread (*Hesperostipa comata*). Other grasses include western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), prairie sandreed (*Calamovilfa longifolia*), and sideoats grama (*B. curtipendula*). Ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus*

scopulorum) occur on the bluff summits, slopes and sheltered ravines. Riparian areas contain plains cottonwoods (*Populus deltoides*), boxelder (*Acer negundo*), and Siberian elm (*Ulmus pumila*). Non-native species include crested wheatgrass (*Agropyron cristatum*), dwarf alyssum (*Alyssum desertorum*), cheatgrass (*Bromus tectorum*), Japanese brome (*B. japonicus*), kochia (*Kochia scoparia*), and Russian thistle (*Salsola tragus*).

PREScribed FIRES

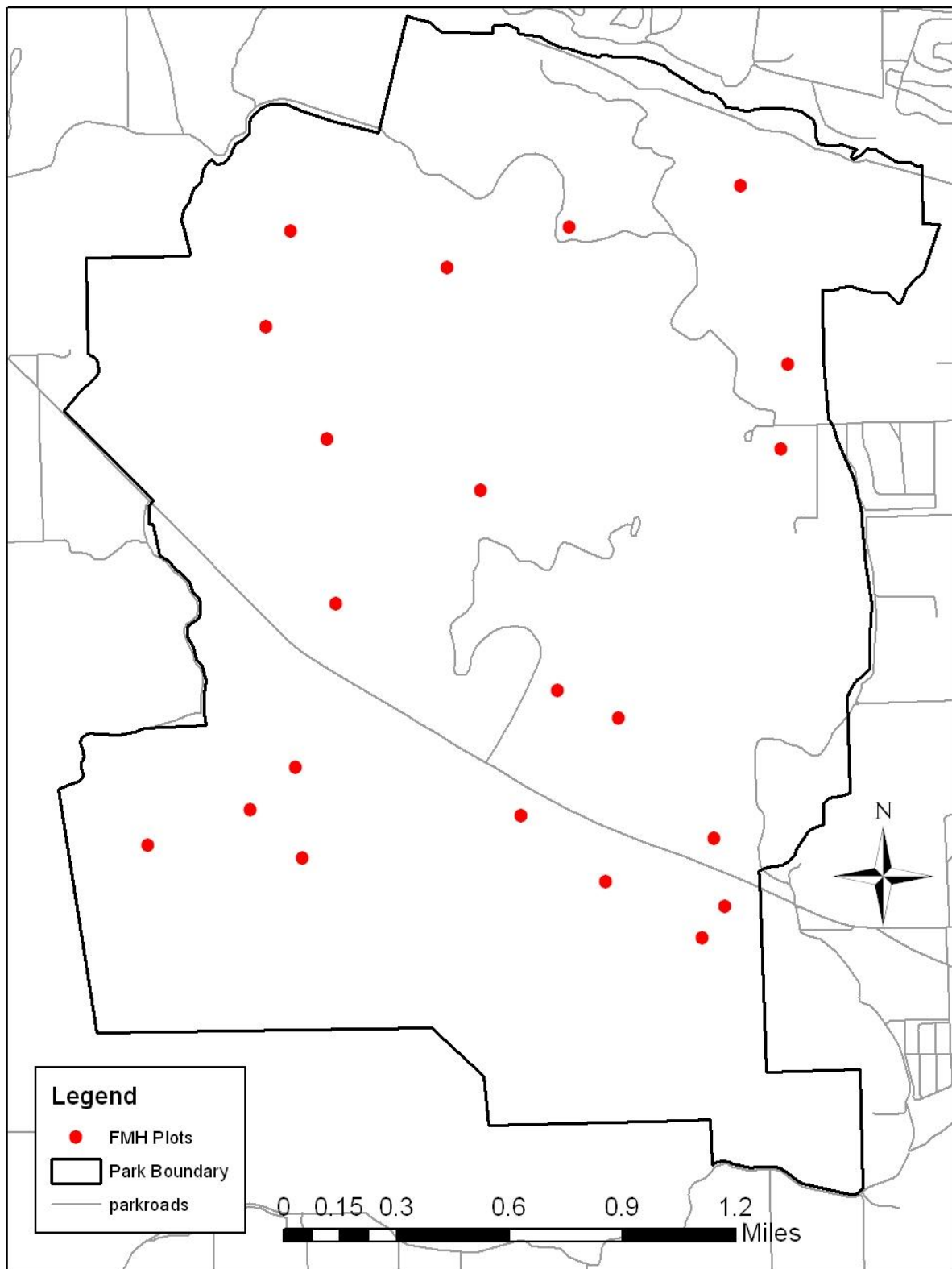
Burn Unit	Date(s)	Season	Size
Crown Rock	3/25/98	Spring	402
South Bluff	3/26/98	Spring	542
North Bluff	8/25/98	Fall	1113
Badlands	9/30/99	Fall	5
Eagle Rock	3/28/00	Spring	45
Scott Spring	5/4/02	Spring	618
North Platte	4/15/03	Spring	250



MONITORING PLOTS

Burn Unit	Monitoring Type	Plot ID	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Crown Rock	Restored Prairie	BOCU-01	V	B/V	V	V			V				
North Bluff	Restored Prairie	BOCU-02		V/B	V	V			V				
Scott Spring	Brome	BROM-01				V		B/V	V			V	
Scott Spring	Brome	BROM-02				V		B/V	V			V	
North Bluff	Juniper woodland	JUSC-01		V/B	V	V			V				
North Bluff	Juniper woodland	JUSC-02		V/B	V	V			V				
South Bluff	Juniper Woodland	JUSC-03		V/B	V	V						V	
South Bluff	Juniper Woodland	JUSC-04		V/B	V	V						V	
South Bluff	Juniper Woodland	JUSC-05		V/B	V	V						V	
South Bluff	Juniper Woodland	JUSC-06		V/B	V	V						V	
Crown Rock	Needlegrass/Sedge	STCO-01	V	B/V	V	V			V				
Crown Rock	Needlegrass/Sedge	STCO-02	V	B/V	V	V			V				
North Bluff	Needlegrass/Sedge	STCO-03		V/B	V	V			V				
North Bluff	Needlegrass/Sedge	STCO-04		V/B	V	V			V				
North Bluff	Needlegrass/Sedge	STCO-05		V/B	V	V			V				
North Platte	Needlegrass/Sedge	STCO-06			V		V		B/V	V			V
Scott Spring	Needlegrass/Sedge	STCO-07				V		B/V	V		V		
Scott Spring	Needlegrass/Sedge	STCO-08				V		B/V	V		V		
Crown Rock	Snowberry Shrubland	SYOC-01	V	B/V					V				
North Platte	Snowberry Shrubland	SYOC-02			V		V		B/V	V			V
Scott Spring	Snowberry Shrubland	SYOC-03				V		B/V	V			V	

V = plot visit; B = burned

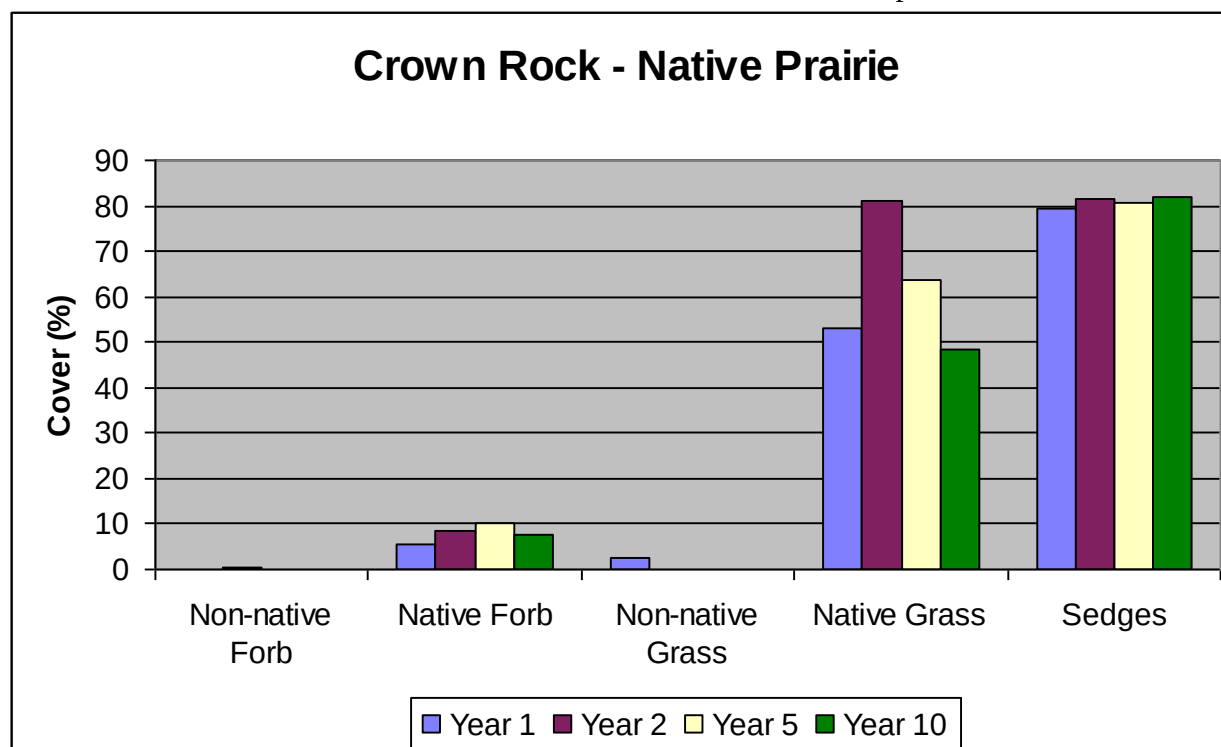


MONITORING RESULTS

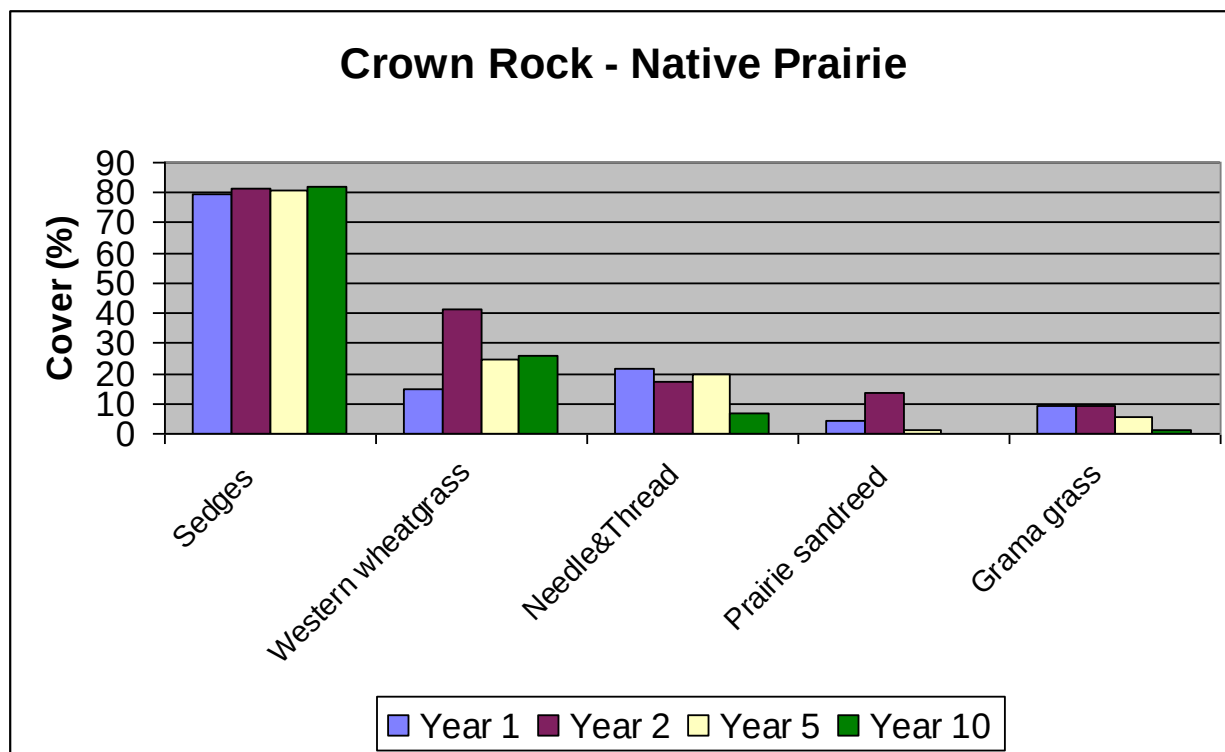
Prescribed Fire Units

Crown Rock

Two needle-grass / sedge mixed-grass prairie (STCO) plots were installed in the Crown Rock burn unit. Standard error bars were not included due to the small sample size.

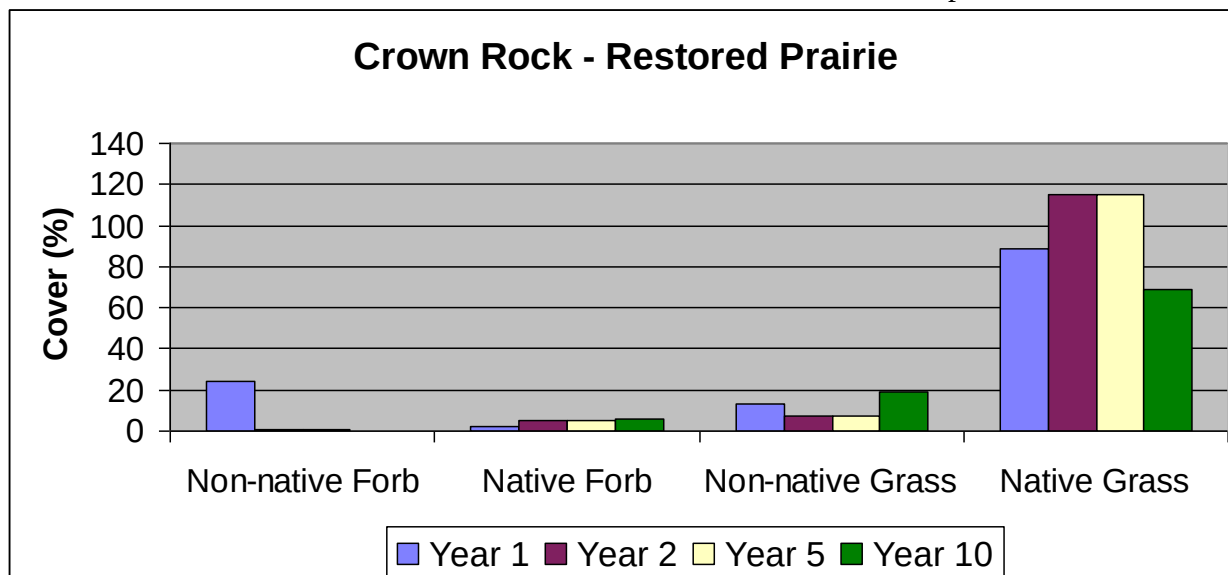


CROWN ROCK							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
<i>Non-native Forb</i>	0.0	0.5	++	0.0	—	0.0	—
Native Forb	5.5	8.5	55%	10.0	82%	7.5	36%
<i>Non-native Grass</i>	2.5	0.0	-100%	0.0	-100%	0	-100%
Native Grass	53.0	81.0	53%	63.5	20%	48.5	-8%
Sedges	79.5	81.5	3%	80.5	1%	82	3%



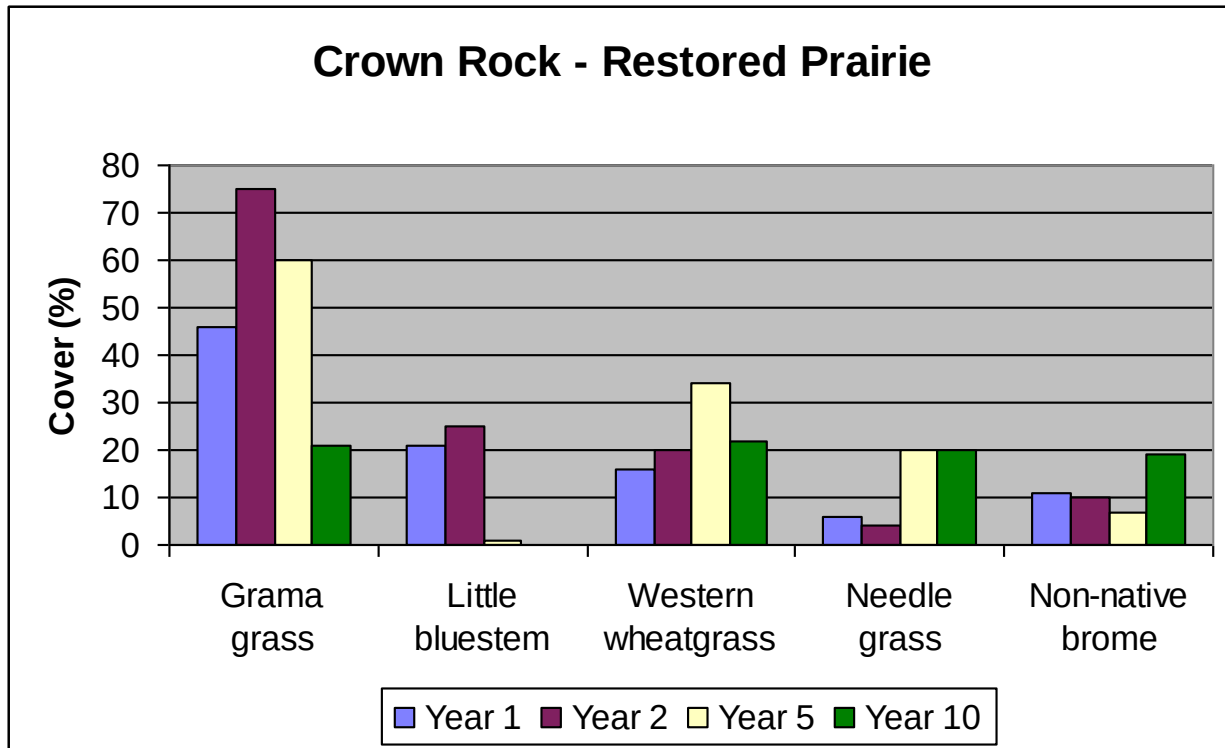
CROWN ROCK							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
Sedges	80	82	3%	81	1%	82	3%
Western wheatgrass	15	41	173%	25	63%	26	73%
Needle-and-thread	22	17	-21%	20	-9%	7	-67%
Prairie sandreed	5	14	200%	2	-67%	0	-100%
Grama grass	9	10	6%	6	-39%	2	-83%

One sideoats grama / needlegrass mixed-grass prairie plot (BOCU) was installed in the Crown Rock burn unit. Standard error bars are not included due to the small sample size.



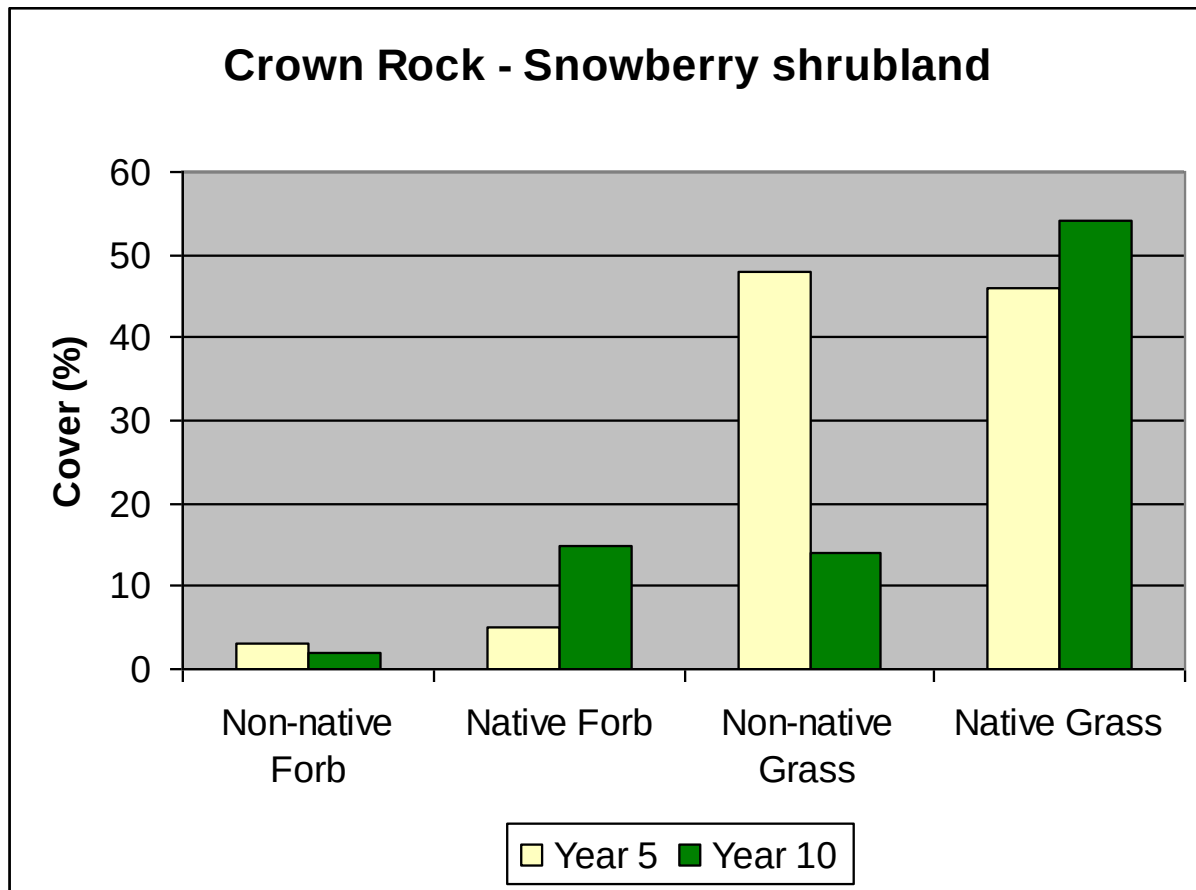
CROWN ROCK							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
<i>Non-native Forb</i>	24	0	-100%	1	-96%	0	-100%
<i>Native Forb</i>	2	7	250%	5	150%	6	200%
<i>Non-native Grass</i>	13	10	-23%	7	-46%	19	46%
<i>Native Grass</i>	89	127	43%	115	29%	69	-22%
<i>Sedges</i>	0	0	---	0	---	0	---



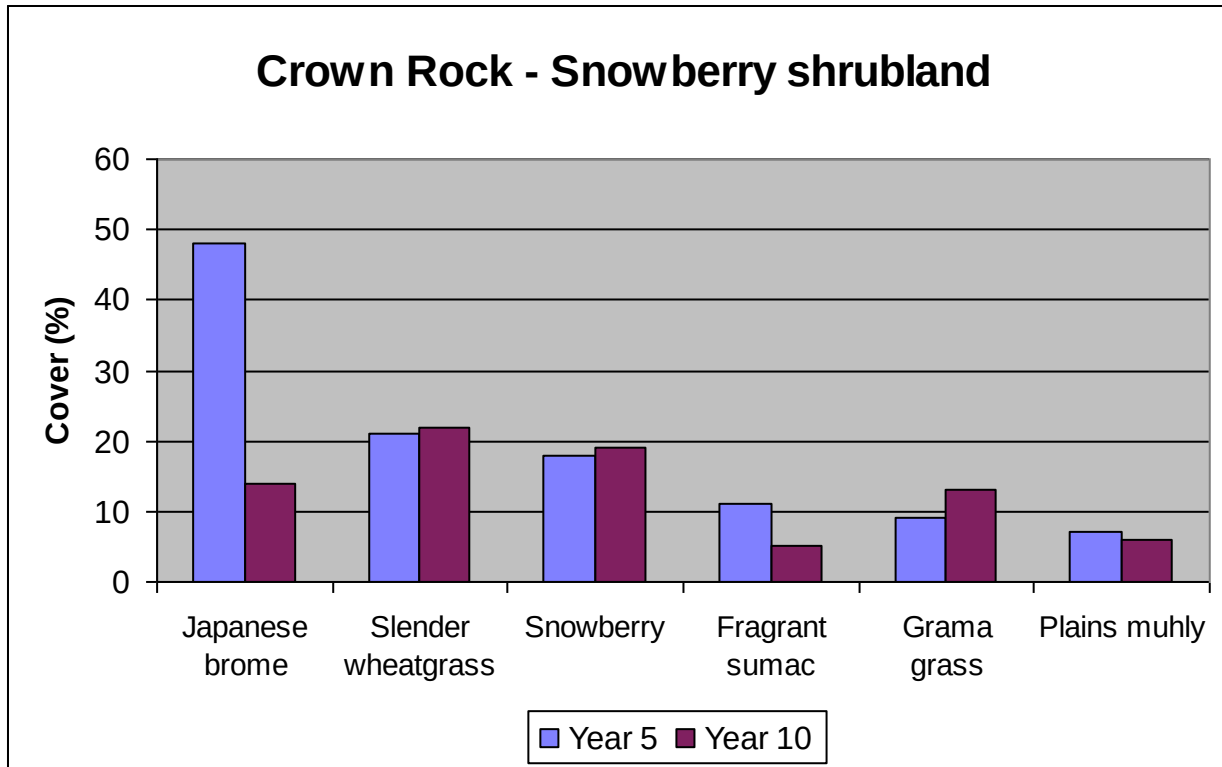


CROWN ROCK							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
Grama grass	46	75	63%	60	30%	21	-54%
Little bluestem	21	25	19%	1	-95%	0	-100%
Western wheatgrass	16	20	25%	34	113%	22	38%
Needle grass	6	4	-33%	20	233%	20	233%
<i>Non-native brome</i>	11	10	-9%	7	-36%	19	73%

One western snowberry shrubland plot was installed in the Crown Rock burn unit. Standard error bars were not included due to the small sample size.



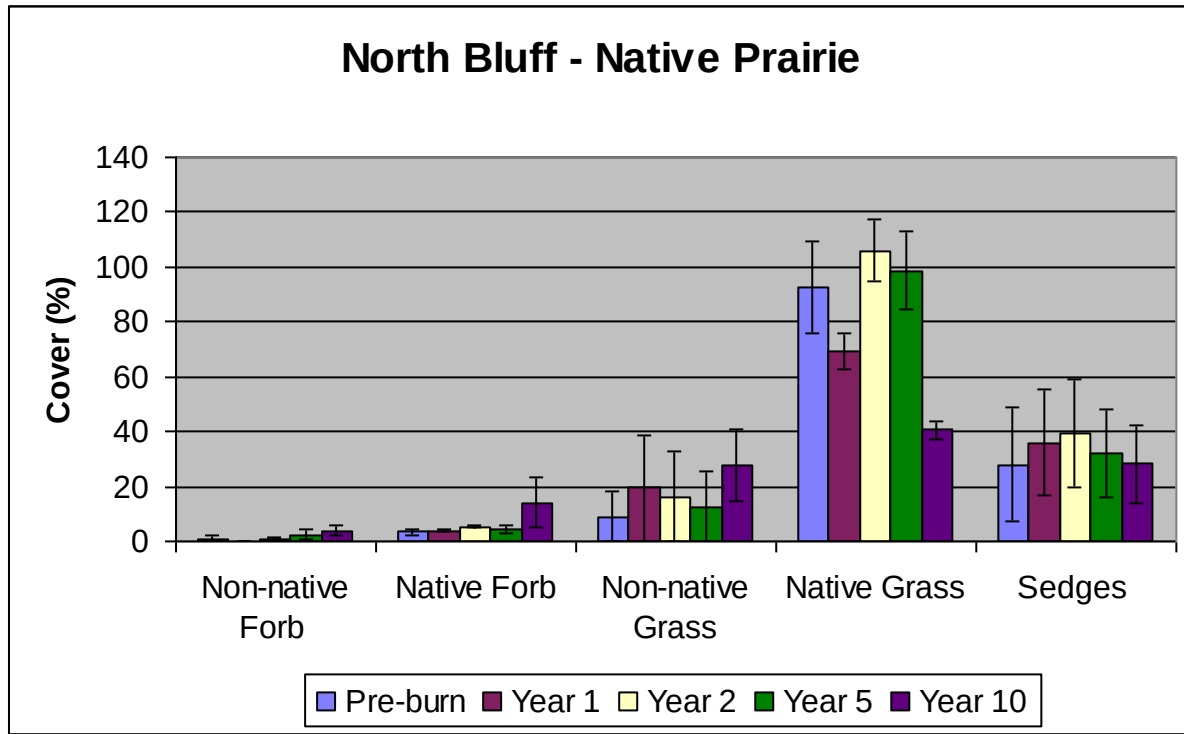
CROWN ROCK			
	Yr 5 Cover	Yr 10 Cover	Change
<i>Non-native Forb</i>	3	2	-33%
Native Forb	5	15	200%
<i>Non-native Grass</i>	48	14	-71%
Native Grass	46	54	17%



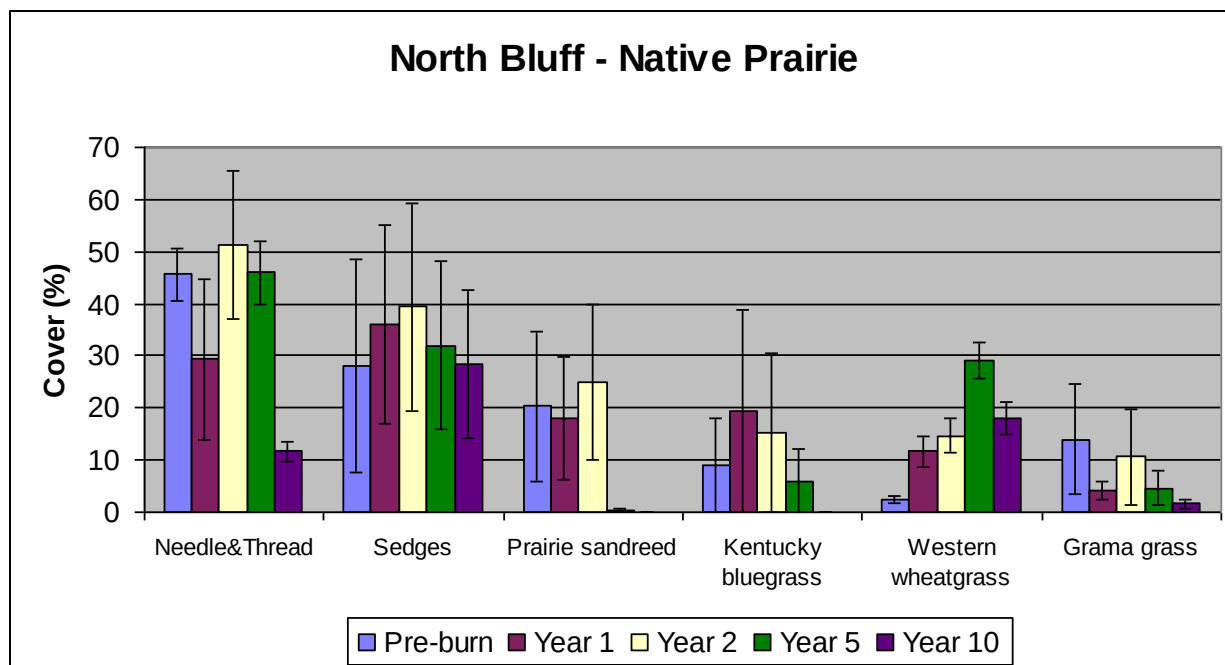
CROWN ROCK			
	Yr 5 Cover	Yr 10 Cover	Change
<i>Japanese brome</i>	48	14	-71%
<i>Slender wheatgrass</i>	21	22	5%
<i>Snowberry</i>	18	19	6%
<i>Fragrant sumac</i>	11	5	-55%
<i>Grama grass</i>	9	13	44%
<i>Plains muhly</i>	7	6	-14%

North Bluff

Three needlegrass / sedge mixed-grass prairie (STCO) plots were installed in the North Bluff burn unit.

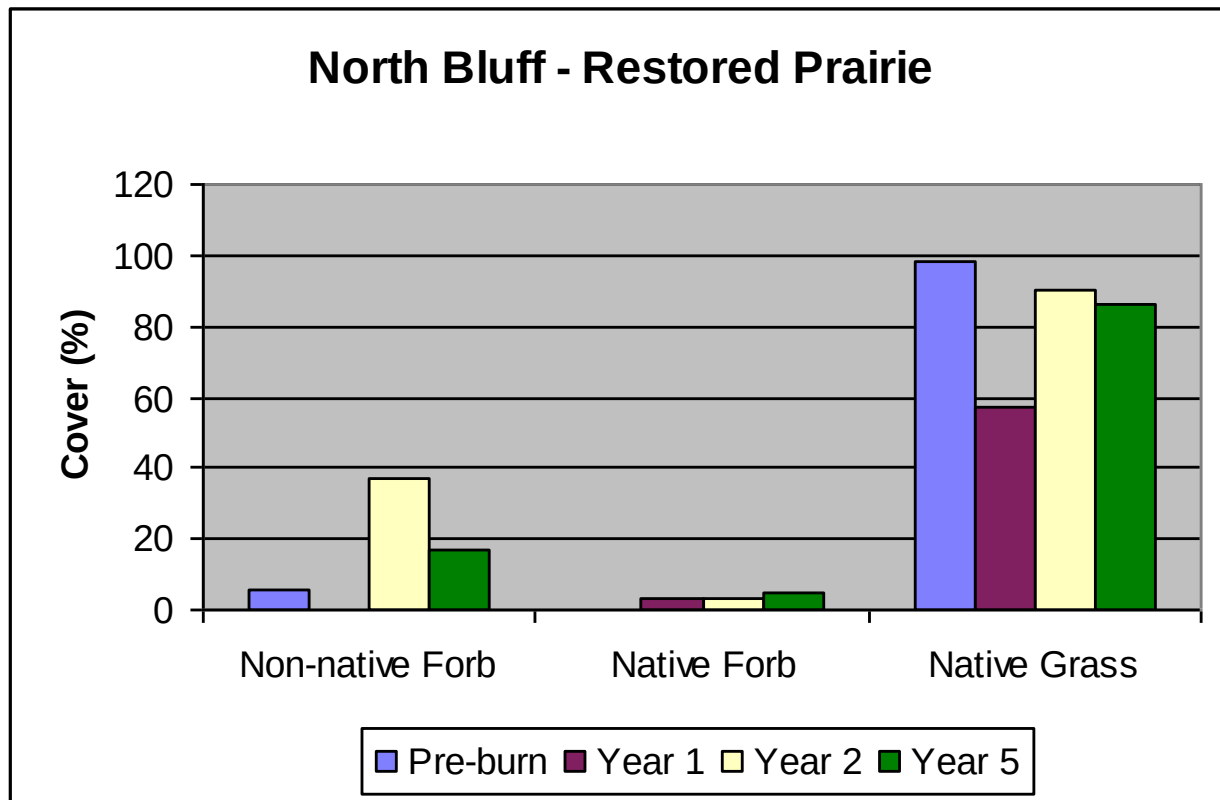


NORTH BLUFF							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
<i>Non-native Forb</i>	1.0	1.0	0%	2.3	133%	4.0	300%
<i>Native Forb</i>	3.3	5.3	60%	4.3	30%	14.0	320%
<i>Non-native Grass</i>	9.0	16.3	81%	12.7	41%	27.7	207%
<i>Native Grass</i>	92.7	106.0	14%	98.7	6%	40.7	-56%
<i>Sedges</i>	28.0	39.3	40%	32.0	14%	28.3	1%

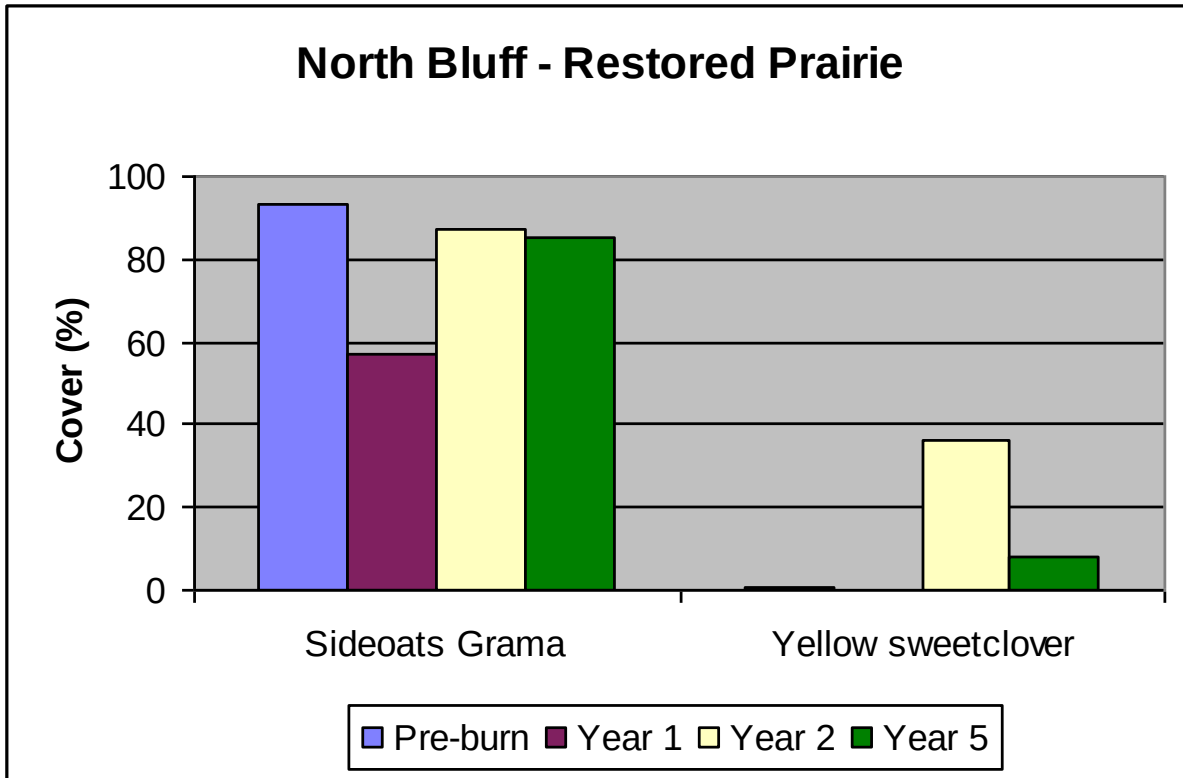


NORTH BLUFF							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
Needle-and-thread	45.7	51.3	12%	46.0	1%	11.7	-74%
Sedges	28.0	39.3	40%	32.0	14%	28.3	1%
Prairie sandreed	20.3	25.0	23%	0.3	-98%	0.0	-100%
Kentucky bluegrass	9.0	15.3	70%	6.0	-33%	0.0	-100%
Western wheatgrass	2.3	14.7	529%	29.0	1143%	18.0	671%
Grama grass	14.0	10.7	-24%	4.7	-67%	1.7	-88%

One sideoats grama / needlegrass mixed-grass prairie (BOCU) plot was installed in the North Bluff burn unit. Standard error bars were not displayed due to the small sample size.



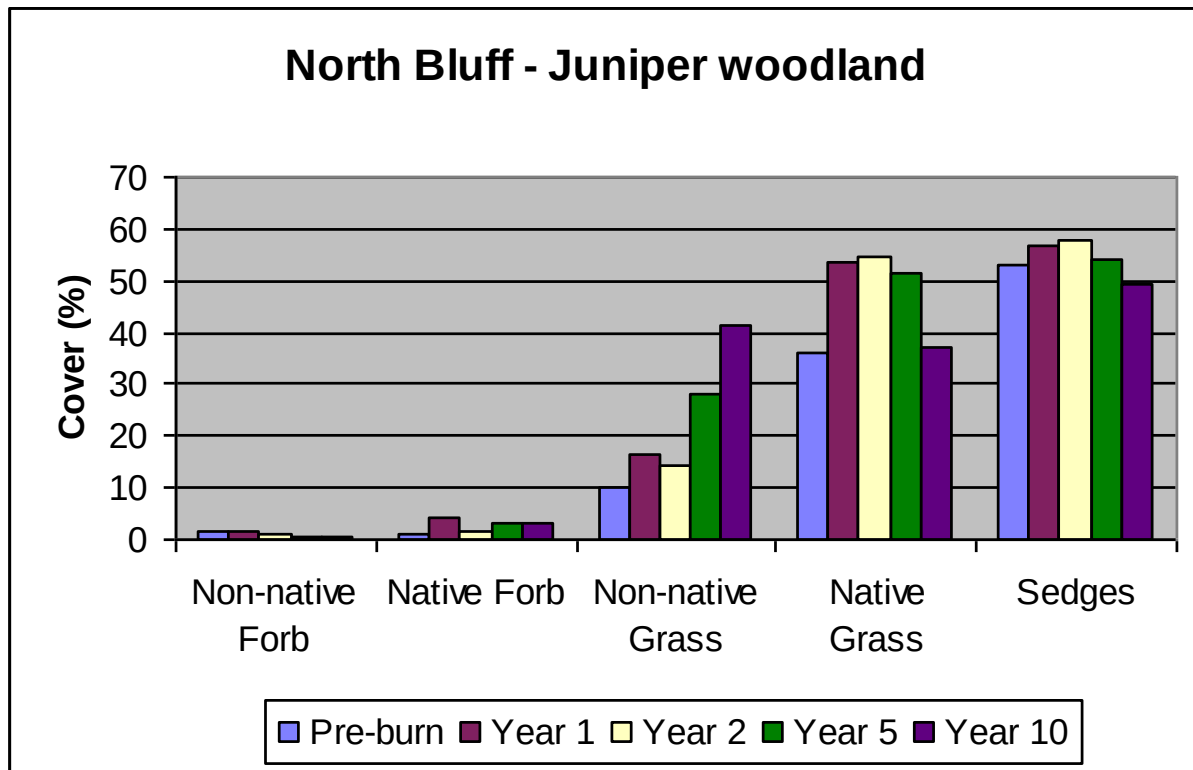
NORTH BLUFF					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	6	37	517%	17	183%
Native Forb	0	3	++	5	++
Native Grass	98	90	-8%	86	-12%



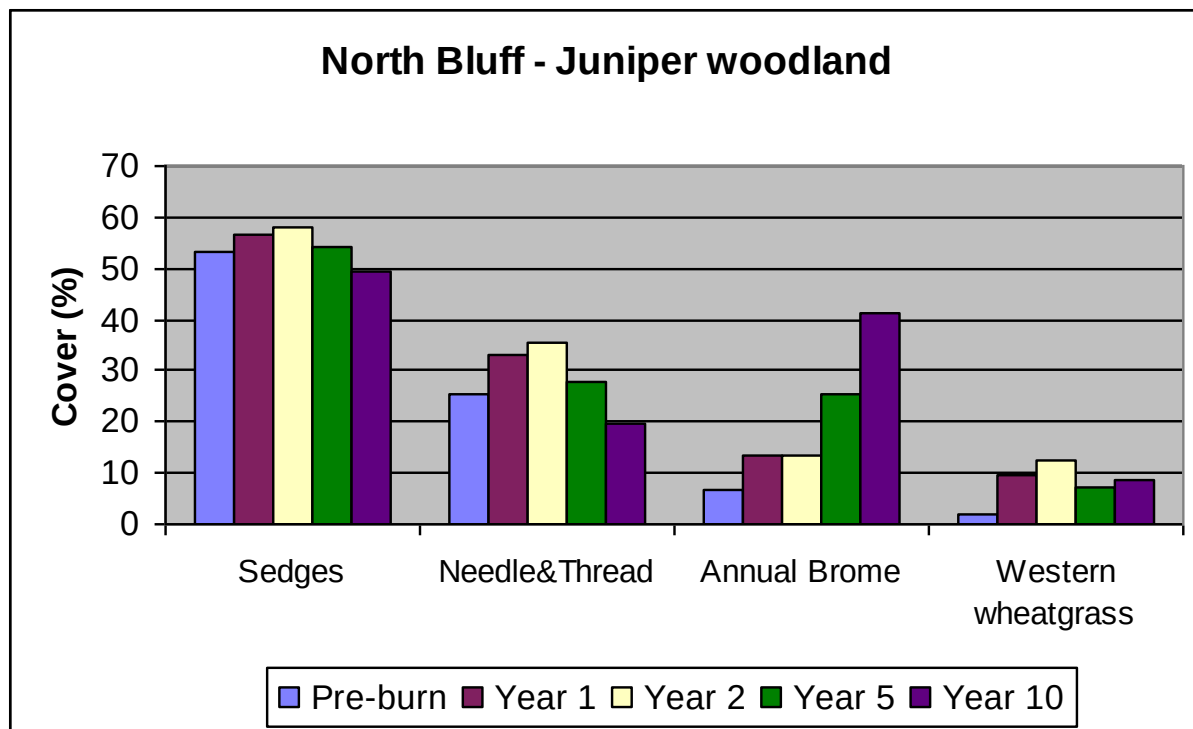
NORTH BLUFF					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Sideoats grama	93	87	-6%	85	-9%
Yellow sweetclover	1	36	3500%	8	700%



Two juniper woodland plots have been installed in the North Bluff burn unit. Standard error bars were not included due to the small sample size.



NORTH BLUFF							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
<i>Non-native Forb</i>	1.8	1.2	-33%	0.3	-83%	0.6	-67%
Native Forb	0.9	1.5	67%	3.0	234%	3.0	233%
<i>Non-native Grass</i>	10.2	14.5	41%	28.3	176%	41.3	303%
Native Grass	36.1	54.8	52%	51.2	42%	37.0	2%
Sedges	53.0	57.8	9%	54.2	2%	49.4	-7%



NORTH BLUFF							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
Sedges	53.0	57.8	9%	54.2	2%	49.4	-7%
Needle-and-thread	25.3	35.2	39%	27.7	10%	19.9	-21%
Annual brome	6.6	13.6	105%	25.6	286%	41.3	523%
Western wheatgrass	1.8	12.3	583%	7.2	300%	8.7	383%

South Bluff

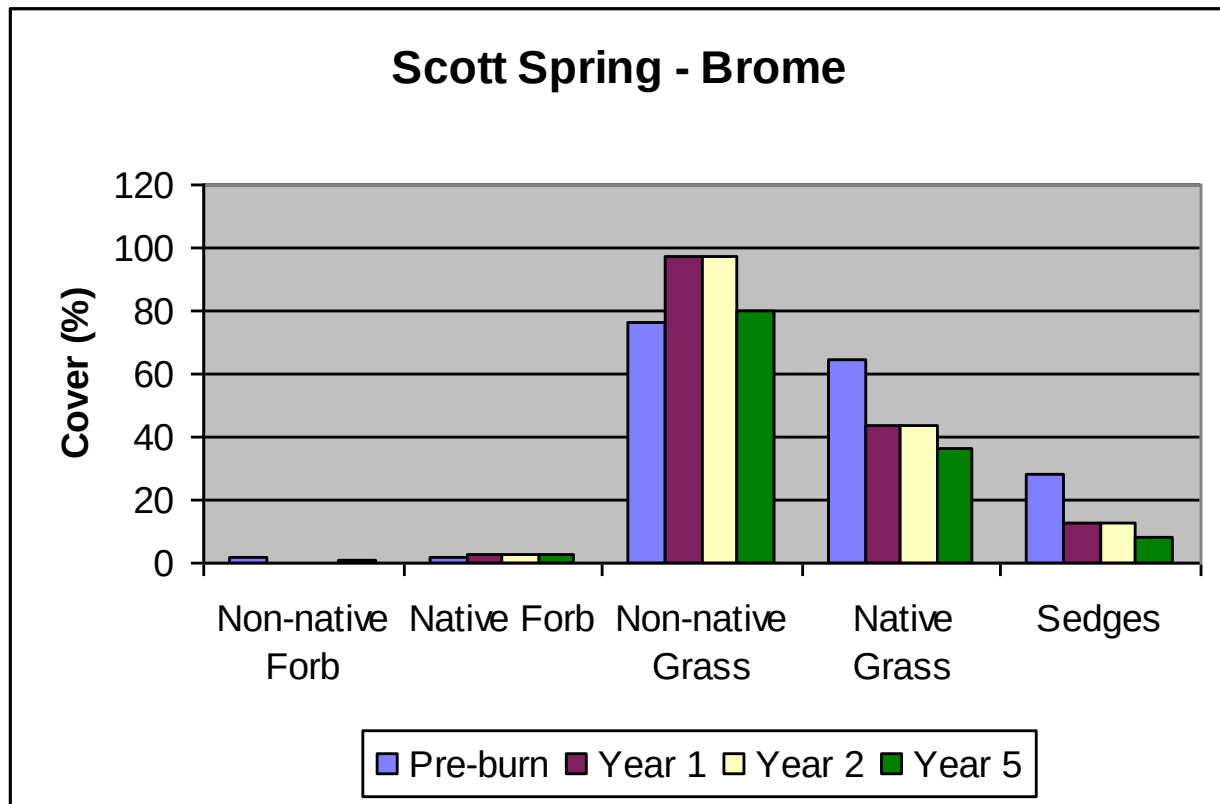
Four juniper draw plots have been installed within the South Bluff burn unit but none of these have been treated with prescribed fire.

Eagle Rock

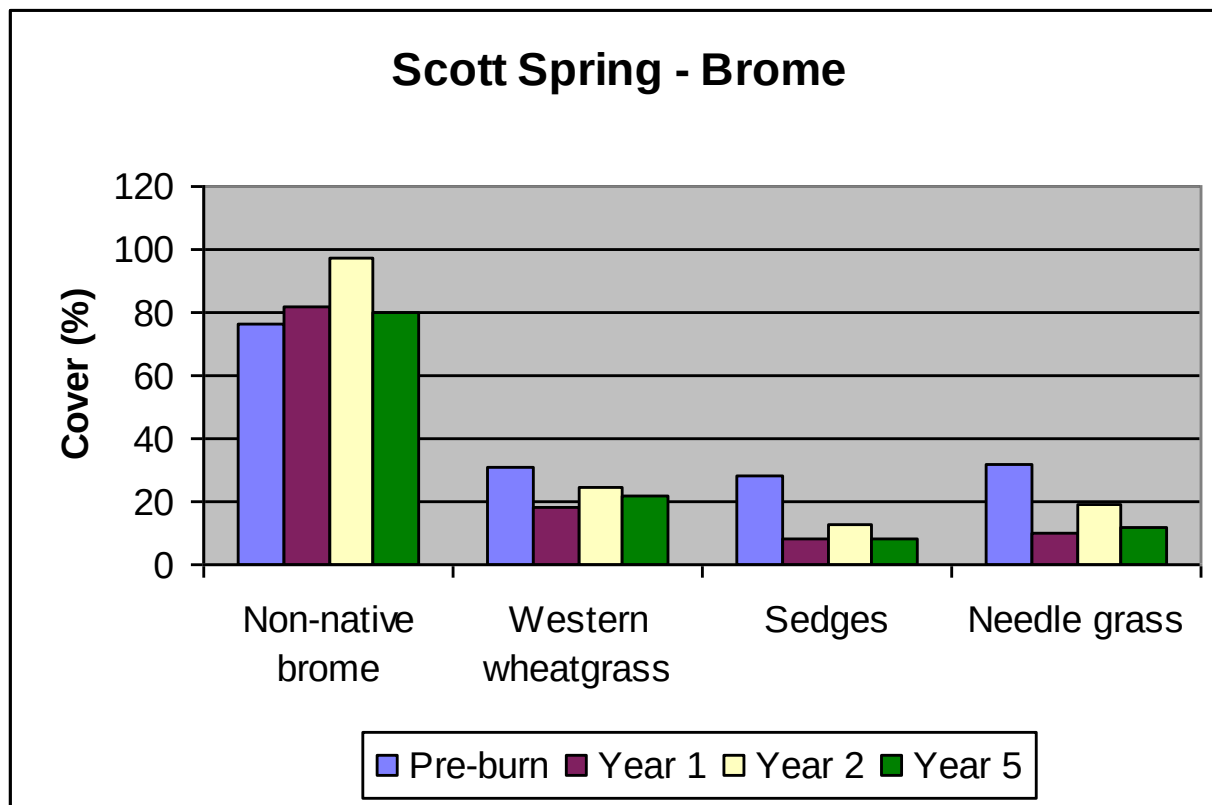
No plots have been installed within this burn unit.

Scott Spring

Two exotic brome plots were installed within the Scott Spring burn unit. Standard error bars are not included due to the small sample size.



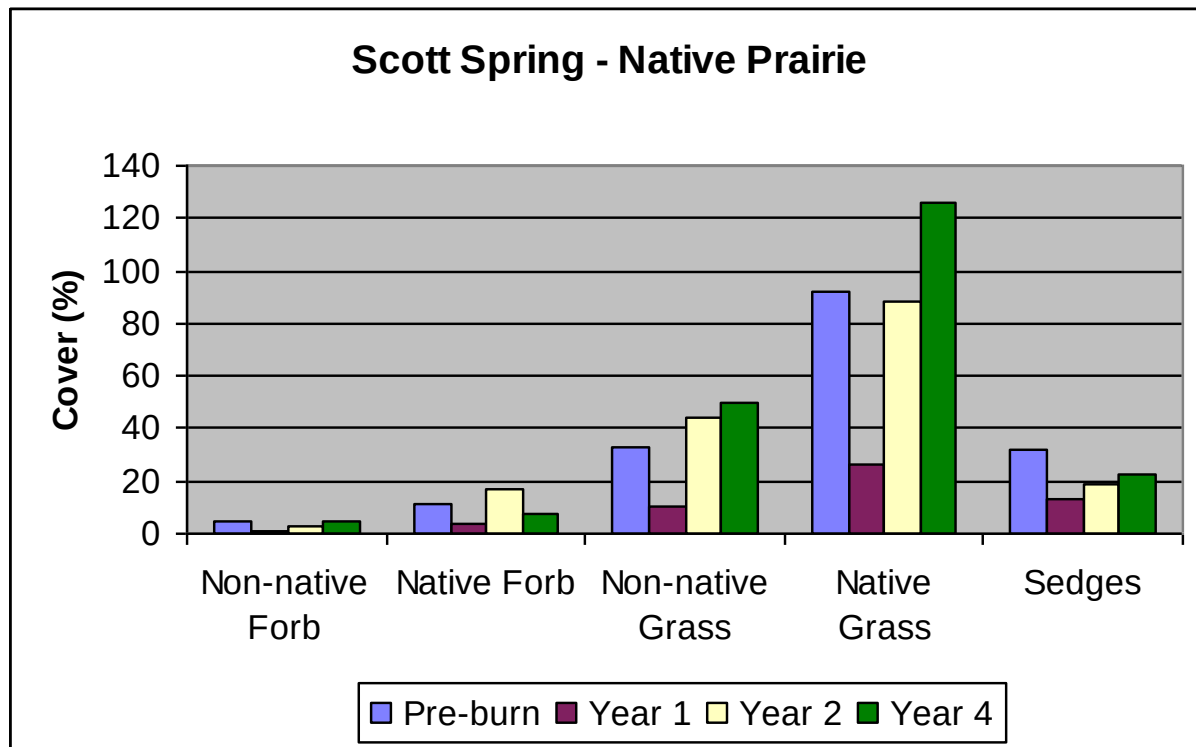
SCOTT SPRING					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	1.5	0.0	-100%	1.0	-33%
Native Forb	2.0	3.0	50%	3.0	50%
<i>Non-native Grass</i>	76.5	97.5	27%	80.0	5%
Native Grass	64.5	44.0	-32%	36.5	-43%
Sedges	28.0	13.0	-54%	8.0	-71%



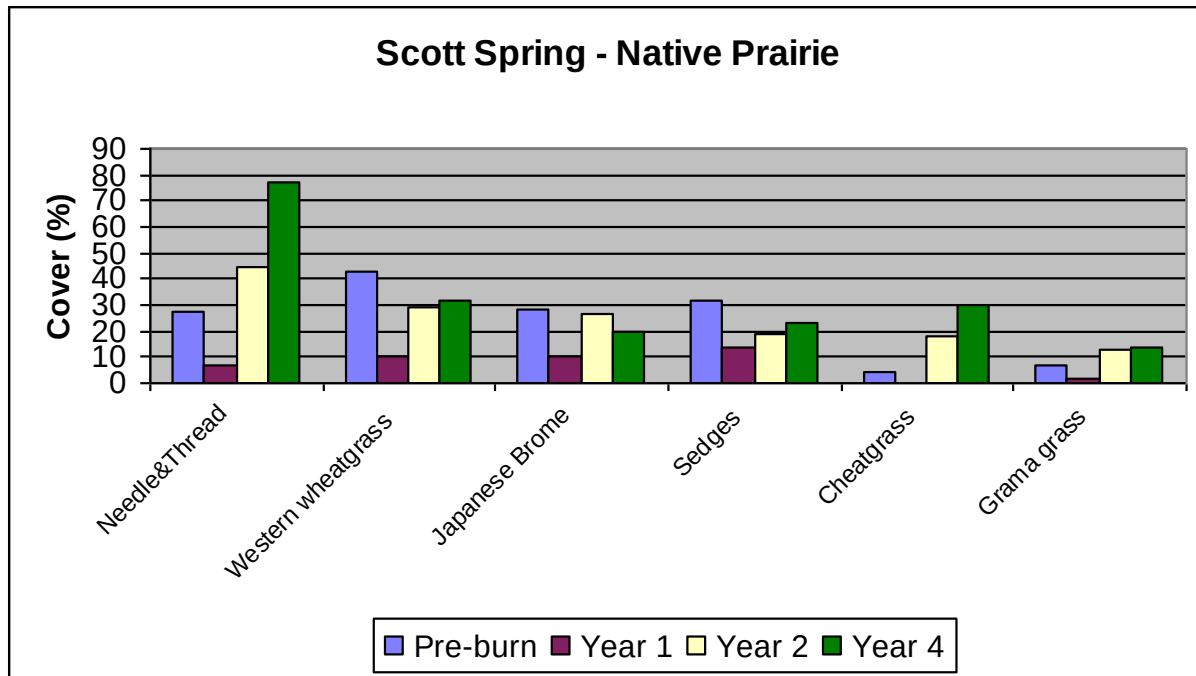
SCOTT SPRING					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native brome</i>	76.5	97.5	27%	80.0	5%
Western wheatgrass	30.5	24.5	-20%	21.5	-30%
Sedges	28.0	13.0	-54%	8.0	-71%
Needlegrass	31.5	19.0	-40%	11.5	-63%



Two needle grass / sedge mixed-grass prairie (native prairie) plots were installed in the Scott Spring burn unit. Standard error bars were not included due to the small sample size.

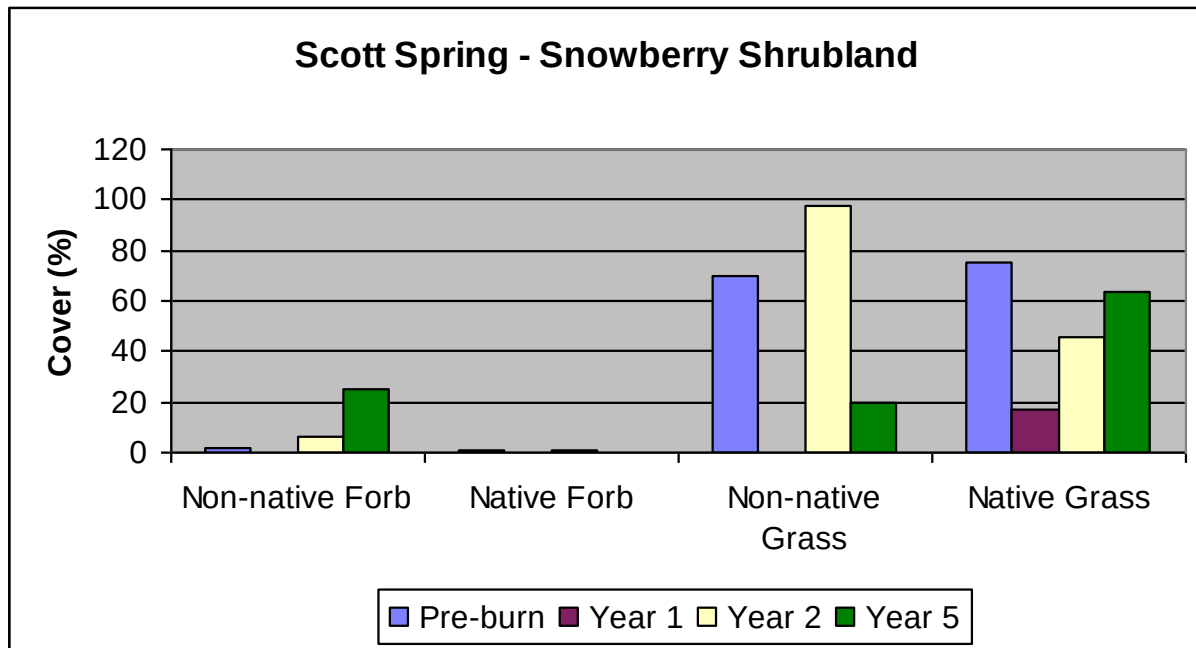


SCOTT SPRING					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 4 Cover	Change
<i>Non-native Forb</i>	4.5	2.5	-44%	4.5	---
<i>Native Forb</i>	11.5	16.5	43%	7.5	-35%
<i>Non-native Grass</i>	32.5	44.5	37%	49.5	52%
<i>Native Grass</i>	92.5	88	-5%	126	36%
<i>Sedges</i>	32	18.5	-42%	23	-28%

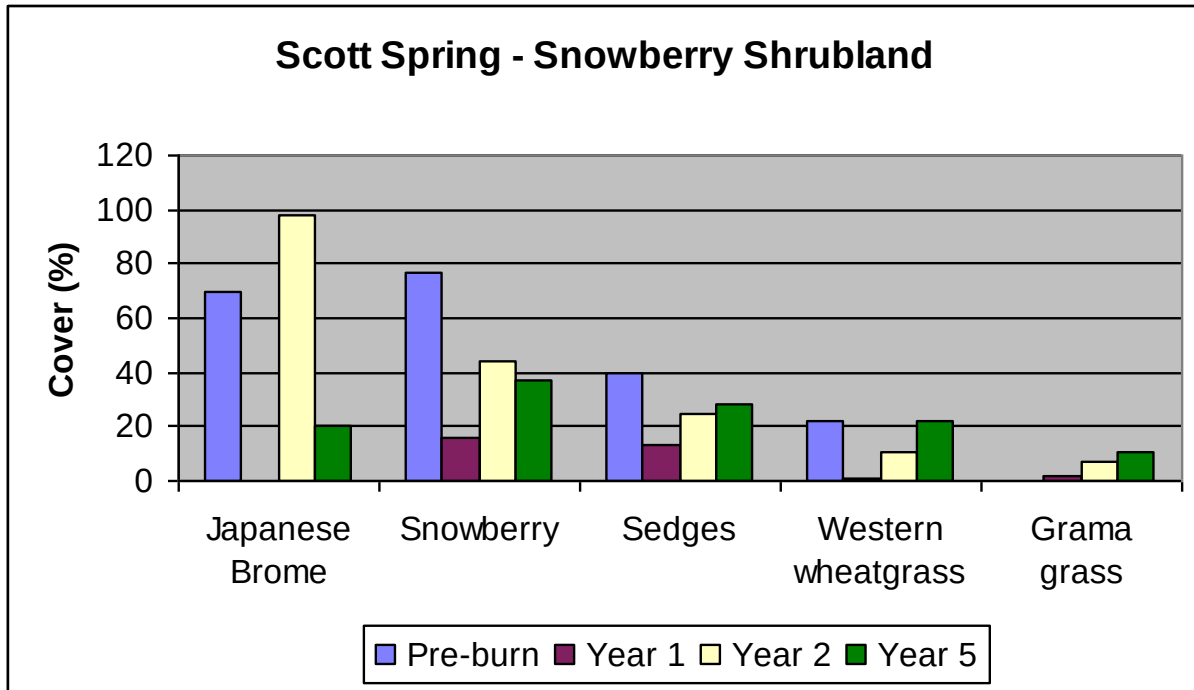


SCOTT SPRING					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 4 Cover	Change
Needle-and-thread	27.5	44.5	62%	77.5	182%
Western wheatgrass	43.0	29.0	-33%	32.0	-26%
Japanese brome	28.5	26.5	-7%	19.5	-32%
Sedges	32.0	18.5	-42%	23.0	-28%
Cheatgrass	4.0	18.0	350%	30.0	650%
Grama grass	6.5	13.0	100%	14.0	115%

One snowberry shrubland plot was installed in the Scott Spring burn unit. Standard error bars are not included due to the small sample size.



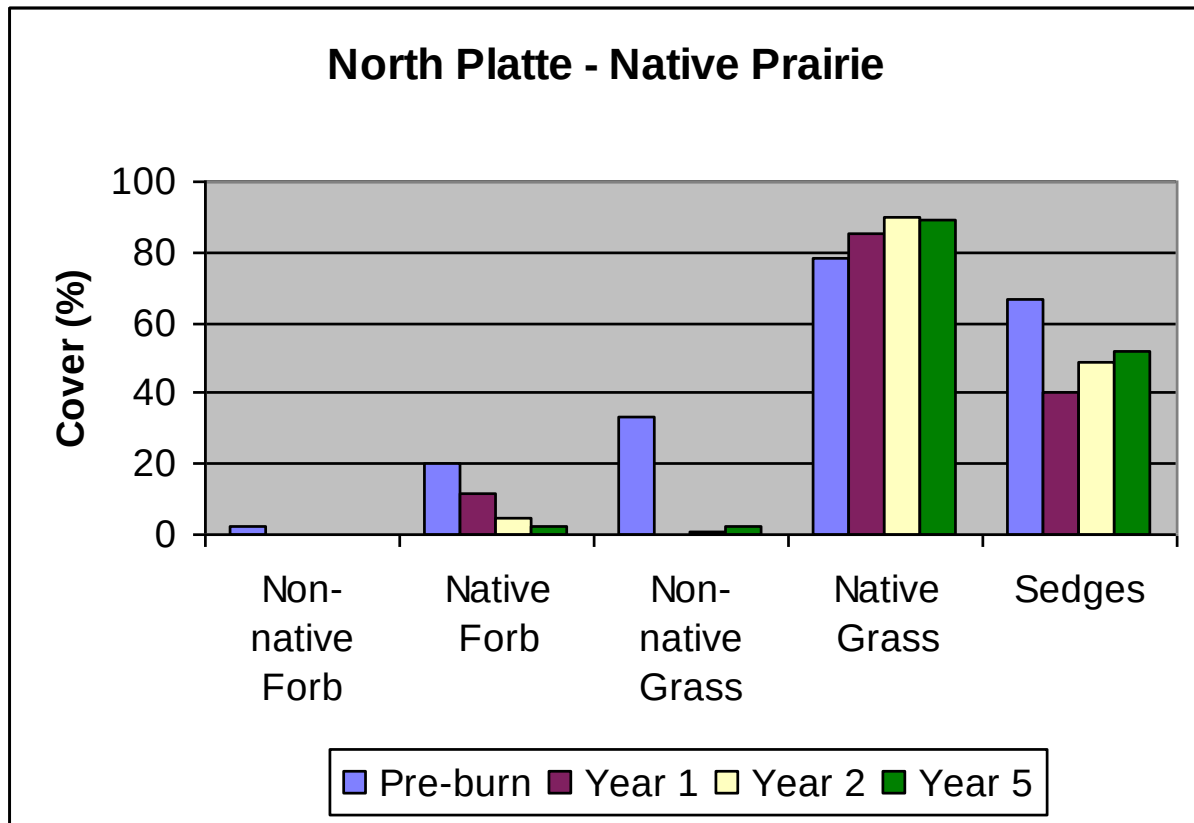
SCOTT SPRING					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	2	6	200%	25	1150%
<i>Native Forb</i>	1	1	---	0	-100%
<i>Non-native Grass</i>	70	98	40%	20	-71%
<i>Native Grass</i>	75	46	-39%	64	-15%



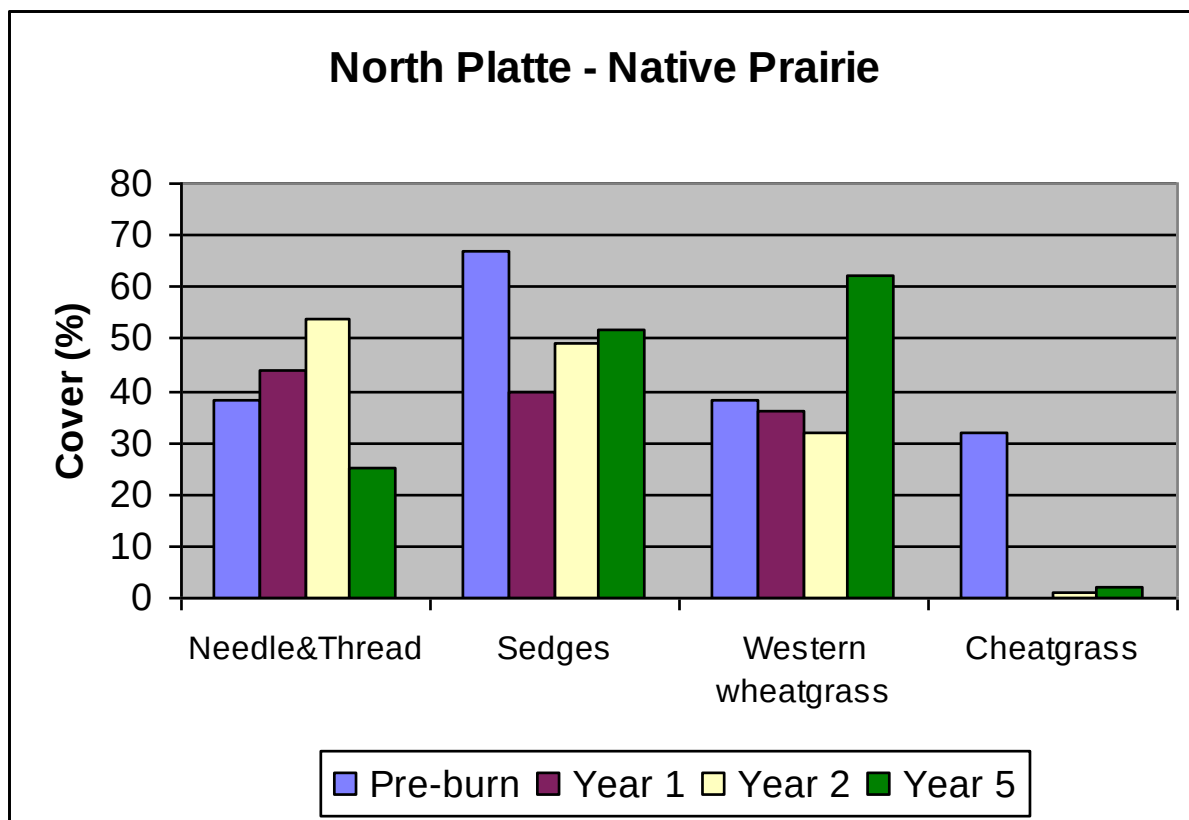
SCOTT SPRING					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Japanese brome</i>	70	98	40%	20	-71%
Snowberry	77	44	-43%	37	-52%
Sedges	40	25	-38%	28	-30%
Western wheatgrass	22	11	-50%	22	---
Grama grass	0	7	+++	11	+++

North Platte

One sideoats grama / needle grass mixed-grass prairie plot was installed in the North Platte burn unit. Standard error bars were not included due to the small sample size.



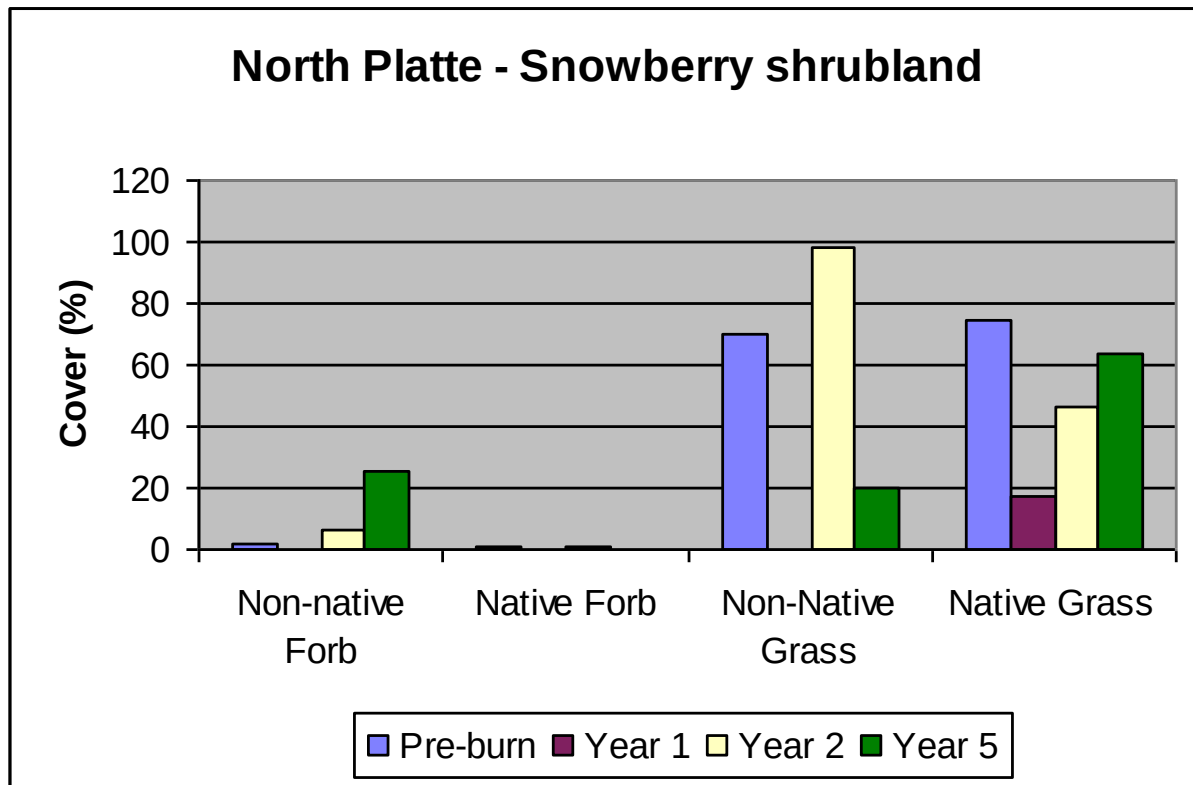
NORTH PLATTE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	2	0	-100%	0	-100%
<i>Native Forb</i>	20	5	-75%	2	-90%
<i>Non-native Grass</i>	33	1	-97%	2	-94%
<i>Native Grass</i>	78	90	15%	89	14%
<i>Sedges</i>	67	49	-27%	52	-22%



NORTH PLATTE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Needle-and-thread	38	54	42%	25	-34%
Sedges	67	49	-27%	52	-22%
Western wheatgrass	38	32	-16%	62	63%
Cheatgrass	32	1	-97%	2	-94%

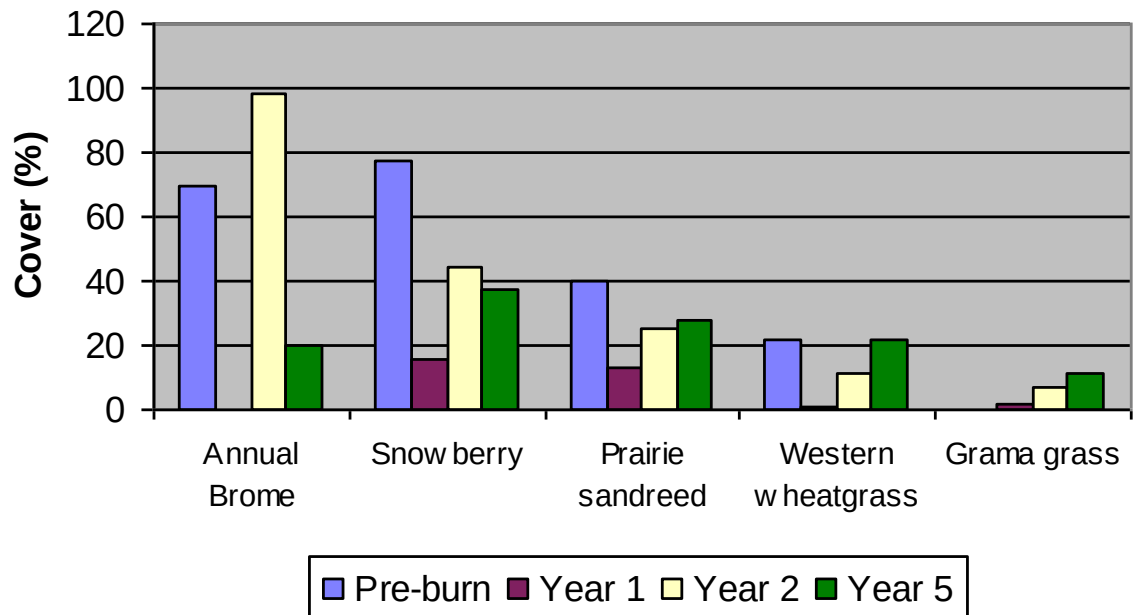


One western snowberry shrubland plot was installed in the North Platte burn unit. Standard error bars were not included due to the small sample size.



NORTH PLATTE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	2	6	200%	25	1150%
<i>Native Forb</i>	1	1	---	0	-100%
<i>Non-native Grass</i>	70	98	40%	20	-71%
<i>Native Grass</i>	75	46	-39%	64	-15%
<i>Sedges</i>	2	6	200%	25	1150%

North Platte - Snowberry shrubland



NORTH PLATTE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Annual brome</i>	70	98	40%	20	-71%
Snowberry	77	44	-43%	37	-52%
Prairie sandreed	40	25	-38%	28	-30%
Western wheatgrass	22	11	-50%	22	---
Grama grass	0	7	++	11	++

Monitoring Units

Juniper woodlands

Prescribed Fire Objectives

Immediate post-burn

- Burn at least 80% of the burnable project area
- Mortality of overstory juniper 10 to 30%
- Reduce litter and duff fuel load by at least 25%

Two years post-burn

- Increase cover of native perennial grass and forb species by at least 20%
- Reduce cover of non-native grasses and forbs by at least 20%
- Limit change in shrub density to no more than $\pm 30\%$ of pre-burn shrub density

Two juniper woodland plots have been installed at SCBL and all are located within the North Bluff burn unit. Graphs and tables of vegetation summary are included on pages 104-107.



Sideoats grama/needlegrass mixed-grass prairie

Prescribed Fire Objectives

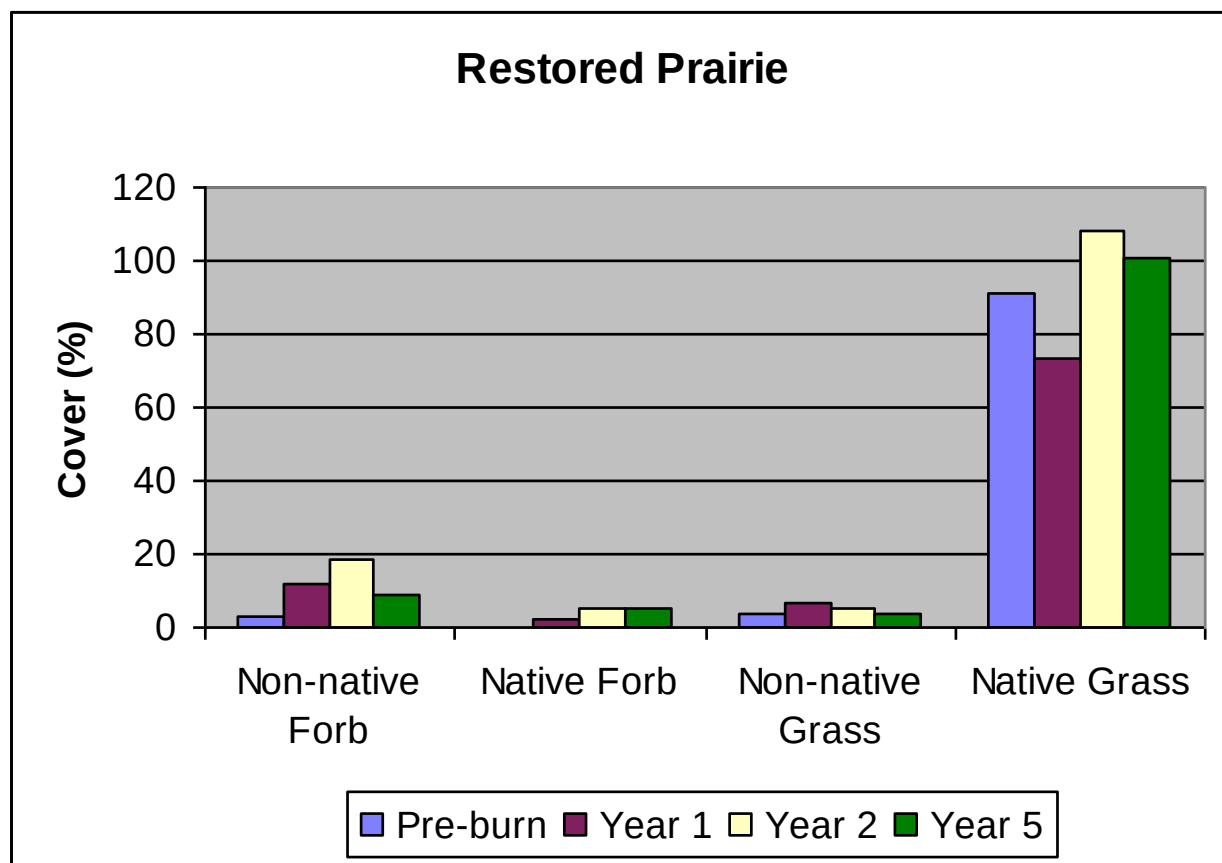
Immediate post-burn

- Burn at least 80% of the burnable project area
- Achieve burn severity of at least 'lightly burned' (3) as defined in the FMH

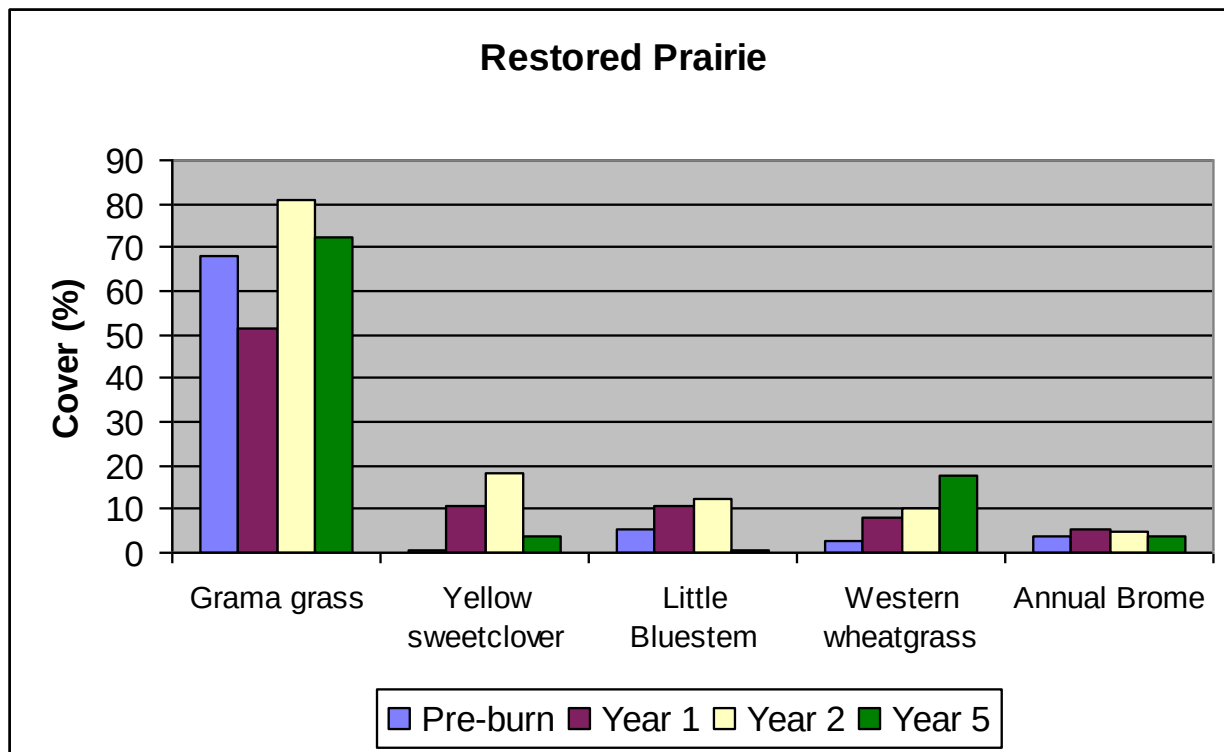
Two years post-burn

- Increase cover of native perennial grass and forb species by at least 20%
- Reduce cover of non-native grasses and forbs by at least 20%

Two sideoats grama / needlegrass mixed-grass prairie plots have been installed at SCBL.



RESTORED PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	3.0	18.5	517%	9.0	200%
<i>Native Forb</i>	0.0	5.0	++	5.0	++
<i>Non-native Grass</i>	3.5	5.0	43%	3.5	---
<i>Native Grass</i>	91.0	108.5	19%	100.5	10%



RESTORED PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Grama grass	68.0	81.0	19%	72.5	7%
Yellow sweetclover	0.5	18.0	3500%	4.0	700%
Little bluestem	5.5	12.5	127%	0.5	-91%
Western wheatgrass	2.5	10.0	300%	17.5	600%
Annual brome	3.5	5.0	43%	3.5	---

Western snowberry shrubland

Prescribed Fire Objectives

Immediate post-burn

- Burn at least 80% of the burnable project area
- Achieve burn severity of at least ‘lightly burned’ (3) as defined in the FMH

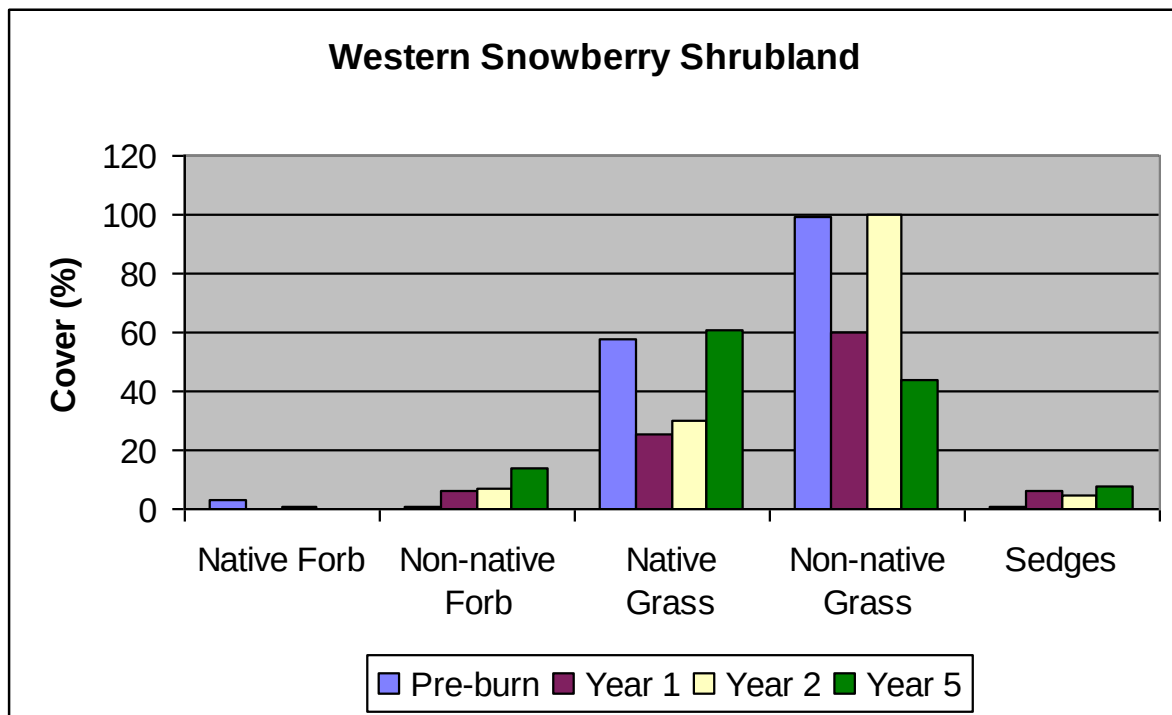
One year post-burn

- Shrub density of snowberry resprouts at least 40% of pre-burn snowberry density

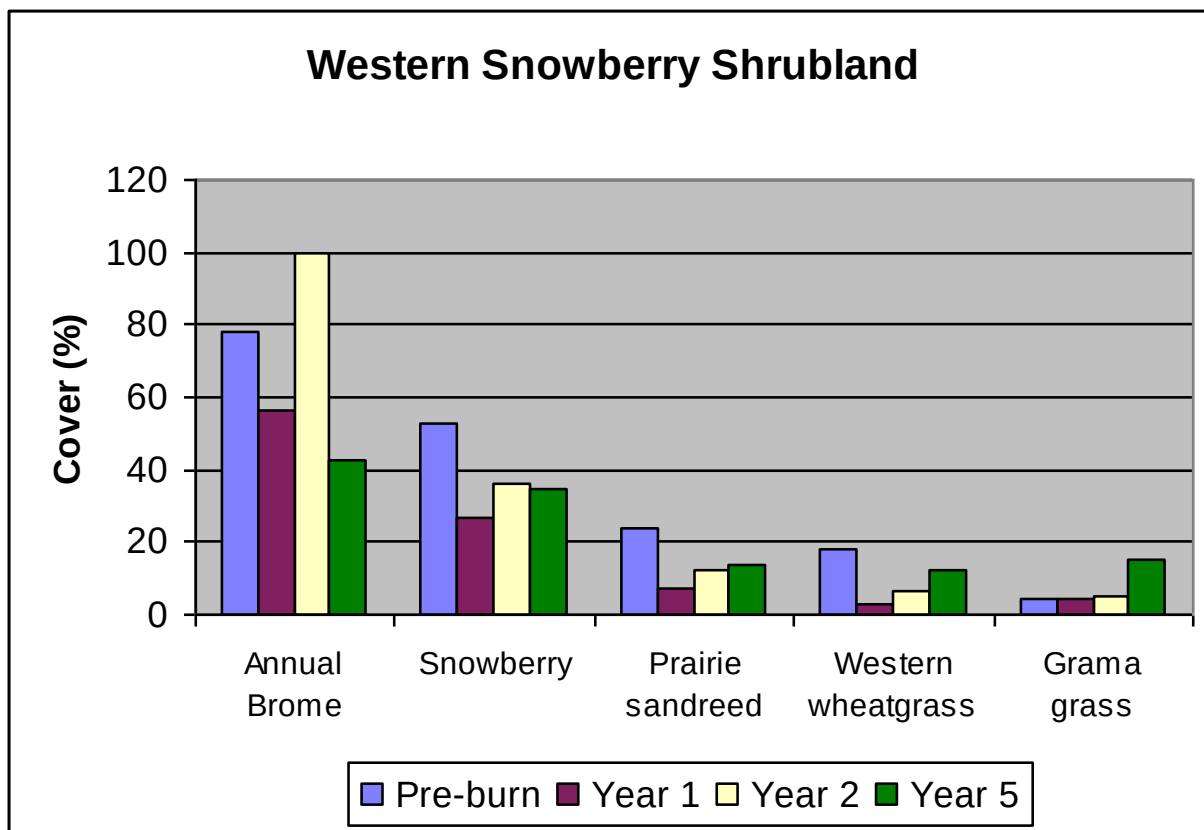
Two years post-burn

- Limit change in shrub density to no more than $\pm 30\%$ of pre-burn shrub density
- Increase cover of native perennial grass and forb species by at least 20%
- Reduce cover of non-native grasses and forbs by at least 20%

Three western snowberry plots have been installed in three burn units within this monitoring type. Only two plots are used for analysis here since one of them had data collection irregularities for the pre-burn data.



SNOWBERRY SHRUBLAND					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	1.0	7.0	600%	13.5	1250%
<i>Native Forb</i>	3.0	0.5	-83%	0.0	-100%
<i>Non-native Grass</i>	99.0	100.0	1%	44.0	-56%
<i>Native Grass</i>	57.5	30.0	-48%	60.5	5%
<i>Sedges</i>	1.0	5.0	400%	7.5	650%



SNOWBERRY SHRUBLAND					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Annual brome</i>	78.0	100.0	28%	42.5	-46%
Snowberry	52.5	36.0	-31%	34.5	-34%
Prairie sandreed	24.0	12.5	-48%	14.0	-42%
Western wheatgrass	18.0	6.5	-64%	12.5	-31%
Grama grass	4.5	5.0	11%	15.5	244%

Needlegrass/sedge mixed-grass prairie

Prescribed Fire Objectives

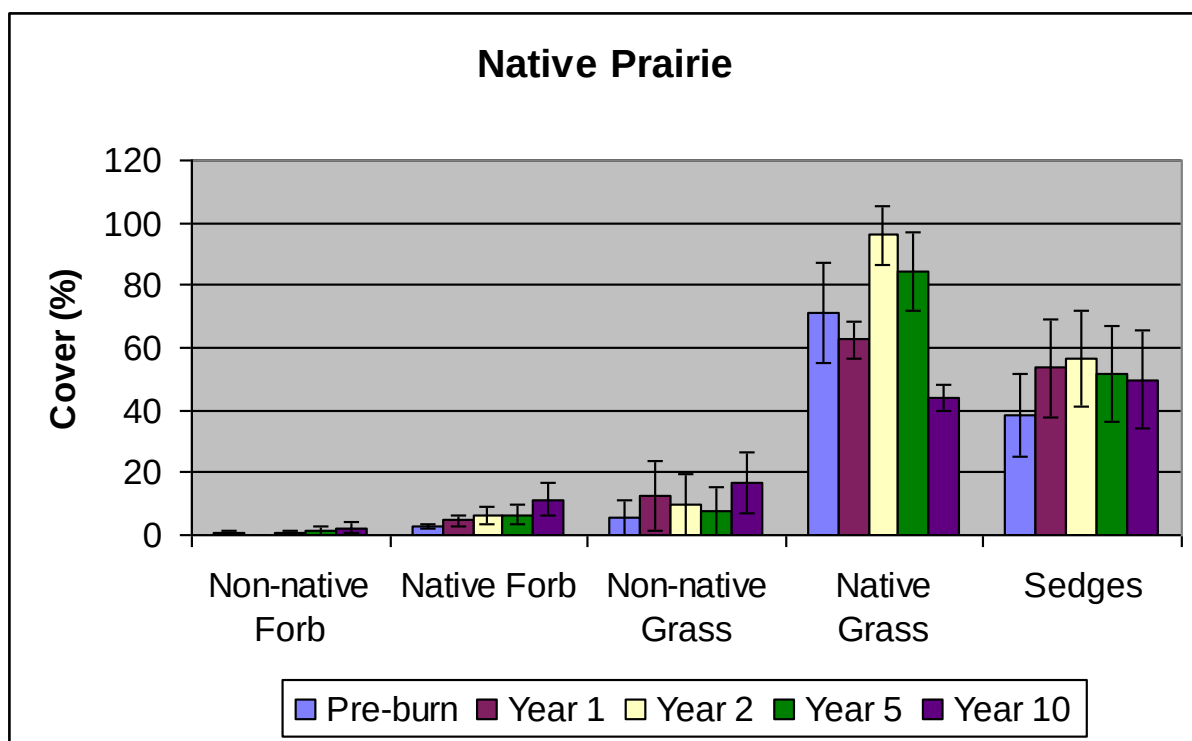
Immediate post-burn

- Burn at least 80% of the burnable project area
- Achieve burn severity of at least ‘lightly burned’ (3) as defined in the FMH

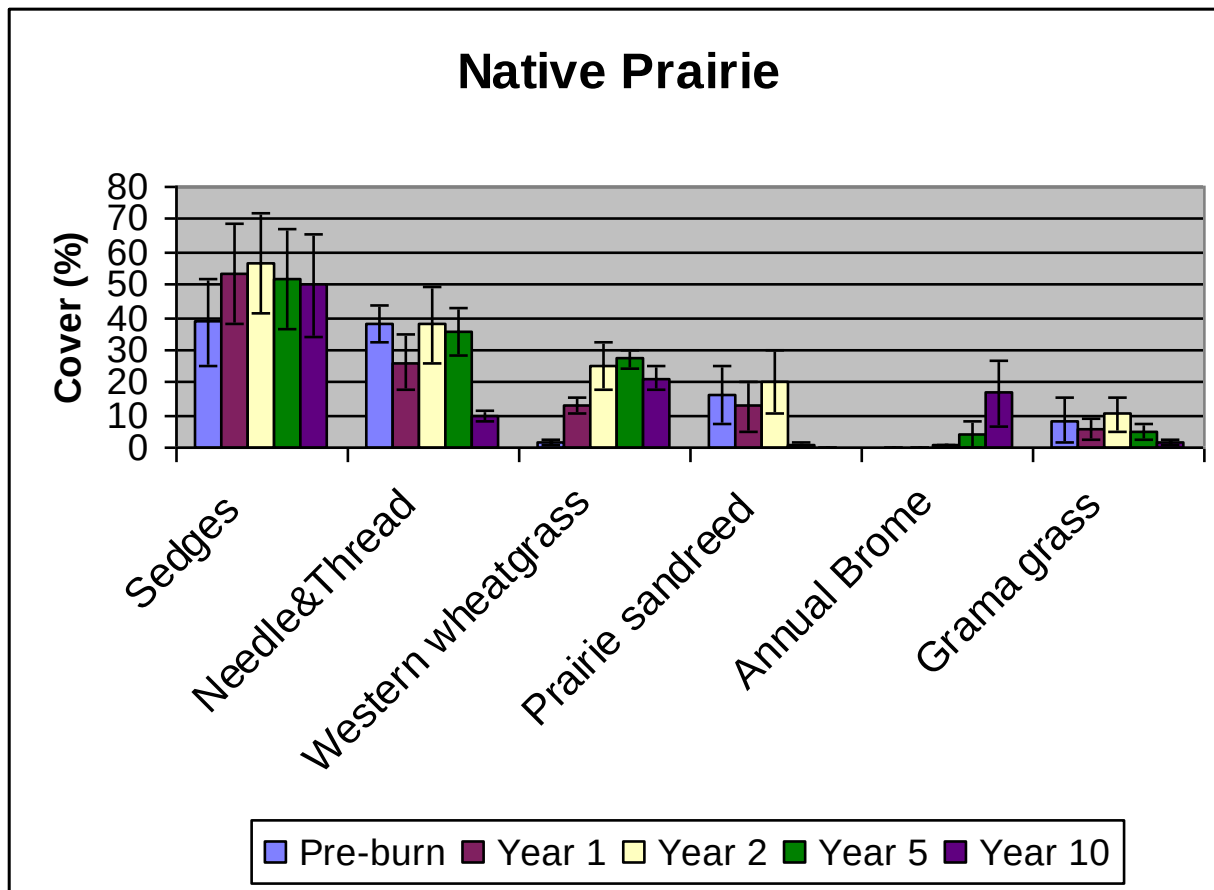
Two years post-burn

- Increase relative cover of native perennial grass and forb species by at least 20%
- Reduce relative cover of non-native grasses and forbs by at least 20%

Eight needlegrass/sedge mixed-grass prairie plots have been installed at SCBL with five of them having year 10 post-burn visits.



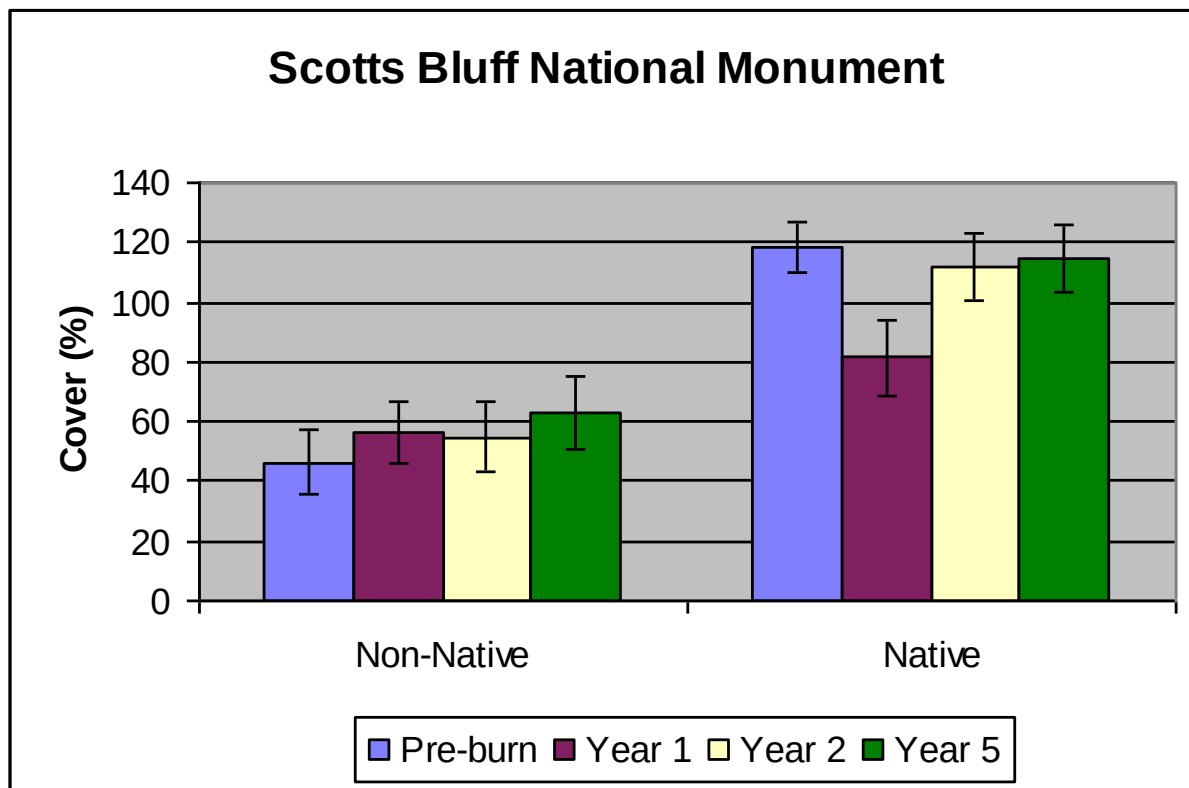
NATIVE PRAIRIE							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
<i>Non-native Forb</i>	0.6	0.8	33%	1.4	133%	2.4	300%
<i>Native Forb</i>	2.8	6.6	136%	6.6	136%	11.4	307%
<i>Non-native Grass</i>	5.6	9.8	75%	7.6	36%	16.6	196%
<i>Native Grass</i>	71.4	96.0	34%	84.6	18%	43.8	-39%
<i>Sedges</i>	38.4	56.2	46%	51.4	34%	49.8	30%



NATIVE PRAIRIE							
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change	Yr 10 Cover	Change
Sedges	38.4	56.2	46%	51.4	34%	49.8	30%
Needle-and-thread	38.0	37.6	-1%	35.4	-7%	9.8	-74%
Western wheatgrass	1.6	25.2	1475%	27.2	1600%	21.2	1225%
Prairie sandreed	16.2	20.4	26%	0.8	-95%	0.0	-100%
Annual brome	0.2	0.6	200%	4.0	1900%	16.6	8200%
Grama grass	8.4	10.2	21%	5.0	-40%	1.6	-81%

Park-wide Summary

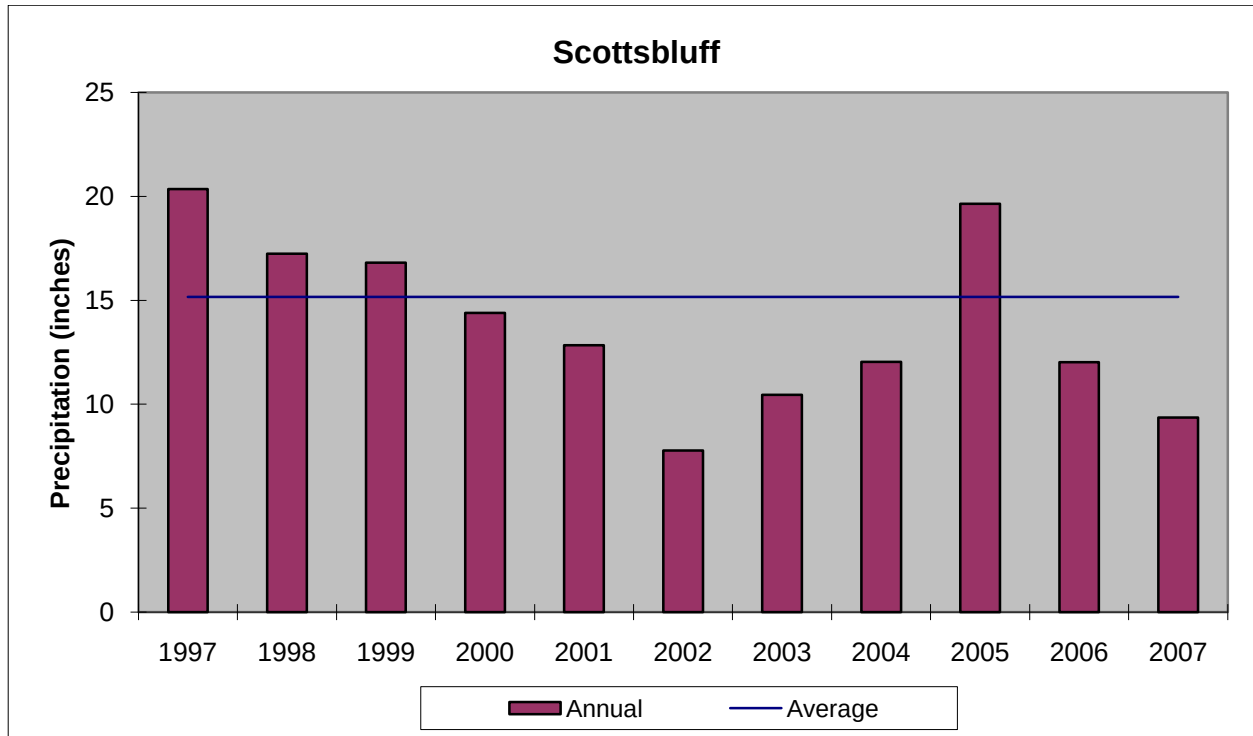
Seventeen FMH plots have been installed at SCBL and all of them have had one prescribed fire event. Due to pre-burn data collection irregularities at four of these plots only thirteen of them are used in the graph and table produced below.



Scotts Bluff National Monument					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Non-native	46.4	54.6	18%	62.8	35%
Native	118.2	112.0	-5%	114.7	-3%

PRECIPITATION

Data from the High Plains Regional Climate Center website (<http://www.hprcc.unl.edu/data/historical/>). Average precipitation for period 1948-2008.





THEODORE ROOSEVELT NATIONAL PARK

MONITORING UNITS

Monitoring units were defined at the initiation of the monitoring program, primarily in 1998 and 1999. At that time, vegetation communities were described, monitoring variables were selected, and objectives were set. Generally monitoring units were selected based on dominant vegetation.

Crested wheatgrass - native prairie interface (AGCR)

Crested wheatgrass (*Agropyron cristatum*) and smooth brome (*Bromus inermis*) dominate the largely exotic community. Native prairie includes: green needlegrass (*Nassella viridula*), needle-and-thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), sideoats grama (*B. curtipendula*), little bluestem (*Schizachyrium scoparium*), with occasional prairie Junegrass (*Koeleria macrantha*), prairie sandreed (*Calamovilfa longifolia*), porcupine grass (*Hesperostipa spartea*), plains muhly (*Muhlenbergia cuspidata*), blackroot sedge (*Carex filifolia*), Sandberg's bluegrass (*Poa sandbergii*), and sand dropseed (*Sporobolus cryptandrus*). Native forbs on site include rough false pennyroyal (*Hedeoma hispida*) and Lewis flax (*Linum lewisii*), blue lettuce (*Lactuca oblongifolia*), yarrow (*Achillea millefolium*), and scarlet globemallow (*Sphaeralcea coccinea*), white locoweed (*Oxytropis sericea*), purple prairie clover (*Dalea purpurea*), white prairie clover (*Dalea candida*), lupine (*Lupinus argenteus*), fringed sage (*Artemisia frigida*), broom snakeweed (*Gutierrezia sarothrae*), and purple coneflower (*Echinacea purpurea*). Shrubs include: skunkbush sumac (*Rhus trilobata*), grey rabbitbrush (*Chrysothamnus nauseosus*), western snowberry (*Symphoricarpos occidentalis*), woods rose (*Rosa woodsii*), and silver sage (*Artemisia cana*)

Silver sagebrush shrubland (ARCA)

Shrubland dominated by silver sage (*Artemisia cana*) with snowberry (*Symphoricarpos occidentalis*) and skunkbush sumac (*Rhus aromatica*). Typical grass species include green needlegrass (*Nassella viridula*), needle and thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), and Kentucky bluegrass (*Poa pratensis*). Forbs present are harebell (*Campanula rotundifolia*), yarrow (*Achillea millefolium*), white milkwort (*Polygala alba*), prairie coneflower (*Ratibida columnifera*), and scurfpea (*Psoralidium* and *Pediomelum* spp.).

Cottonwood/Rocky Mountain juniper forest (PODE)

Cottonwood (*Populus deltoides*) and rocky mountain juniper (*Juniperus scopulorum*) dominate the perennial water courses, along with green ash (*Fraxinus pennsylvanica*) chokecherry (*Prunus virginiana*), box elder (*Acer negundo*) and American elm (*Ulmus americana*). Understory vegetation includes: Canada thistle (*Cirsium arvense*), yellow sweetclover (*Melilotus officinalis*), western wheat (*Agropyron smithii*), smooth brome (*Bromus inermis*) western virgins bower (*Clematis ligusticifolia*), and Virginia creeper (*Parthenocissus inserta*).

Green needlegrass mixed-grass prairie (STVI)

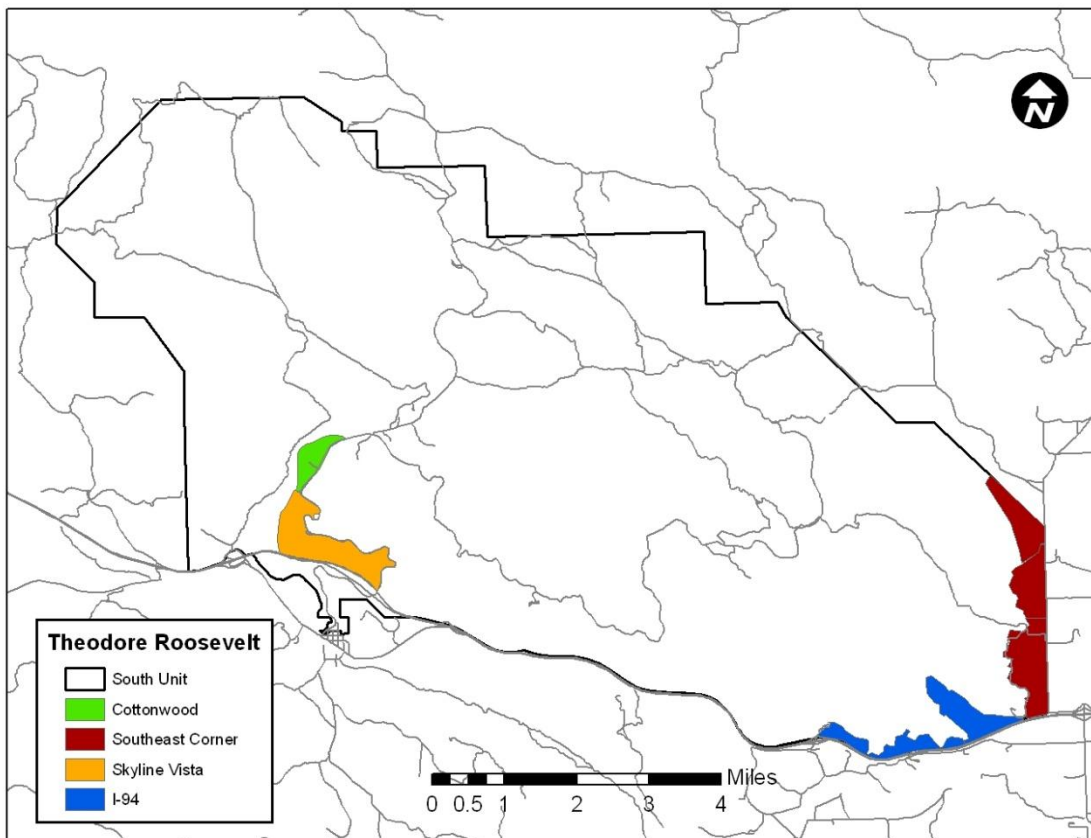
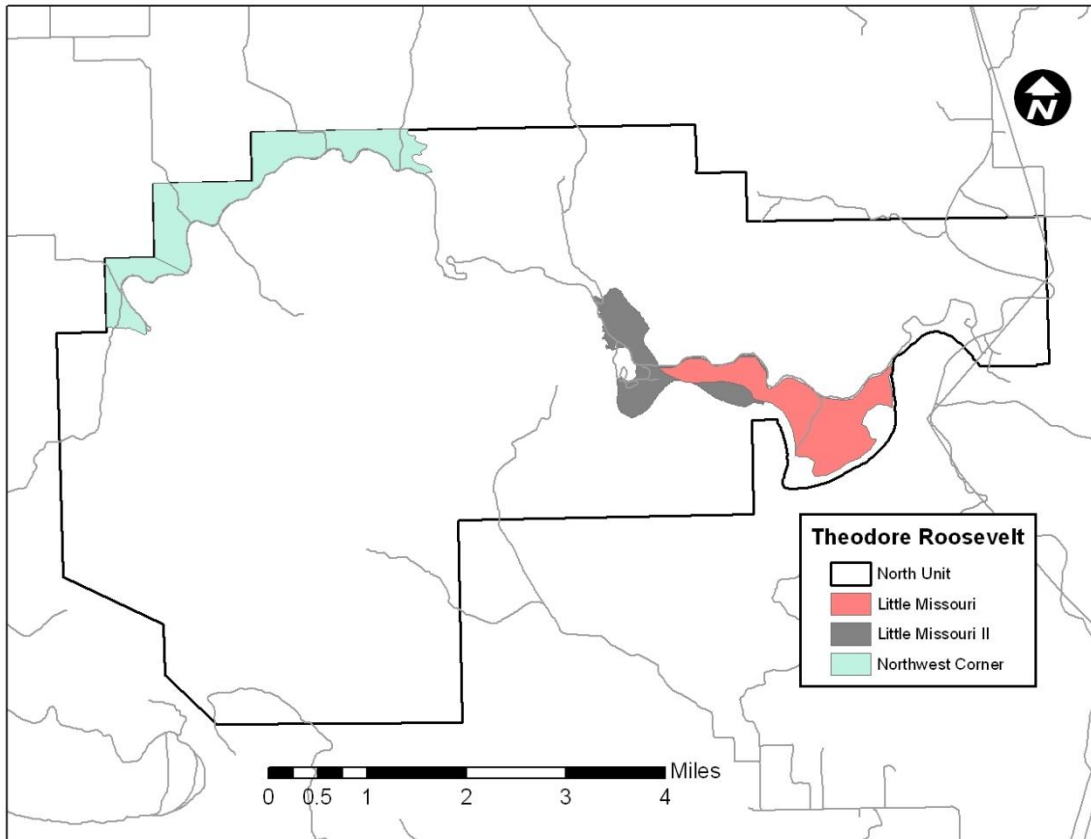
Mixed grass prairie dominated by native perennial grass including green needlegrass (*Nassella viridula*), needle and thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), and Junegrass (*Koeleria macrantha*). Several non-native grasses are also present including; Kentucky bluegrass (*Poa pratensis*), and smooth brome (*Bromus inermis*). Shrubs include western snowberry (*Symphoricarpos occidentalis*), silver sagebrush (*Artemisia cana*), and wild rose (*Rosa woodsii*). Common native forbs are prairie coneflower (*Ratibida columnifera*), silver scurfpea (*Pedimelum argophyllum*), man sage (*Artemisia ludoviciana*), broom snakeweed (*Gutierrezia sarothrae*), sage (*Artemisia filifolia*) and skeleton weed (*Lygodesmia juncea*). Non-native forbs are Western salsify (*Tragopogon dubius*), and yellow sweetclover (*Melilotus officinalis*).

Snowberry shrubland (SYOC)

Primarily a mixed-grass prairie consisting of a shrub/grass mix. Typical species include snowberry (*Symphoricarpos occidentalis*), creeping juniper (*Juniperus horizontalis*), winterfat (*Krascheninnikovia lanata*), Woods' rose (*Rosa woodsii*), fringed sage (*Artemisia frigida*), broom snakeweed (*Gutierrezia sarothrae*) and prickly pear (*Opuntia* spp.). Graminoids include little bluestem (*Schizachyrium scoparium*), green needlegrass (*Nassella viridula*), western wheatgrass (*Pascopyrum smithii*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), threadleaf sedge (*Carex filifolia*), Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*). Common forbs present are harebell (*Campanula rotundifolia*), yarrow (*Achillea millefolium*), white milkwort (*Polygala alba*), prairie coneflower (*Ratibida columnifera*), prairie-turnip (*Pedimelum esculentum*), purple prairie clover (*Petalostemon purpurea*).

PRESCRIBED FIRES

Unit	Date(s)	Season	Size (acres)
Little Missouri	9/21/99	Fall	650
SE Corner	4/19/99	Spring	475
SE Corner	4/11/00	Spring	331
NW Corner	10/18-21/01	Fall	700
Little Mo II	5/13/02	Spring	800
Peaceful Valley	5/29/02	Spring	18
Skyline Vista	10/9/02	Fall	534
I-94	10/10/02	Fall	300
Cottonwood CG	4/25/03	Spring	250
I-94	5/2/03	Spring	250
SE Corner	4/23/04	Spring	910

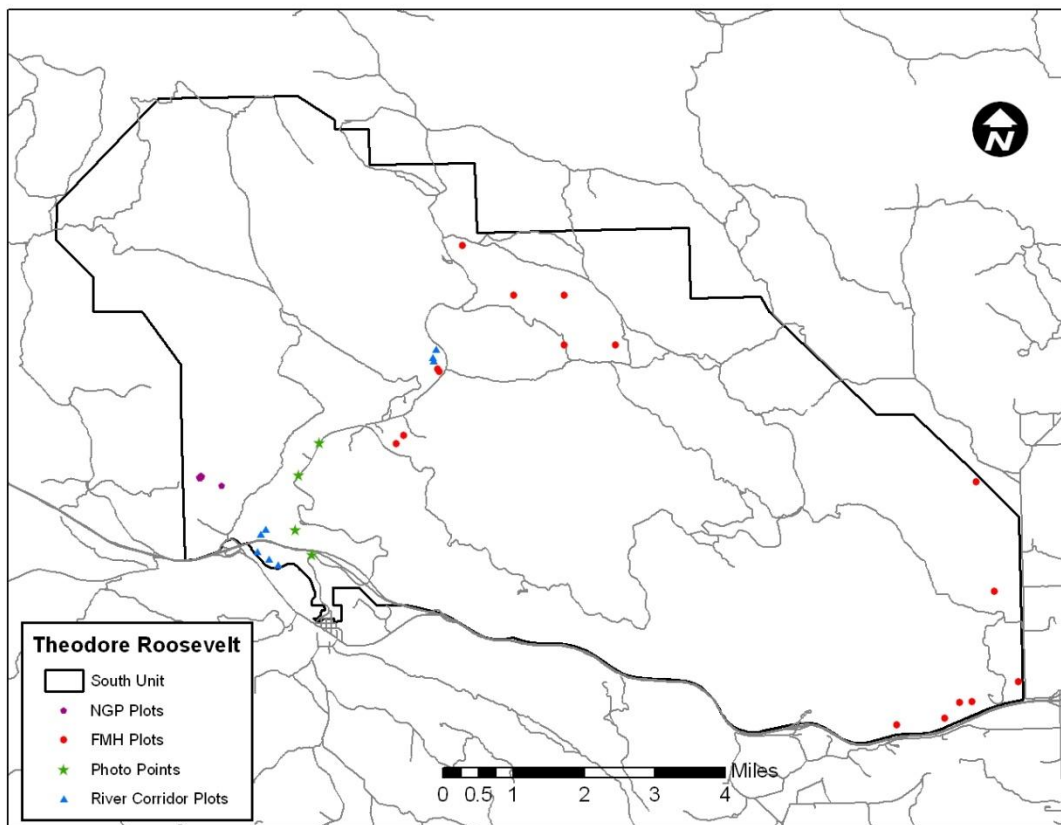
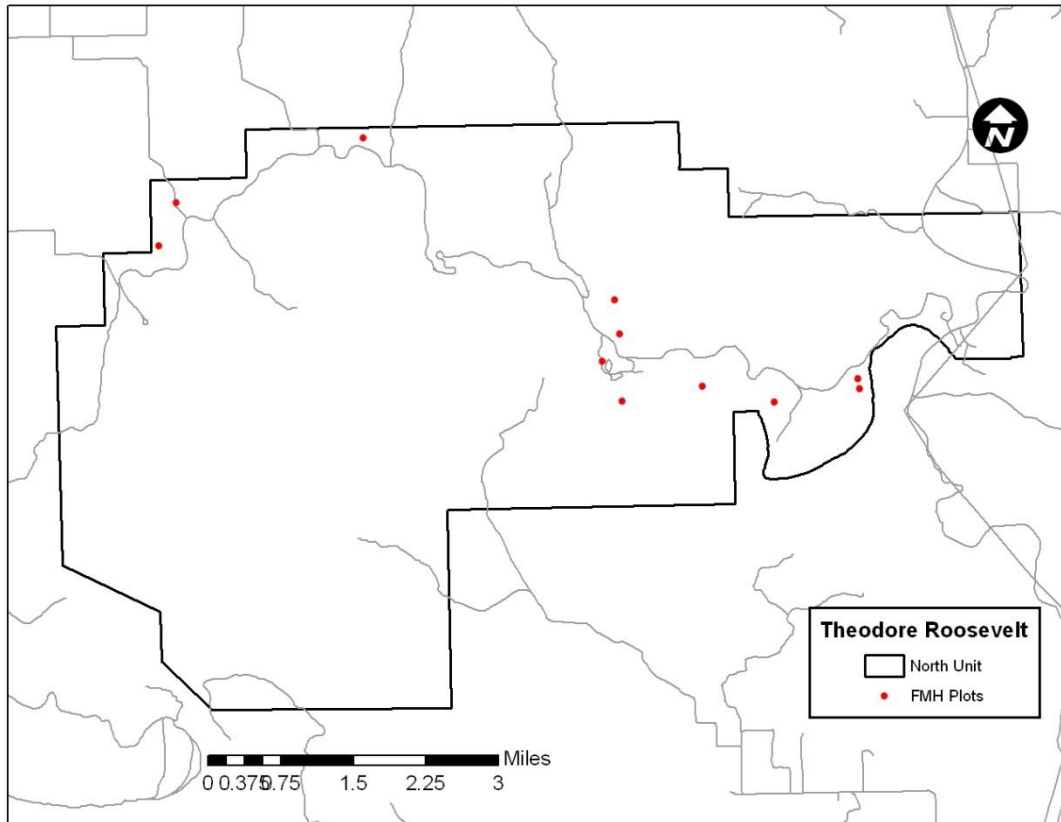


MONITORING PLOTS

Burn Unit	Monitoring Unit	Plot ID	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Cottonwood Campground	Photo Point	PP1							V/B			
Cottonwood Campground	Photo Point	PP2							V/B			
I-94	Crested Wheatgrass	AGCR-01		V		V			B/V	V		
I-94	Crested Wheatgrass	AGCR-02		V		V			B/V	V		
I-94	Crested Wheatgrass	AGCR-03				V		B/V	V	V		
I-94	Crested Wheatgrass	AGCR-04				V						X
I-94	Photo Point	PP3							V			
Jones Creek	Needlegrass	STVI-07								V		
Jones Creek	Needlegrass	STVI-08								V		
Jones Creek	Needlegrass	STVI-09								V		
Jones Creek	Needlegrass	STVI-10								V		
Jones Creek	Silver Sagebrush	ARCA-08								V		
Little Missouri	Cottonwood/Juniper	PODE-01	V		V							
Little Missouri	Silver Sagebrush	ARCA-01		V	B/V	V	V			V		
Little Missouri	Silver Sagebrush	ARCA-02		V	B/V	V	V			V		
Little Missouri	Snowberry	SYOC-01	V		B/V	V	V			V		
Little Mo II	Cottonwood/Juniper	PODE-02		V				B/V	V			V
Little Mo II	Cottonwood/Juniper	PODE-03		V				B/V	V			V
Little Mo II	Silver Sagebrush	ARCA-03					V	B/V	V			V
Little Mo II	Silver Sagebrush	ARCA-04					V	B/V	V			V
NW Corner	Needlegrass	STVI-04			V		V/B	V	V			V
NW Corner	Needlegrass	STVI-05			V		V/B	V	V			V
NW Corner	Needlegrass	STVI-06			V		V/B	V	V			V
Peaceful Valley	Green Ash/Boxelder	FRPE-01					V					
Peaceful Valley	Silver Sagebrush	ARCA-05					V			V		
Peaceful Valley	Silver Sagebrush	ARCA-06					V					
Peaceful Valley	Silver Sagebrush	ARCA-07					V			V		
River Corridor	Cottonwood	RC 7T1								V		X
River Corridor	Cottonwood	RC 7T2								V		X
River Corridor	Mesic Shrubland	RC 1-1								V		X

Burn Unit	Monitoring Unit	Plot ID	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
River Corridor	Mesic Shrubland	RC 1-2								V		X
River Corridor	Mesic Shrubland	RC 2-1								V		X
River Corridor	Mesic Shrubland	RC 2-2								V		X
River Corridor	Mesic Shrubland	RC 2-3								V		X
River Corridor	Mesic Shrubland	RC 7-3								V		X
SE Corner	Needlegrass	STVI-01		V	B/V	V			V	B/V	V	
SE Corner	Needlegrass	STVI-02		V	B/V	V			V	B/V	V	
SE Corner	Needlegrass	STVI-03		V		B/V	V			B/V	V	
Skyline Vista	Photo Point	PP4						V/B				
Skyline Vista	Photo Point	PP5						V/B	V			

V = Plot visit; B = Burned; X = Plot removed

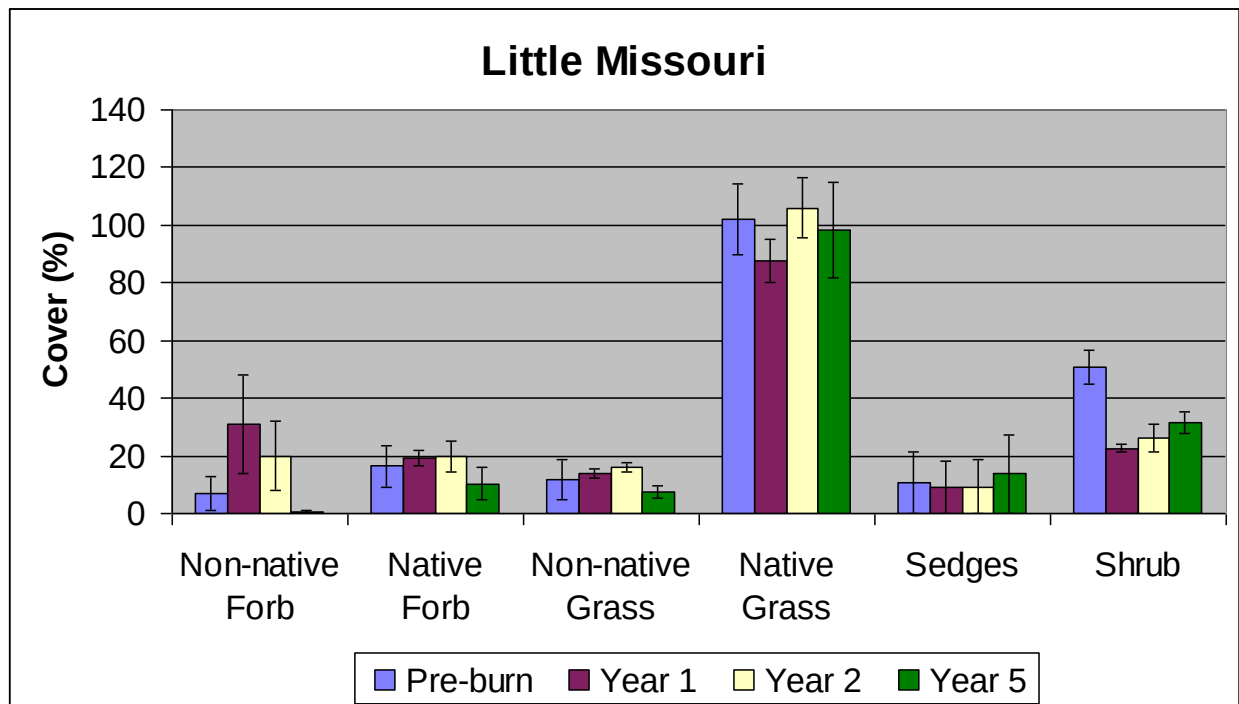


MONITORING RESULTS

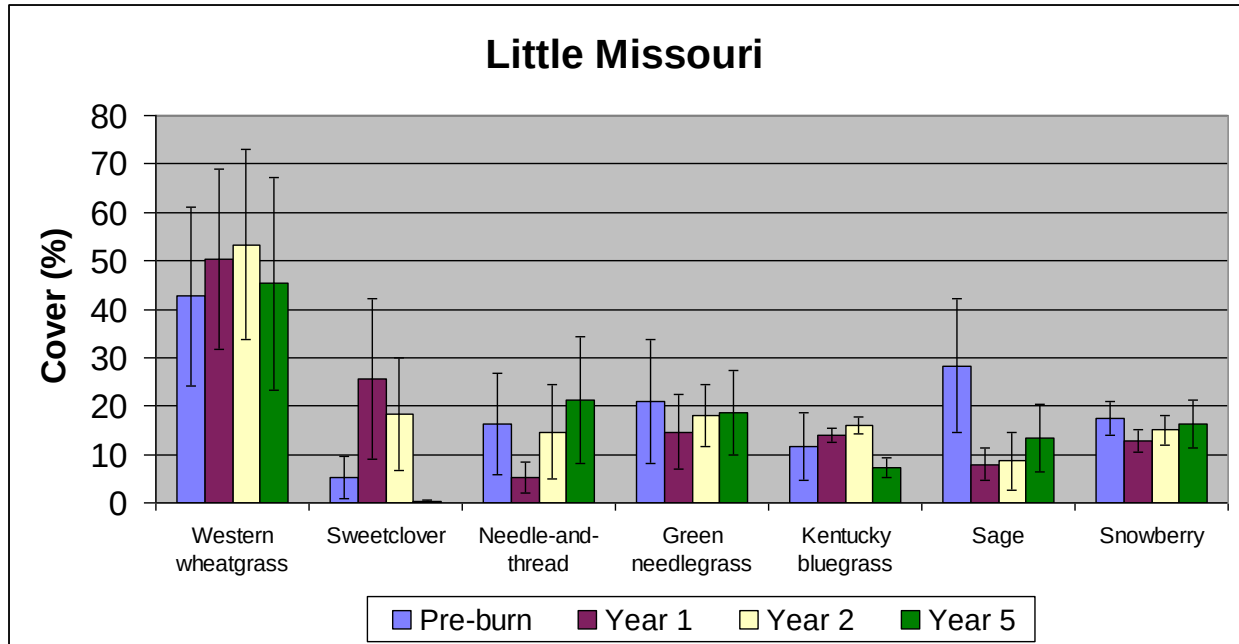
Prescribed Fire Units

Little Missouri

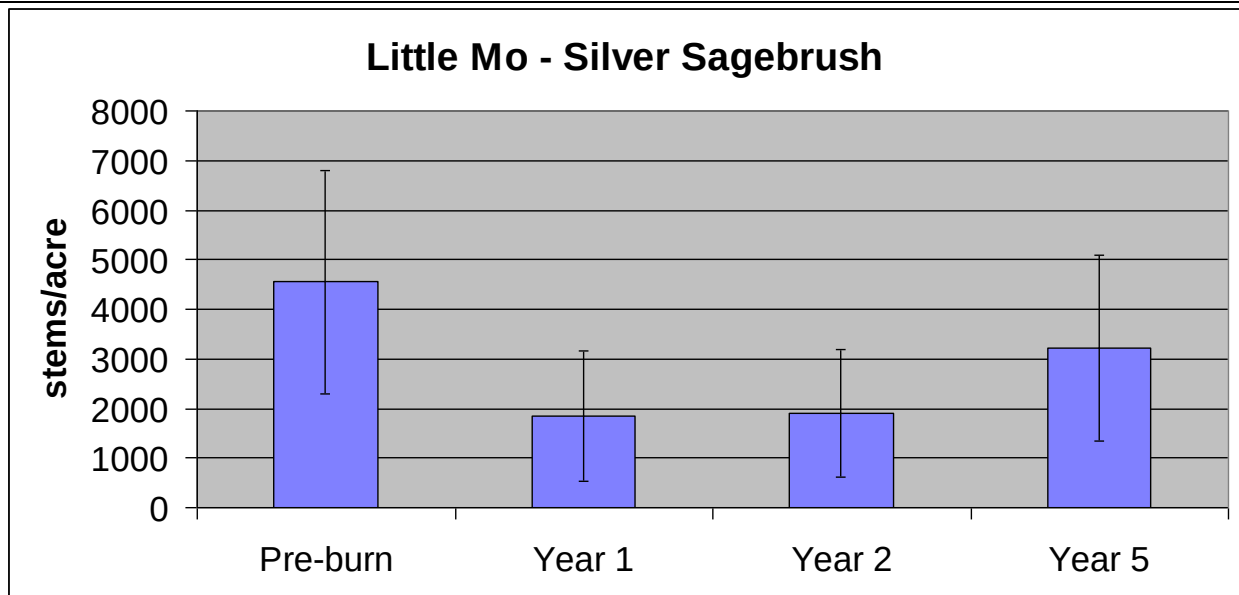
Three shrub plots, 2 silver sagebrush and one snowberry, and one cottonwood plot were installed in the Little Missouri unit. The cottonwood plot has never burned, so only the three shrub plots are included in the summaries below. Variability is fairly high among these plots, so sample size appears to be too small to statistically detect changes within this burn unit, especially at the species level.



LITTLE MISSOURI					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	7.0	20.0	186%	0.7	-90%
<i>Native Forb</i>	16.3	19.7	20%	10.3	-37%
<i>Non-native Grass</i>	11.7	16.0	37%	7.3	-37%
<i>Native Grass</i>	102.0	106.0	4%	98.3	-4%
<i>Sedges</i>	10.7	9.3	-13%	13.7	28%
<i>Shrub</i>	50.7	26.0	-49%	31.7	-38%



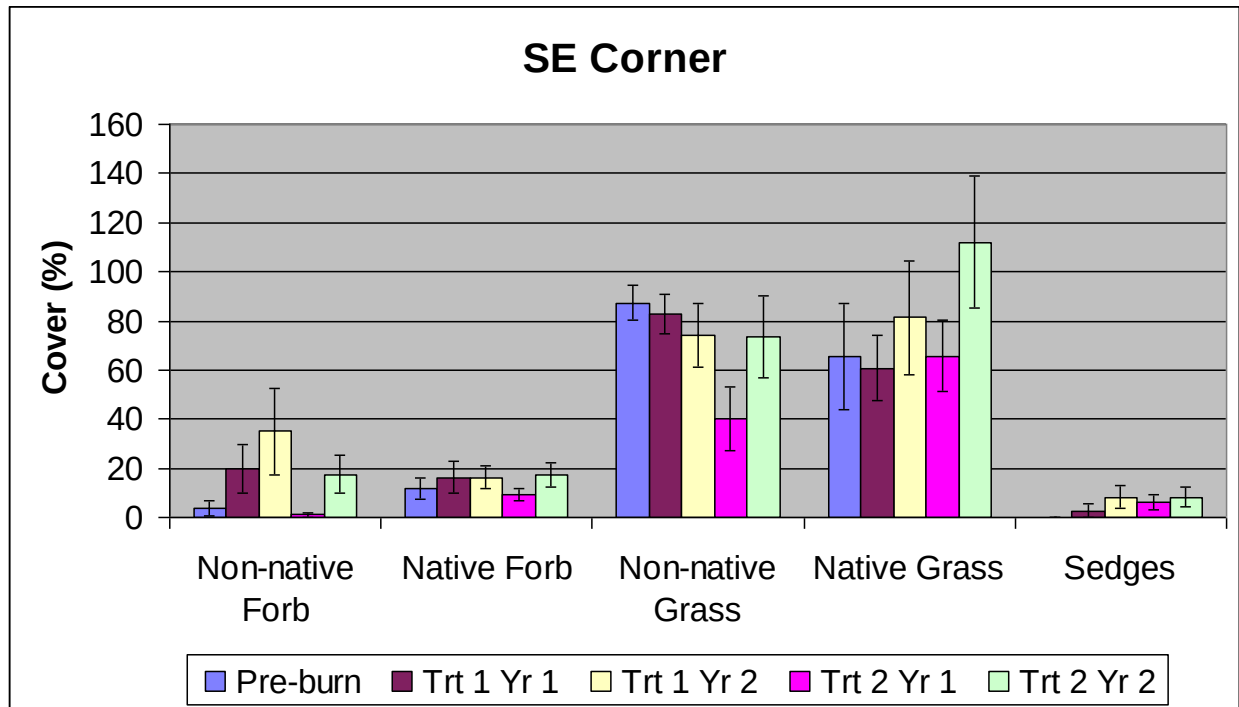
LITTLE MISSOURI					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	42.7	53.3	25%	45.3	6%
Sweetclover	5.3	18.3	244%	0.3	-94%
Needle-and-thread	16.3	14.7	-10%	21.3	31%
Green needlegrass	21.0	18.0	-14%	18.7	-11%
Kentucky bluegrass	11.7	16.0	37%	7.3	-37%
Sage	28.3	8.7	-69%	13.3	-53%
Snowberry	17.3	15.0	-13%	16.3	-6%



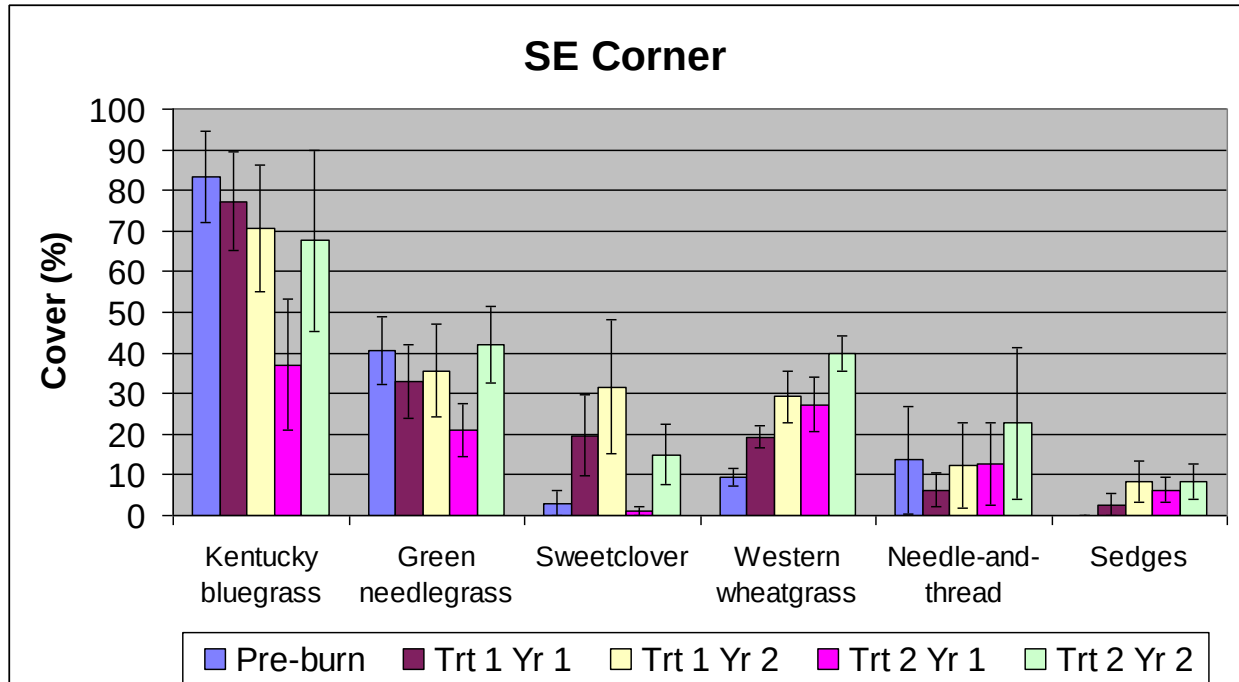
LITTLE MISSOURI					
stems/acre	Pre-burn	Yr 2	Change	Yr 5	Change
Silver sagebrush	4546	1902	-58%	3206	-29%

Southeast Corner

Three green needlegrass plots were installed, although the plots would be more appropriately described as Kentucky bluegrass plots. All three plots have burned twice.



SOUTHEAST CORNER					
	Pre-burn Cover	Trt 1Yr 2 Cover	Change	Trt 2Yr 2 Cover	Change
<i>Non-native Forb</i>	3.7	35.0	855%	17.3	373%
<i>Native Forb</i>	11.7	16.3	40%	17.0	46%
<i>Non-native Grass</i>	87.3	74.0	-15%	73.3	-16%
<i>Native Grass</i>	65.3	81.3	24%	112.0	71%
<i>Sedges</i>	0.0	8.3	+	8.3	+

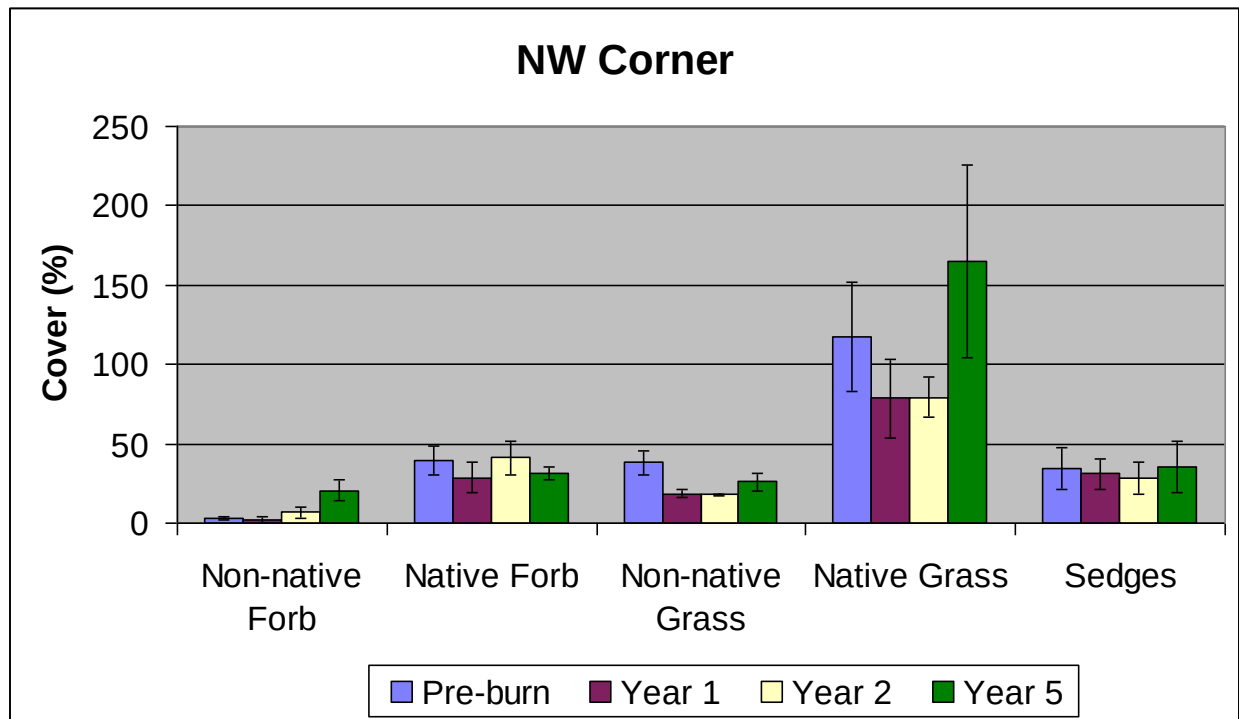


LITTLE MISSOURI					
	Pre-burn cover	Trt 1 Yr 2 Cover	Change	Trt 2 Yr 2 Cover	Change
<i>Kentucky bluegrass</i>	83.3	70.7	-15%	67.7	-19%
<i>Green needlegrass</i>	40.7	35.7	-12%	42.0	3%
<i>Sweetclover</i>	3.0	31.7	956%	15.0	400%
<i>Western wheatgrass</i>	9.3	29.3	214%	40.0	329%
<i>Needle-and-thread</i>	13.7	12.3	-10%	22.7	66%
<i>Sedges</i>	0.0	8.3	+	8.3	+

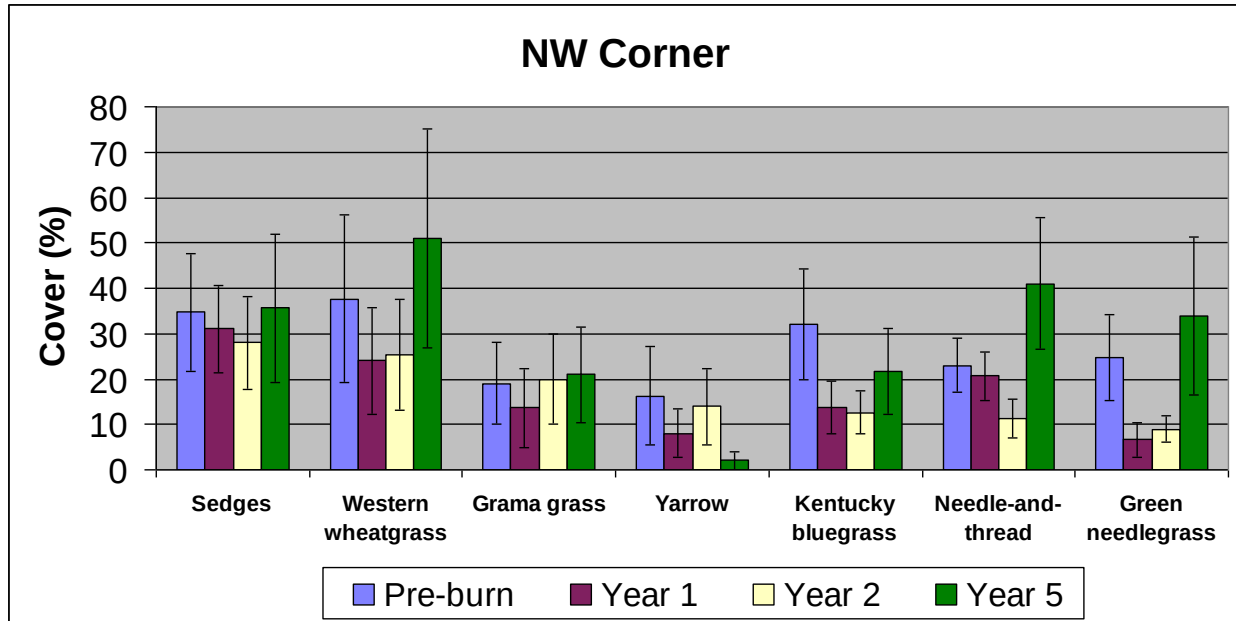


Northwest Corner

Three green needlegrass plots were installed in the Northwest Corner prescribed fire unit.



NORTHWEST CORNER					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	3.3	6.7	100%	20.7	520%
<i>Native Forb</i>	39.3	41.0	4%	31.3	-20%
<i>Non-native Grass</i>	38.3	18.0	-53%	26.0	-32%
<i>Native Grass</i>	117.7	79.3	-33%	164.7	40%
<i>Sedges</i>	34.7	28.0	-19%	35.7	3%

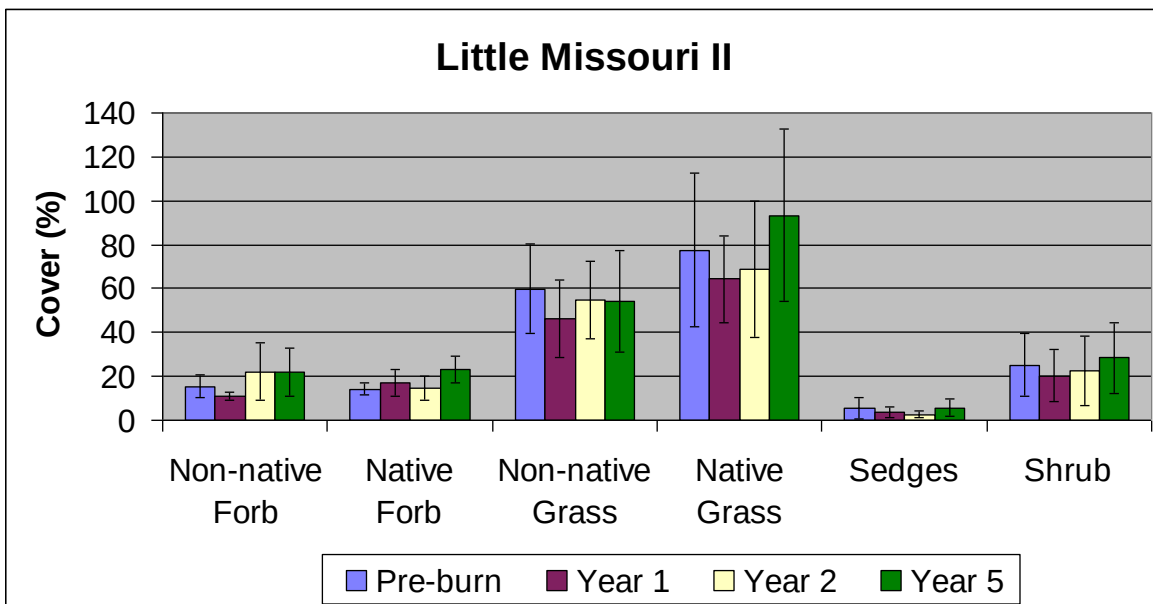


NORTHWEST CORNER					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Sedges	34.7	28.0	-19%	35.7	3%
Western wheatgrass	37.7	25.3	-33%	51.0	35%
Grama grasses	19.0	20.0	5%	21.0	11%
Common yarrow	16.3	14.0	-14%	2.0	-88%
Kentucky bluegrass	32.0	12.7	-60%	21.7	-32%
Needle-and-thread	23.0	11.3	-51%	41.0	78%
Green needlegrass	24.7	9.0	-64%	34.0	38%

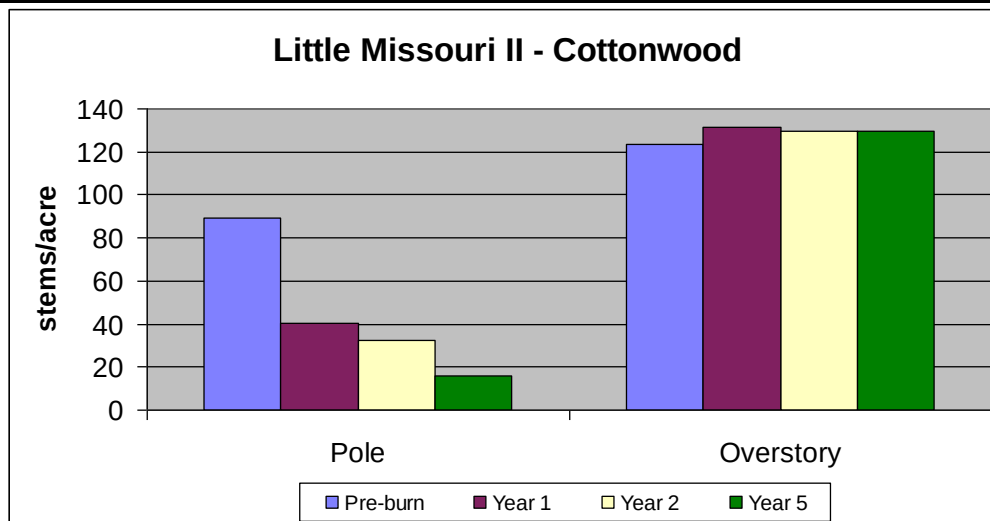


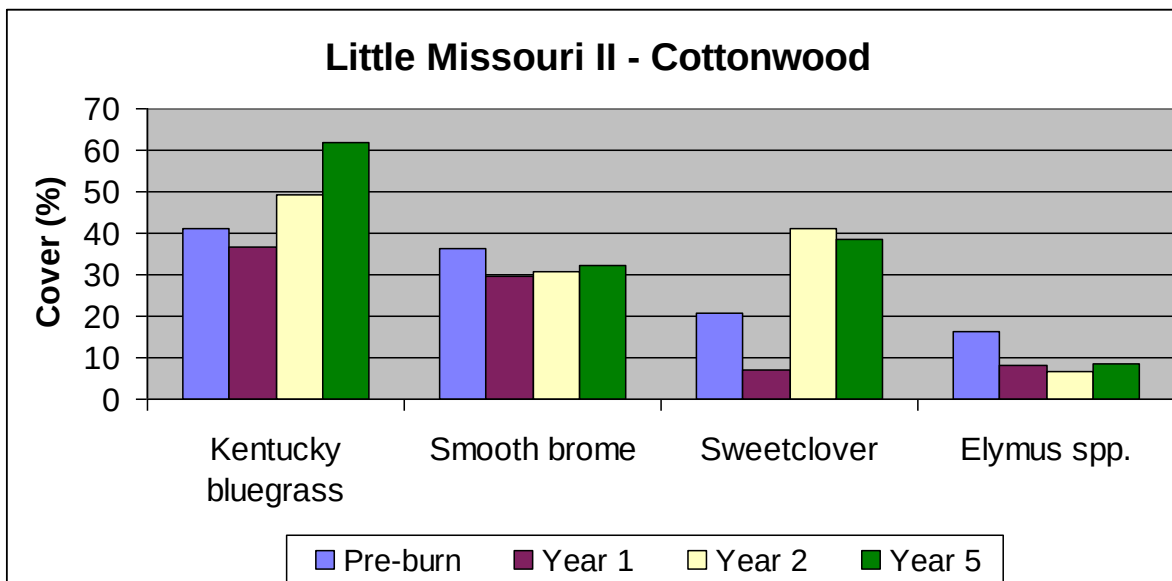
Little Missouri II

Two silver sagebrush and two cottonwood plots were installed in this unit. The summary by lifeform includes all four plots while the vegetation types were separated for the summary of cover by species, tree density, fuel load, and shrub density. Standard error bars were not included with the figures for the summaries by species because of the small sample size.



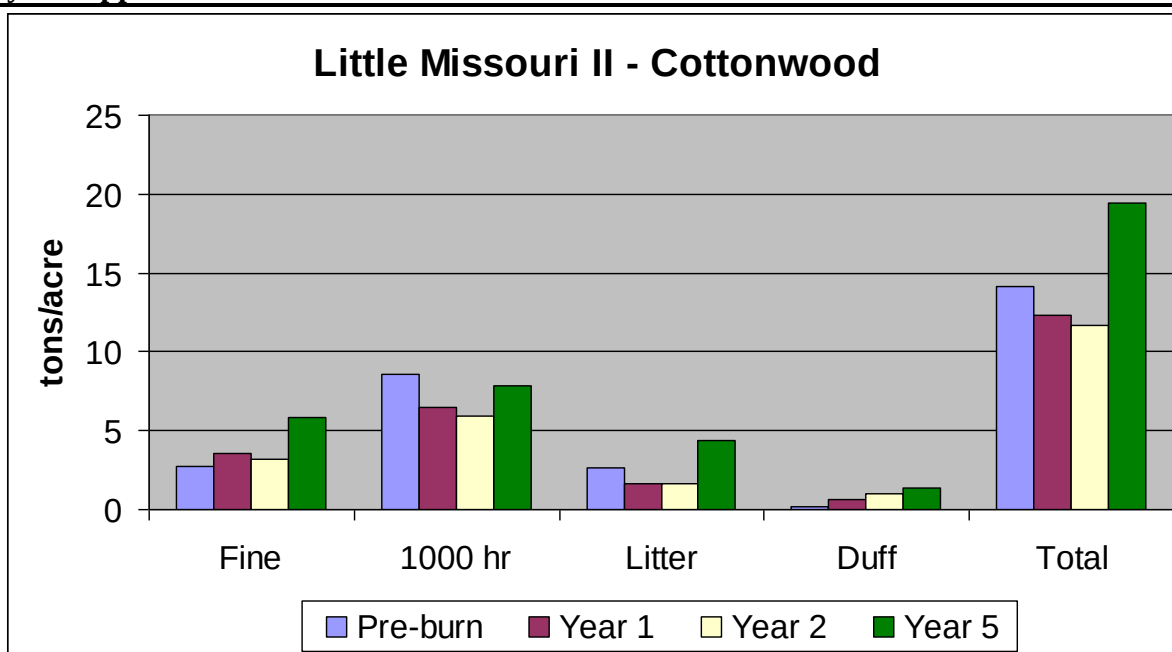
LITTLE MISSOURI II					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	15.3	22.1	44%	21.8	42%
<i>Native Forb</i>	14.3	14.4	1%	23.1	62%
<i>Non-native Grass</i>	59.9	54.9	-8%	54.2	-9%
<i>Native Grass</i>	77.5	68.8	-11%	93.3	20%
<i>Sedges</i>	5.5	2.6	-53%	5.6	2%
<i>Shrub</i>	25.1	22.7	-10%	28.5	14%





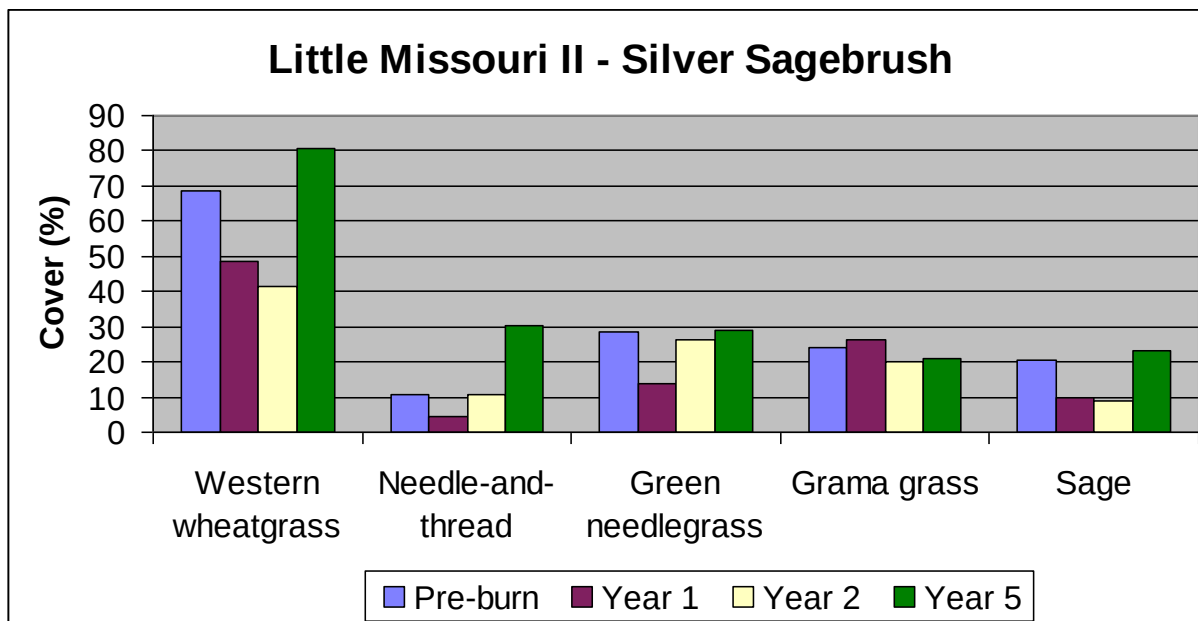
LITTLE MISSOURI II - COTTONWOOD

	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Kentucky bluegrass</i>	41.3	49.1	19%	61.7	50%
<i>Smooth brome</i>	36.1	30.7	-15%	32.2	-11%
<i>Sweetclover</i>	20.8	41.0	97%	38.6	86%
<i>Elymus spp.</i>	16.3	6.6	-59%	8.4	-48%

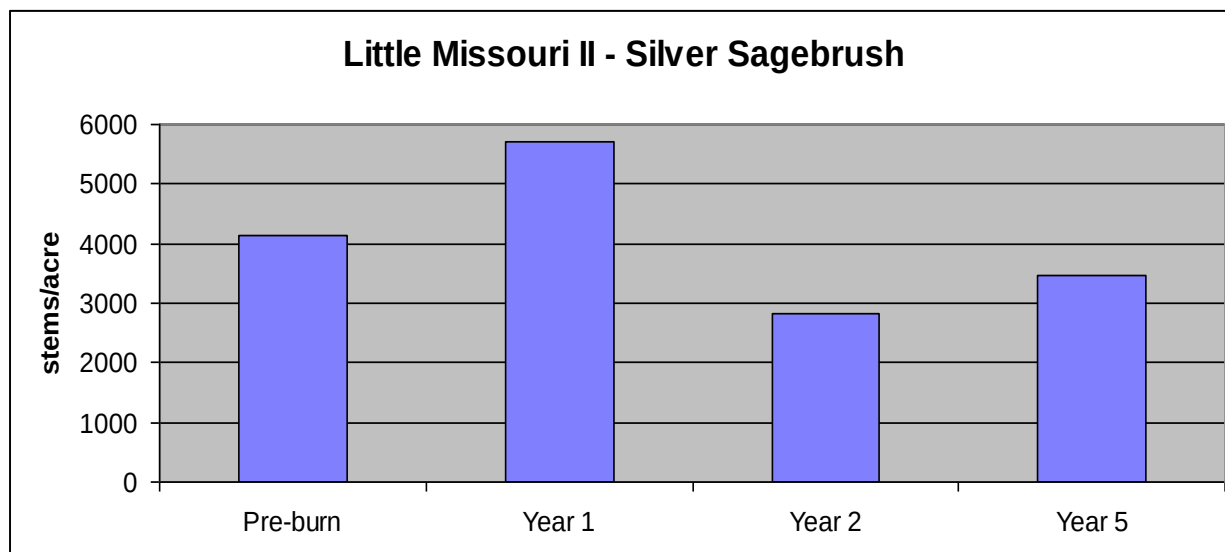


Little Missouri II - Cottonwood

	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	11.3	10.1	-20%	13.6	21%
Litter & Duff	2.8	2.3	-7%	5.8	106%
Total	14.1	12.3	-17%	19.5	38%



LITTLE MISSOURI II – SILVER SAGEBRUSH					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	68.5	41.5	-39%	80.5	18%
Needle-and-thread	10.5	10.5	0%	30.5	190%
Green needlegrass	28.5	26.5	-7%	29.0	2%
Grama grass	24.0	20.0	-17%	21.0	-13%
Artemisia spp.	20.5	9.0	-56%	23.0	12%



LITTLE MISSOURI II					
stems/acre	Pre-burn	Yr 2	Change	Yr 5	Change
Silver sagebrush	4148	2833	-32%	3474	-16%

Peaceful Valley

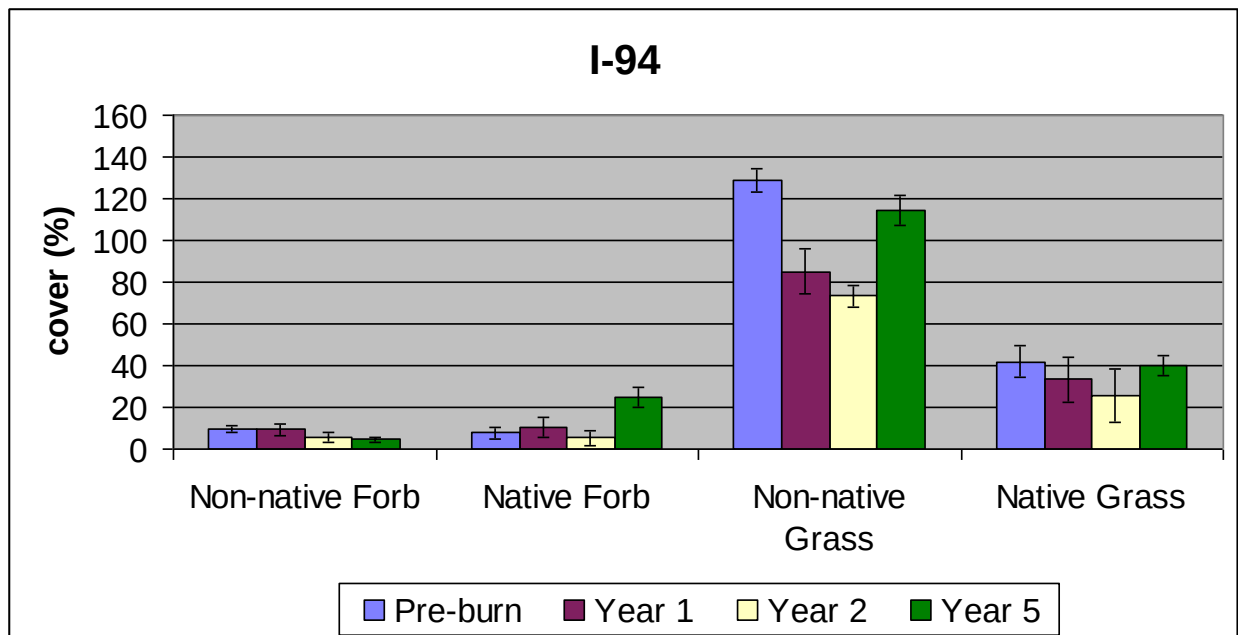
No plots have burned in this unit.

Skyline Vista

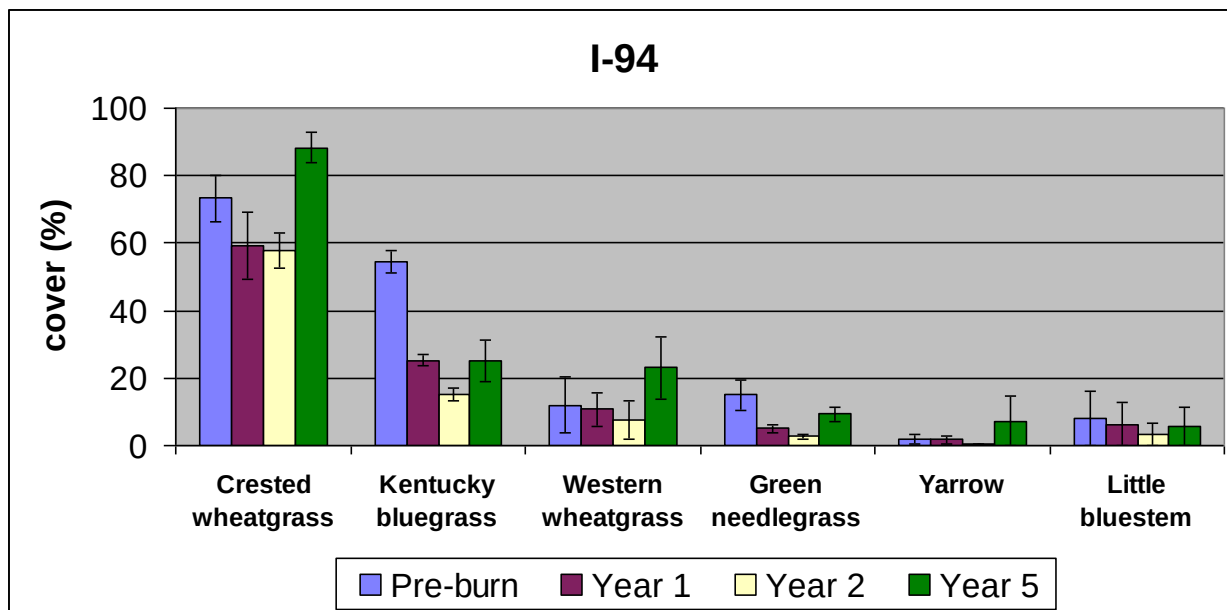
No plots have been installed in this unit.

I-94

Four crested wheatgrass plots were installed in this unit. One of the plots was mowed through during preparation for the prescribed fire, so only three plots are included in the summary.



I-94					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	9.7	5.3	-45%	4.7	-52%
<i>Native Forb</i>	7.7	5.3	-30%	24.7	222%
<i>Non-native Grass</i>	128.7	73.3	-43%	114.3	-11%
<i>Native Grass</i>	42.0	25.7	-39%	40.0	-5%



I-94					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Crested wheatgrass</i>	73.3	58.0	-21%	88.3	20%
<i>Kentucky bluegrass</i>	54.7	15.3	-72%	25.3	-54%
<i>Western wheatgrass</i>	12.0	7.7	-36%	23.0	92%
<i>Green needlegrass</i>	15.0	2.7	-82%	9.3	-38%
<i>Common yarrow</i>	2.0	0.3	-83%	7.3	267%
<i>Little bluestem</i>	8.0	3.3	-58%	5.7	-29%



Cottonwood Campground

Photo points were installed in this burn unit.



Monitoring Units

Crested Wheatgrass

This monitoring unit only exists in one prescribed fire unit (I-94). Four plots were installed between 1998 and 2000. One of these plots was mowed through during the preparation for the 2002 prescribed fire, so this plot was not revisited following the prescribed fire. One plot burned in the 2002 prescribed fire and two plots burned in the 2003 prescribed fire. Refer to the I-94 summary for figures and tables.

Prescribed Fire Objectives

Immediate Post-burn

- Burn 60-90% of project area.
- Reduce fuel load by 50-85%.

Two Years Post-burn

- Reduce cover of non-native grass by at least 20%.
- Increase cover of native grass by at least 20%.
- Limit hardwood mortality to less than 10%.

Five Years Post-burn

- Maintain reduction in non-native species
- Maintain increase in native species

Cover of both native and non-native grasses were reduced two years following the prescribed fire. Overall grass cover generally is reduced the first year following fire, but usually increases the second year. This leads me to believe that the response observed on these plots is a combined effect of fire and some other variable, possibly precipitation. All three plots were visited during summer of 2004.

Cover of all common grass species was reduced two years after prescribed fire. *Poa* species *Nassella viridula* tend to be relatively sensitive to fire, so it is not surprising that cover of these species decreased following prescribed fire. Wheatgrass species generally respond favorably to fire, but it was not troubling to see cover of crested wheatgrass remain below pre-burn levels. It was, however, more troubling that western wheatgrass cover decreased two years following fire. It appears that western wheatgrass cover was unchanged year one and decreased year two. This may be support for the idea that the response of grass cover was influenced by precipitation.

Silver sagebrush shrubland

Plots from this monitoring unit occur in four prescribed fire units, two of which have burned. Two plots burned in 1999 and two in 2002. Four other plots have been installed but have not yet burned.

Prescribed Fire Objectives

Immediate Post-burn

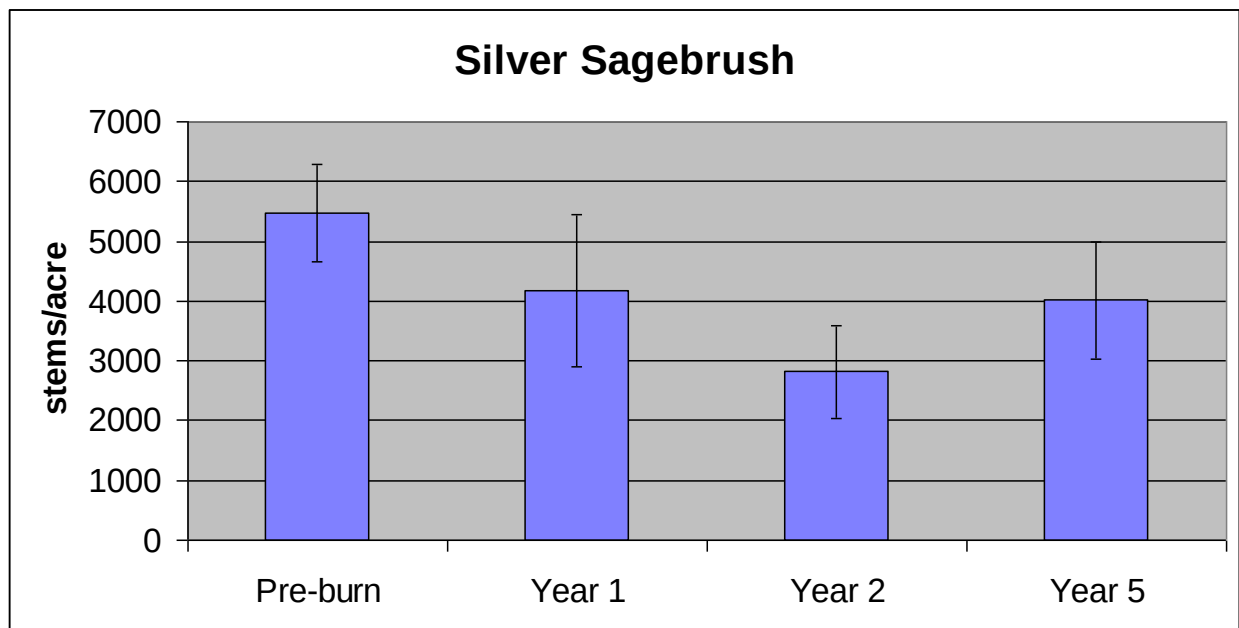
- Burn 60-90% of the burnable project area.

Two Years Post-burn

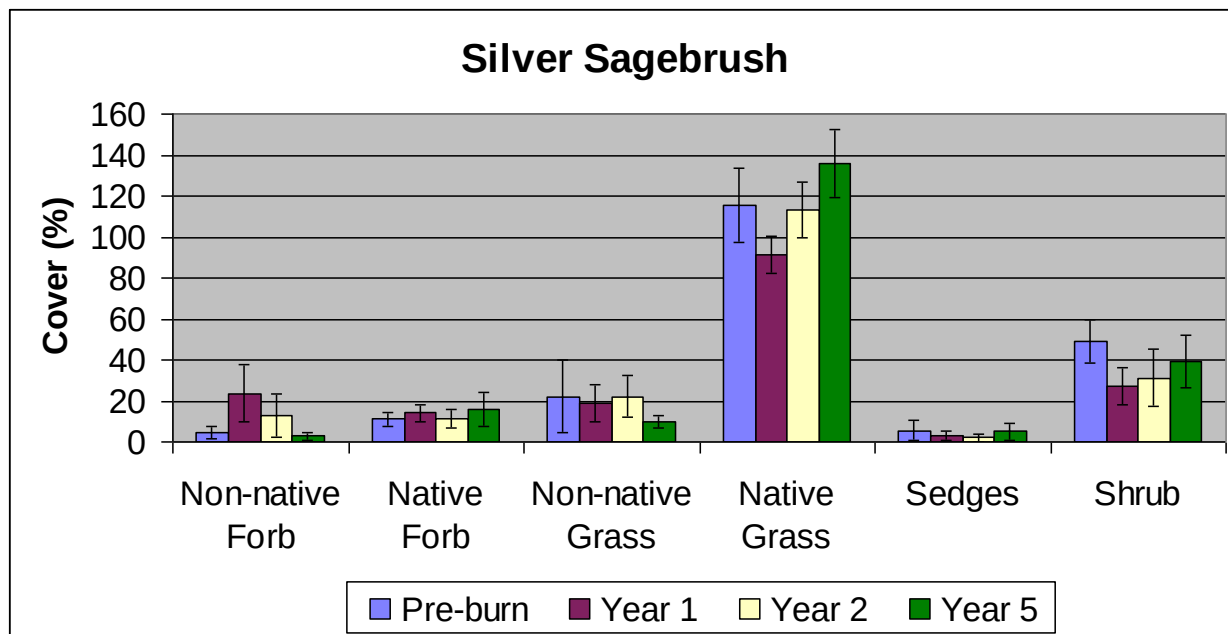
- Reduce silver sage density by 40-60%.
- Increase native herbaceous cover by 20%.
- Reduce non-native cover by at least 25% and increase native perennial grass cover by at least 25%.

Five Years Post-burn

- Maintain reduction of shrub density.
- Maintain increase in native species.
- Maintain reduction in non-native species.

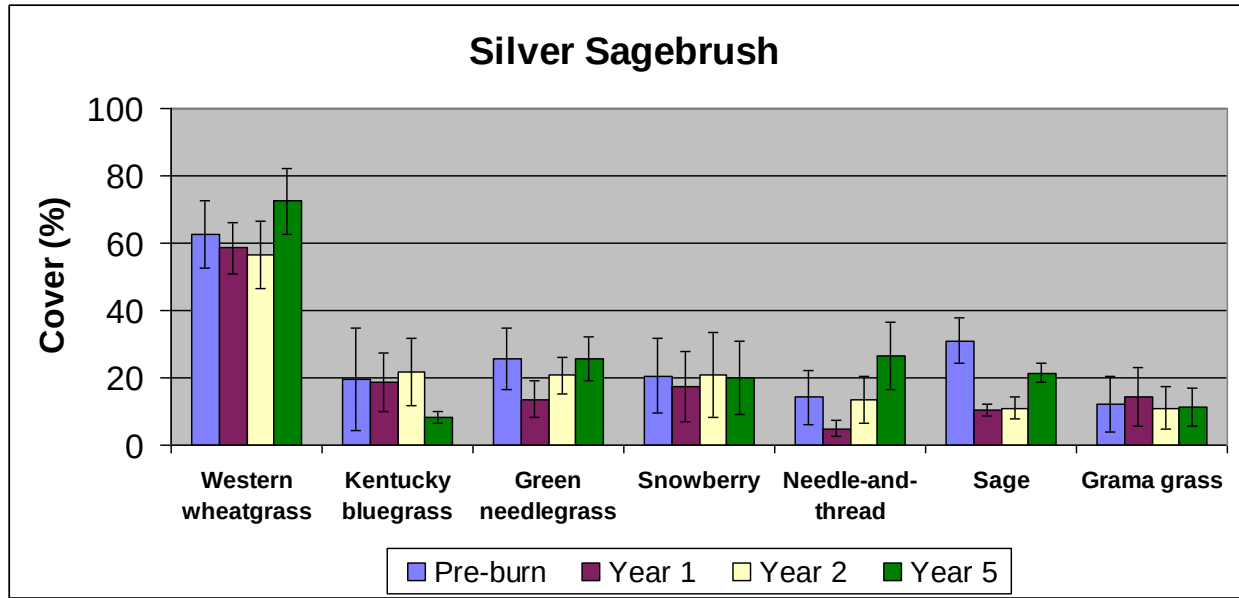


LITTLE MISSOURI II					
stems/acre	Pre-burn	Yr 2	Change	Yr 5	Change
Silver sagebrush	5463	2816	-48%	4013	-27%



SILVER SAGEBRUSH					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	4.3	12.8	200%	2.8	-35%
<i>Native Forb</i>	11.0	11.3	2%	16.0	45%
<i>Non-native Grass</i>	22.3	22.3	0%	10.0	-55%
<i>Native Grass</i>	115.5	113.0	-2%	135.8	18%
<i>Sedges</i>	5.5	2.0	-64%	5.0	-9%
<i>Shrub</i>	49.0	31.3	-36%	39.3	-20%





SILVER SAGEBRUSH					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Western wheatgrass	62.8	56.5	-10%	72.5	16%
<i>Kentucky bluegrass</i>	19.5	21.8	12%	8.3	-58%
Green needlegrass	25.8	20.8	-19%	25.5	-1%
Snowberry	20.5	20.8	1%	20.0	-2%
Needle-and-thread	14.3	13.5	-5%	26.5	86%
Sage	31.0	11.0	-65%	21.5	-31%
Grama grass	12.3	11.0	-10%	11.3	-8%

Cottonwood/Rocky Mountain juniper forest

Three plots have been installed in this monitoring unit and only two have burned. Refer to the Little Missouri II summary for figures and tables for these two plots.

Prescribed Fire Objectives

Immediate Post Burn

- Reduce total fuel loading by 60 - 80%

Two Year Post Burn

- Reduce total brush density by 30 - 50%.
- Reduce conifers 50 - 70%.
- Acceptable mortality of deciduous overstory trees is 20%.

Green needlegrass mixed-grass prairie

Ten plots have been installed in this monitoring type, six of which have burned. Three of the plots are in the Southeast Corner burn unit and three are in the Northwest Corner unit. The three Southeast Corner plots should be reclassified as Kentucky bluegrass plots. Because of this, we do not feel that it would be useful to analyze all six plots together. Refer to the Northwest Corner summary for figures and tables for the three green needlegrass plots that have burned.

Prescribed fire Objectives

Immediate Post Burn

- Reduce thatch by 20-30%

Two Year Post Burn

- Reinvigorate native species and decadent vegetation
- Reduce brush species
- Restore and maintain native plant communities.
- Reduce non-native cover by at least 20 to 30%
- Increase native perennial grass cover by at least 20 to 30%
- Reduce brush by 20 to 30%
- Increase native herbaceous and shrub cover by 20-30.

Snowberry shrubland

Only one plot has been installed in this monitoring type, so no analysis is required at the monitoring type level.

Prescribed Fire Objectives

Immediate Post Burn

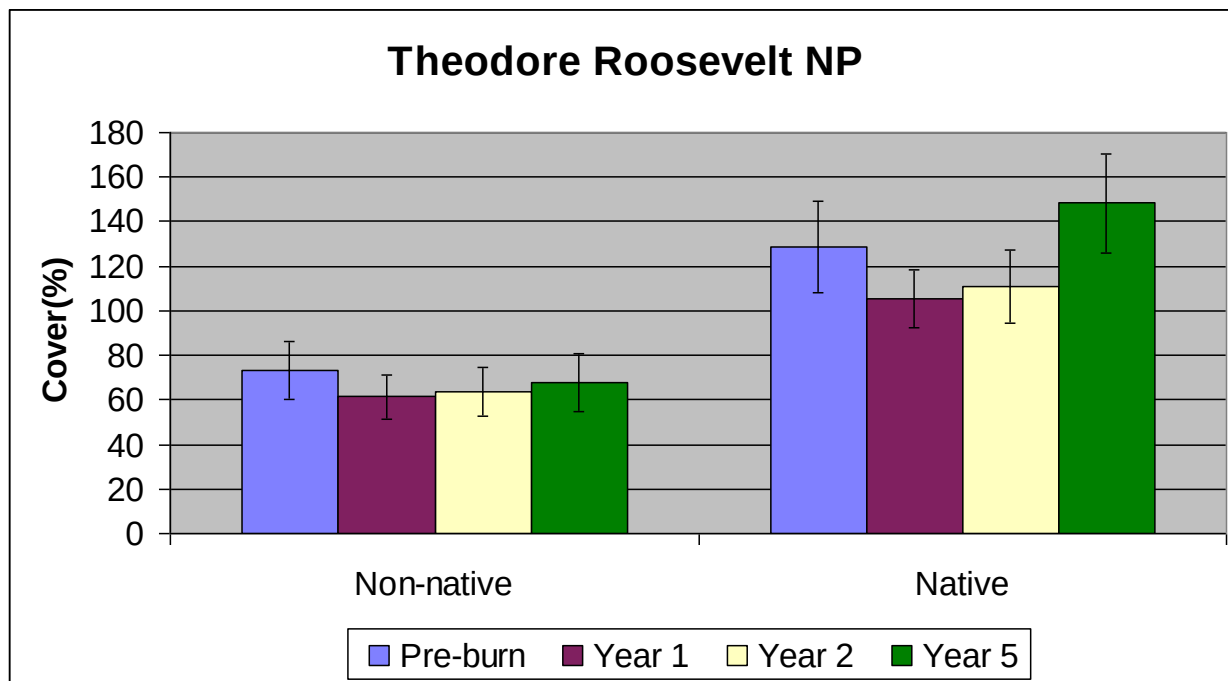
- Reduce silver sage (*Artemisia cana*) density by 40 - 60%.

Two Year Post Burn

- Reduce non-native cover by at least 25%
- Increase native perennial grass cover by at least 25
- Reduce silver sage by 50%
- Reduce total fuel load by 75%

Park-wide Summary

Sixteen plots have burned at Theodore Roosevelt and 15 of the plots have been visited five years post-fire. The following summary includes these 15 plots.

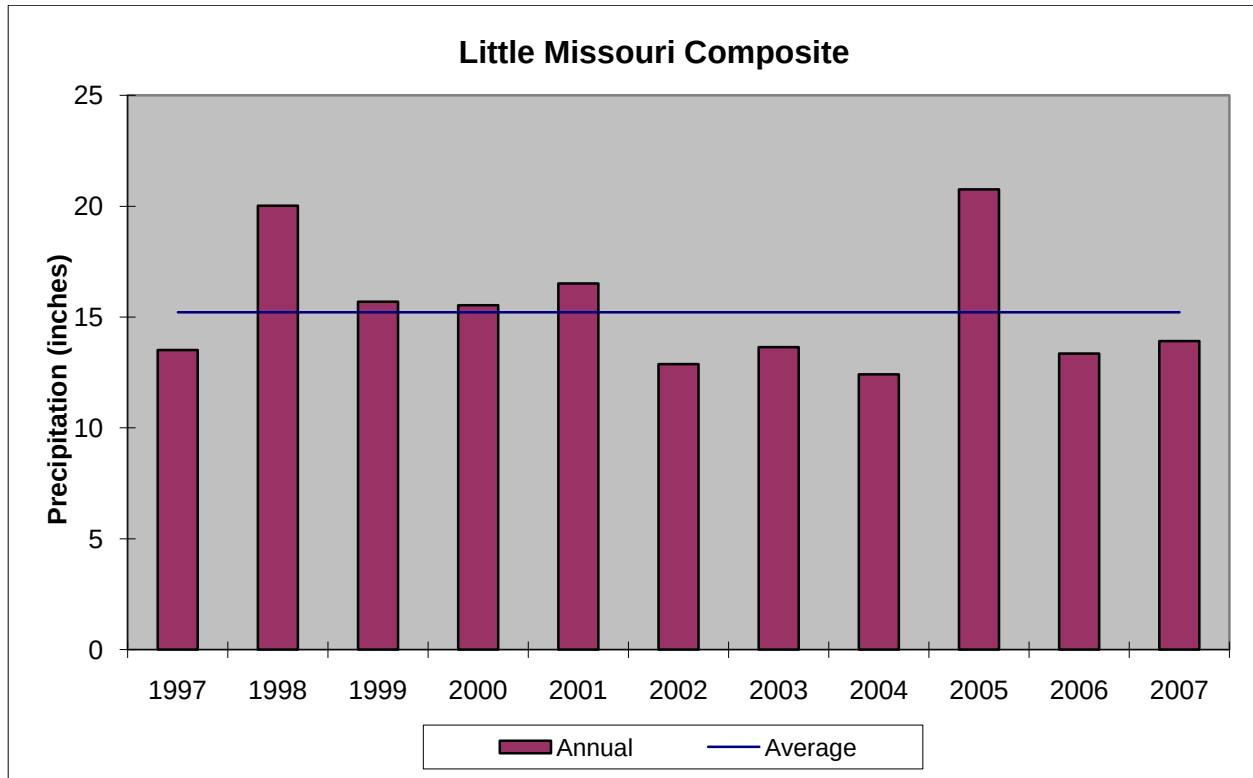


THEODORE ROOSEVELT NP					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native</i>	73.1	63.5	-13%	68.0	-7%
Native	128.4	110.9	-14%	148.2	15%



PRECIPITATION

Data presented here is an average of monthly precipitation from NWS weather stations at Dickinson, ND, Watford City, ND and Trotters, ND. (<http://www.hprcc.unl.edu/data/historical/>).





WIND CAVE NATIONAL PARK

The first fire effects plots were installed at Wind Cave in 1997. There are issues with the vegetation data that was collected that year, so this data is not usually included in summaries or analyses. No additional plots were installed until 1999, so for all practical purposes that marks the first year of fire effects data collection at Wind Cave. Long-term photo points were first installed in 2002 and modified project-level plots were added in 2003.

MONITORING UNITS

Monitoring units (or types) are defined in the NPS Fire Monitoring Handbook as a major fuel-vegetation complex or vegetation association that is treated with a particular burn prescription. Five monitoring units have been described at Wind Cave, but for the purposes of this report and the much of the included analyses, the monitoring units have been simplified into three general units.

Native mixed-grass prairie (ANSC & AGSM)

A blend of tall-grass and short-grass prairie species, typical dominant grasses include: little bluestem (*Schizachyrium scoparium*), western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*), buffalo grass (*Buchloe dactyloides*), and Kentucky bluegrass (*Poa pratensis*). Sedges such as threadleaf sedge (*Carex filifolia*), needleleaf sedge (*Carex duriuscula*) may also be present. Forbs such as sageworts (*Artemisia* spp.), scurfpea (*Psoralidium tenuiflorum*), dotted gayfeather (*Liatris punctata*), purple coneflower (*Echinacea angustifolia*), and upright prairie coneflower (*Ratibida columnifera*), are common. Low shrubs include leadplant (*Amorpha canescens*) and Woods' rose (*Rosa woodsii*).

Non-native prairie - Kentucky bluegrass (POPR)

Grassy areas dominated by Kentucky bluegrass (*Poa pratensis*) with some native species intermingled. Native grasses include little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*), buffalo grass (*Buchloe dactyloides*), and western wheatgrass (*Pascopyrum smithii*). Sedges such as threadleaf sedge (*Carex filifolia*) may also be present. Forbs such as sageworts (*Artemisia* spp.), slimflower scurfpea (*Psoralidium tenuiflorum*), dotted blazing star (*Liatris punctata*), purple coneflower (*Echinacea angustifolia*), and upright prairie coneflower (*Ratibida columnifera*), are common. Low shrubs include leadplant (*Amorpha canescens*) and Woods' rose (*Rosa woodsii*).

Ponderosa pine forest (PIPO)

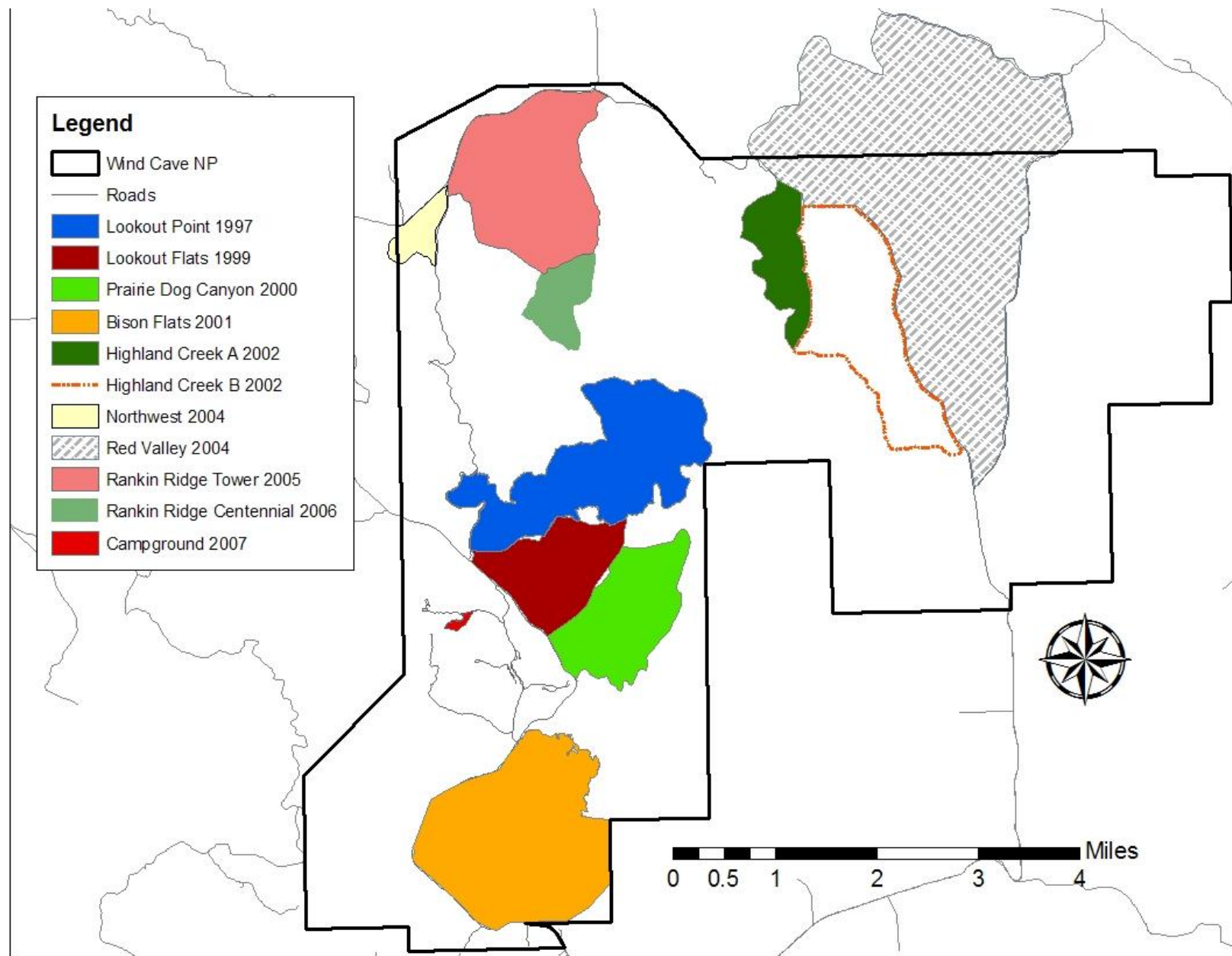
Ponderosa pine (*Pinus ponderosa*) with occasional Rocky Mountain juniper (*Juniperus scopulorum*) and bur oak (*Quercus macrocarpa*). Shrubs include chokecherry (*Prunus virginiana*), American plum (*Prunus americana*), Oregon grape (*Mahonia repens*), common juniper (*Juniperus communis*), western red current (*Ribes cereum*), golden currant (*R. aureum*), western snowberry (*Symphoricarpos occidentalis*), mountain mahogany (*Cercocarpus montanus*), skunkbush sumac (*Rhus trilobata* Nutt. var. *trilobata*), and Woods' rose (*Rosa*

woodsii). Grasses occur throughout ponderosa pine stands but tend to dominate the understory in more open stands. Common grasses include poverty oat grass (*Danthonia spicata*), needle-and-thread (*Stipa comata*), western wheatgrass (*Pascopyrum smithii*), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), and Kentucky bluegrass (*Poa pratensis*). Forbs include downy paintbrush (*Castilleja sessiliflora*), Hood's phlox (*Phlox hoodii*), prairie groundsel (*Packera plattensis*), stemless four-nerve daisy (*Tetraneuris acaulis* [Pursh] Greene var. *acaulis*), common starlily (*Leucocrinum montanum*) and darkthroat shootingstar (*Dodecatheon pulchellum*).

PREScribed FIRES

Burn Unit	Date(s)	Season	Size
Lookout Point	5/9-12/97	Spring	500
Lookout Flats	4/19/99	Spring	604
Prairie Dog Canyon	5/2/00	Spring	759
Bison Flats	10/8/01	Fall	1848
Highland Creek	5/5/02	Spring	406
Highland Creek	10/19/02	Fall	1100
Northwest	4/1/04	Spring	100
Red Valley	4/15/04	Spring	4200
Rankin - Tower	10/25/05	Fall	1231
Rankin - Centennial 1	11/3/06	Fall	113
Rankin - Centennial 2	11/5/06	Fall	140
Campground	4/20/07	Spring	35



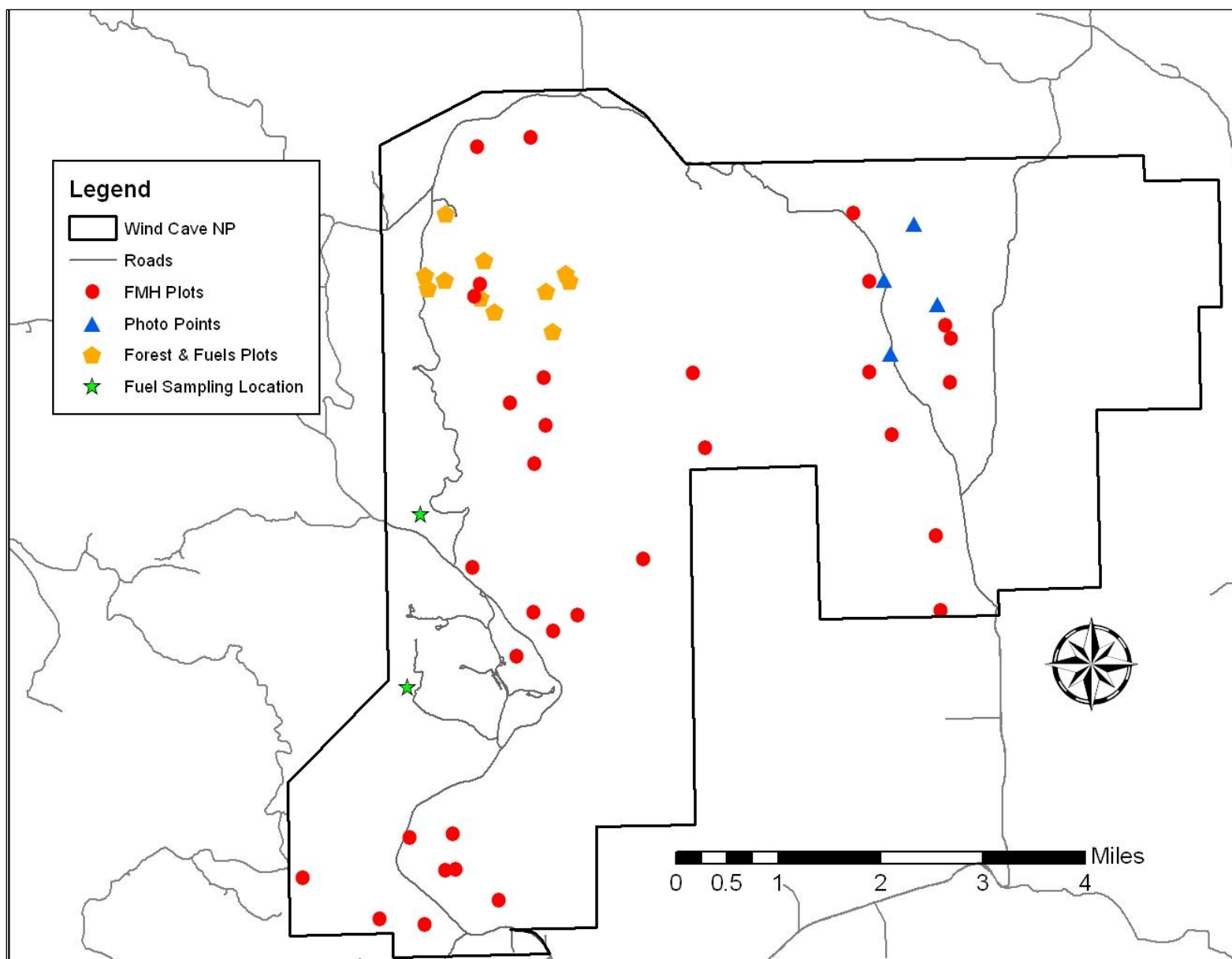


MONITORING PLOTS

Burn Unit	Monitoring Type	FEAT ID	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Bison Flats	Little Bluestem	ANSC-05					V/B	V	V		V		
Bison Flats	Little Bluestem	ANSC-06					V/B	V	V		V		
Bison Flats	Ponderosa Pine	PIPO_02-04					V/B	V	V			V	
Bison Flats	Kentucky Bluegrass	POPR-03					V/B	V	V		V		
Bison Flats	Kentucky Bluegrass	POPR-04					V/B	V	V		V		
Bison Flats	Prairie Dog Town	WPCM01									V	V	
Dry Creek	Western Wheatgrass	AGSM-04	V		V								X
Dry Creek	Little Bluestem	ANSC-01	V		V								X
Highland Creek	Little Bluestem	ANSC-03	V		V			V/B	V	V			V
Highland Creek	Little Bluestem	ANSC-04	V		V			V/B	V	V			V
Highland Creek	Ponderosa Pine	PIPO_02-05						V/B	V	V			V
Highland Creek	Photo Point	PP1						V/B	V	V			V
Highland Creek	Photo Point	PP2						V/B	V	V			V
Lookout Flats	Western Wheatgrass	AGSM-01	V		B/V	V			V				
Lookout Flats	Western Wheatgrass	AGSM-03	V		B/V	V			V				
No burn unit	Western Wheatgrass	AGSM-02	V										X
No burn unit	Little Bluestem	ANSC-02	V		V								X
No burn unit	Ponderosa Pine	PIPO_09-01	V										X
Northwest	Pine Seedling	1								V/B	X		
Northwest	Pine Seedling	2								V/B	X		
Northwest	Pine Seedling	3								V/B	X		
Prairie Dog Canyon	Ponderosa Pine	PIPO_02-01			V	B/V	V	V			V		
Prairie Dog Canyon	Kentucky Bluegrass	POPR-01			V	B/V	V			V			
Prairie Dog Canyon	Kentucky Bluegrass	POPR-02			V	B/V	V			V			
RR Centennial	Ponderosa Pine	PIPO_02-07							V			V	
RR Centennial	Ponderosa Pine	PIPO_02-10							V			V	
RR Centennial	Ponderosa Pine	PIPO_09-05									V	V	
RR Centennial	Forest & Fuels	F&F2										V	
RR Centennial	Forest & Fuels	F&F3										V	
RR Centennial	Forest & Fuels	F&F4										V/B	V
RR Centennial	Forest & Fuels	F&F5										V/B	V

Burn Unit	Monitoring Type	FEAT ID	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
RR Centennial	Forest & Fuels	F&F6										V/B	V
RR Centennial	Forest & Fuels	F&F7										V/B	V
RR Centennial	Forest & Fuels	F&F8										V	
RR Centennial	Forest & Fuels	F&F9										V	
RR Centennial	Forest & Fuels	F&F10										V	
RR Centennial	Forest & Fuels	F&F11										V	
RR Centennial	Forest & Fuels	F&F1										V	
RR Curley Canyon	Ponderosa Pine	PIPO_09-03							V				
RR Curley Canyon	Ponderosa Pine	PIPO_09-04								V	V		
RR Pigtail	Ponderosa Pine	PIPO_02-08							V				
RR Pigtail	Ponderosa Pine	PIPO_02-11								V			
RR Tower	Ponderosa Pine	PIPO_02-06							V		V/B	V	V
RR Tower	Ponderosa Pine	PIPO_02-09							V		V/B	V	V
Red Valley	Seedling	1							V	V	X		
Red Valley	Seedling	2							V	V	X		
Red Valley	Seedling	3							V	V	X		
Red Valley	Seedling	4							V	V	X		
Red Valley	Western Wheatgrass	AGSM-05							V	B/V	V		
Red Valley	Western Wheatgrass	AGSM-06							V	B/V	V		
Red Valley	Western Wheatgrass	AGSM-07							V	B/V	V		
Red Valley	Kentucky Bluegrass	POPR-05							V	B/V	V		
Red Valley	Photo Point	PP3							V	V	V		
Red Valley	Photo Point	PP4							V	V	V		
Red Valley	Prairie Dog Town	WPCM02									V	V	X
South Cold Brook	Little Bluestem	ANSC-07					V						
South Cold Brook	Ponderosa Pine	PIPO_02-03					V						
South Cold Brook	Ponderosa Pine	PIPO_09-02					V						X

V = Plot visit; B = Burned; X = Plot removed



MONITORING RESULTS

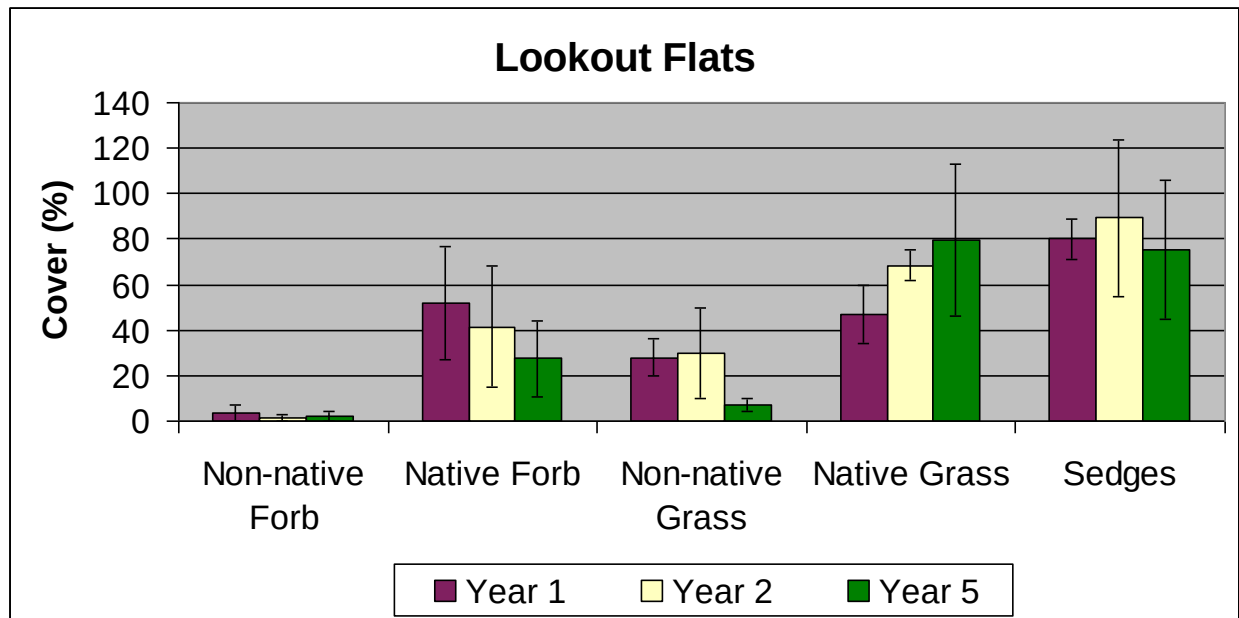
Prescribed Fire Units

Lookout Point

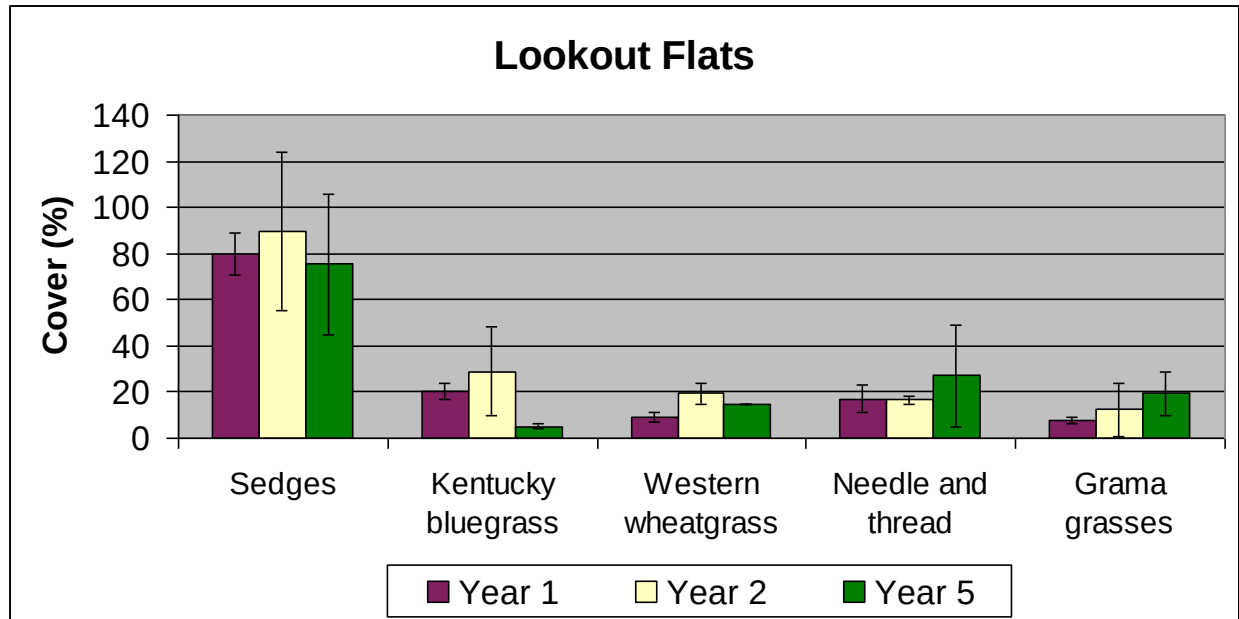
No monitoring plots installed.

Lookout Flats

Two western wheatgrass plots were installed in the Lookout Flats unit in 1997. During the installation, only the highest vegetation hitting the pole was recorded. As a result, comparing pre-burn vegetation cover to post-burn cover was not possible. Only post-burn results are shown in the two figures below.



LOOKOUT FLATS					
	Yr 1 Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	3.5	1.5	-57%	2.0	-43%
<i>Native Forb</i>	52.0	41.5	-20%	27.5	-47%
<i>Non-native Grass</i>	28.0	30.0	7%	7.0	-75%
<i>Native Grass</i>	47.0	68.5	46%	79.5	69%
<i>Sedges</i>	80.0	89.5	12%	75.5	-6%

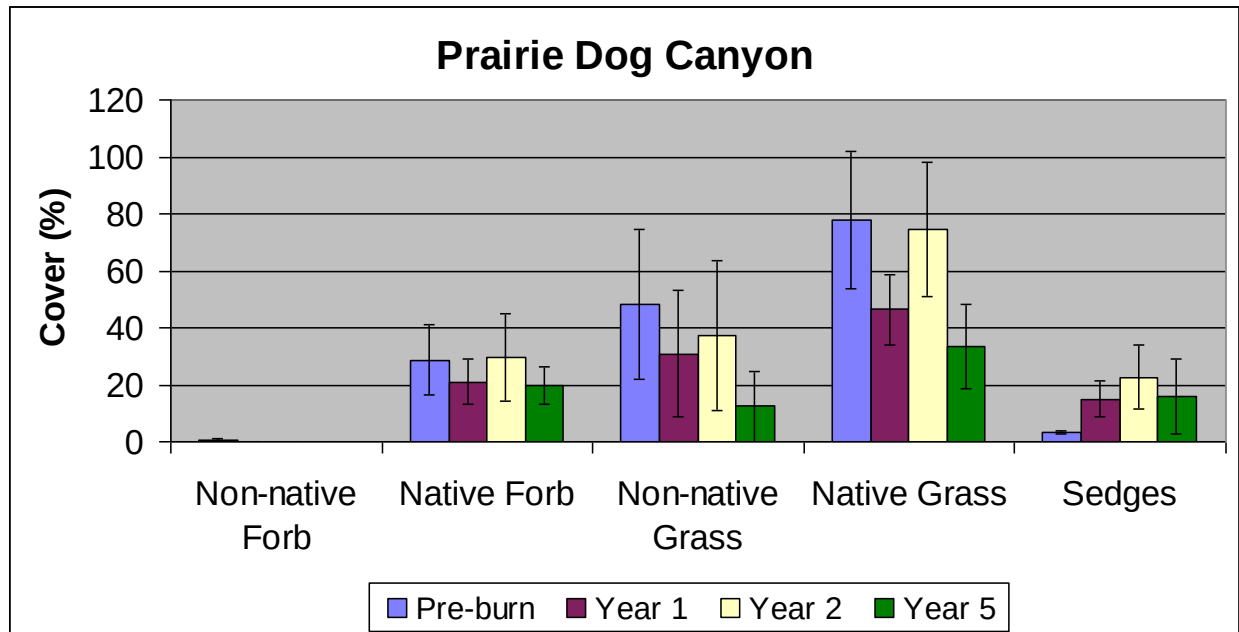


LOOKOUT FLATS					
	Yr 1 cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Sedges	80.0	89.5	12%	75.5	-6%
<i>Kentucky bluegrass</i>	20.5	29.0	42%	5.0	-76%
Western wheatgrass	9.0	19.5	117%	15.0	67%
Needle-and-thread	17.0	16.5	-3%	27.0	59%
Grama grasses	7.5	12.5	67%	19.5	160%

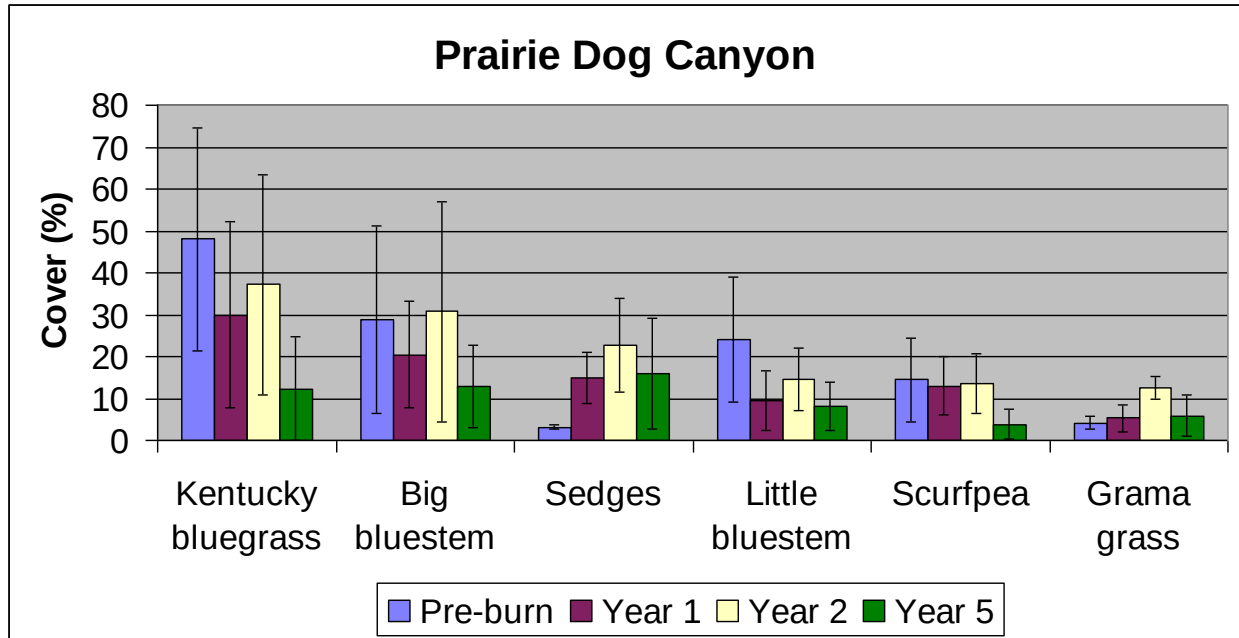


Prairie Dog Canyon

Three plots, 2 Kentucky bluegrass and 1 ponderosa pine, were installed in Prairie Dog Canyon. Herbaceous vegetation for all three plots was summarized together.

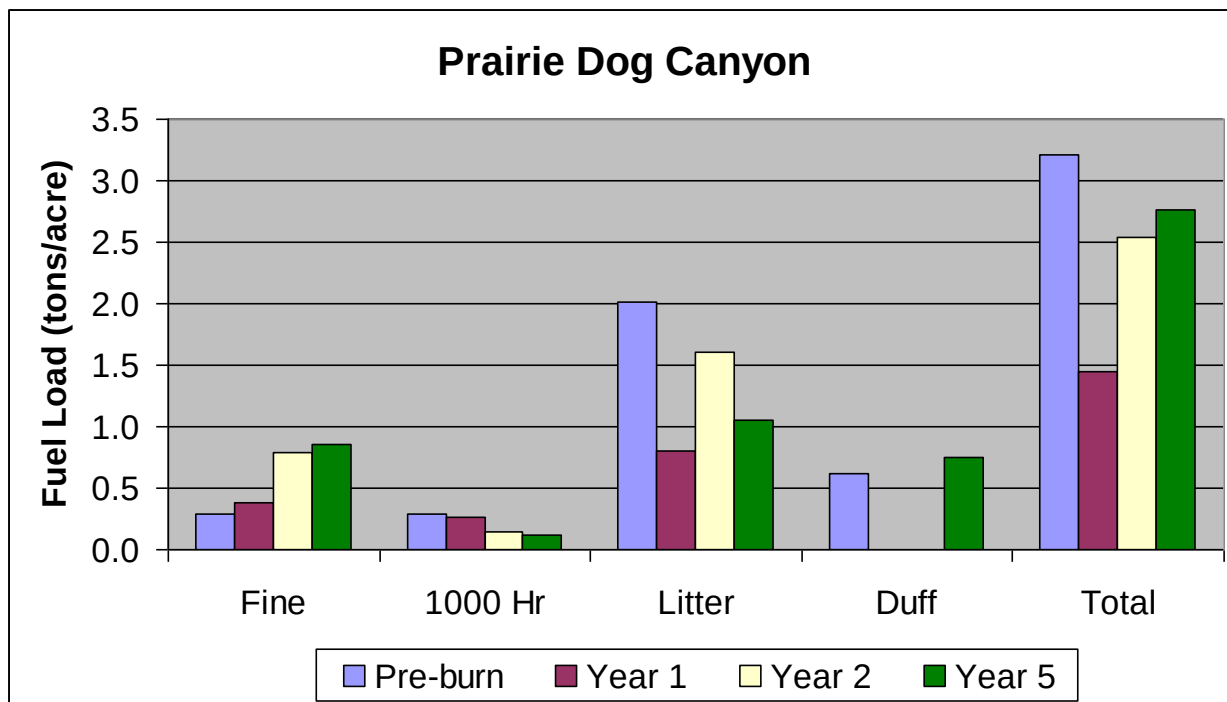


PRAIRIE DOG CANYON					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	0.5	0.0	-100%	0.0	-100%
<i>Native Forb</i>	28.6	29.7	4%	19.5	-32%
<i>Non-native Grass</i>	48.2	37.2	-23%	12.3	-74%
<i>Native Grass</i>	77.8	74.5	-4%	33.4	-57%
<i>Sedges</i>	3.1	22.7	625%	15.8	404%



PRAIRIE DOG CANYON					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Kentucky bluegrass</i>	48.0	37.2	-23%	12.3	-74%
Big bluestem	28.8	30.7	7%	12.9	-55%
Sedges	3.1	22.7	625%	15.8	404%
Little bluestem	24.1	14.6	-39%	8.1	-66%
Scurfpea	14.5	13.7	-6%	3.9	-73%
Grama grasses	4.1	12.5	202%	5.9	42%





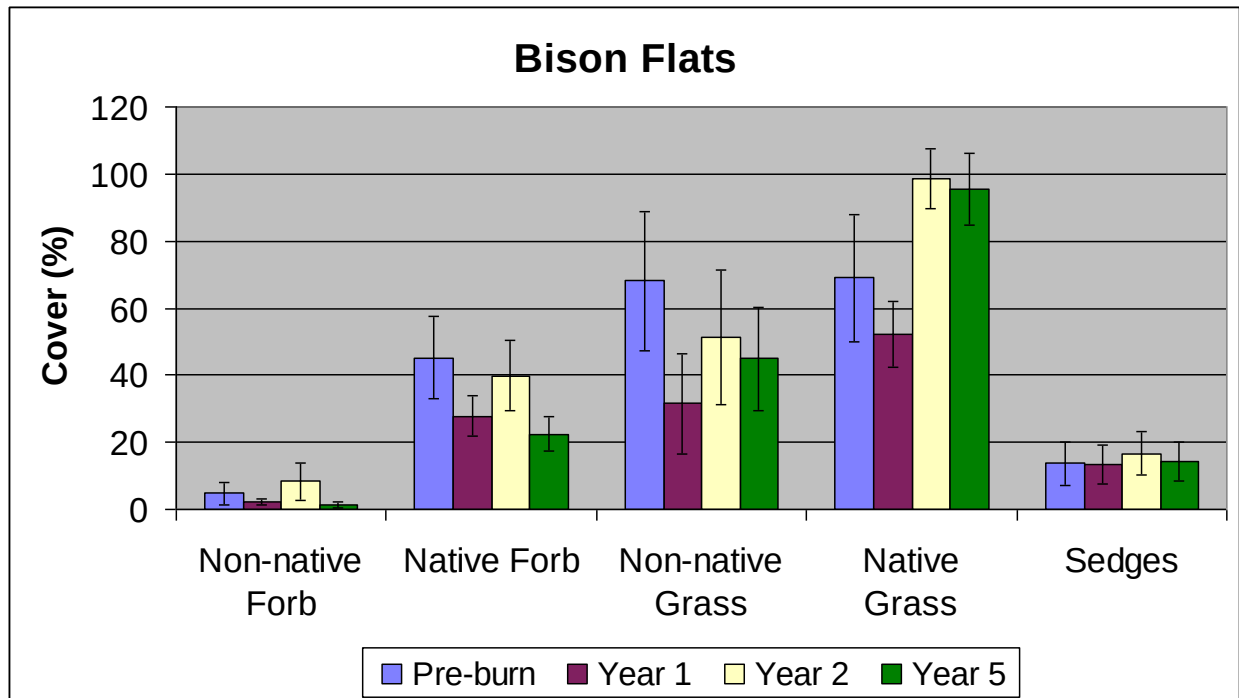
PRAIRIE DOG CANYON					
tons/acre	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	0.6	0.6	—	1.0	67%
Litter & Duff	2.6	0.8	-69%	1.8	-32%
Total	3.2	1.4	-55%	2.8	-14%

Tree density changed very little following prescribed fire in the one ponderosa pine plot located in the Prairie Dog Canyon unit.

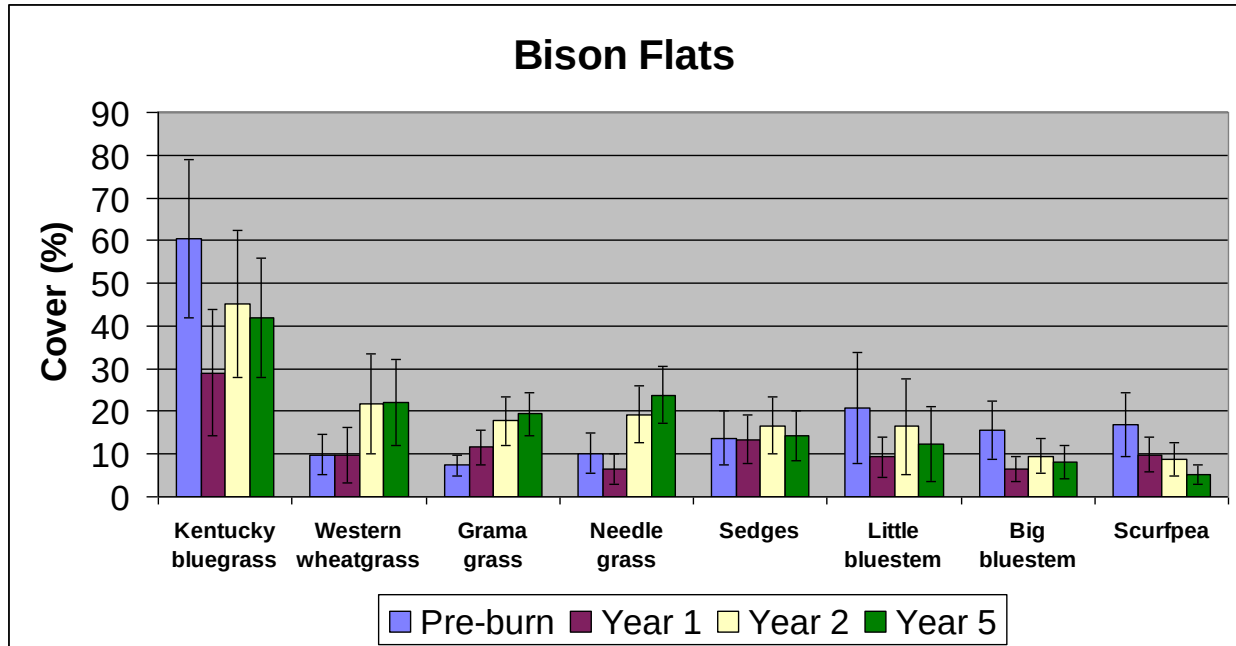
PRAIRIE DOG CANYON					
stems/acre	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Poles	16.2	16.2	—	16.2	—
Overstory	89.0	85.0	-5%	85.0	-5%

Bison Flats

Two non-native prairie, two native prairie, and one ponderosa pine plot have been installed in the Bison Flats unit. Herbaceous vegetation data is summarized from all five plots in the two figures below.

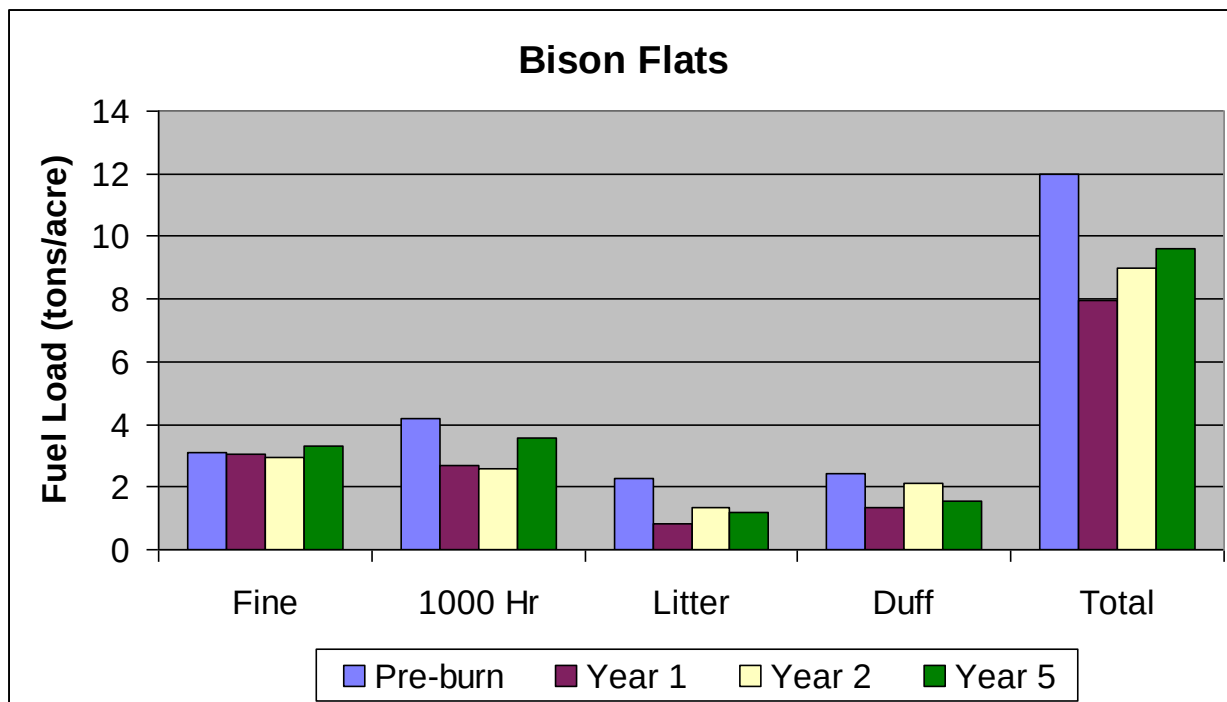


BISON FLATS					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	4.7	8.4	79%	1.3	-73%
<i>Native Forb</i>	45.2	39.9	-12%	22.5	-50%
<i>Non-native Grass</i>	68.2	51.3	-25%	44.9	-34%
<i>Native Grass</i>	68.9	98.7	43%	95.4	38%
<i>Sedges</i>	13.7	16.7	22%	14.2	4%



	BISON FLATS				
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Kentucky bluegrass</i>	60.4	45.1	-25%	41.8	-31%
Western wheatgrass	9.8	21.8	123%	22.1	125%
Grama grasses	7.4	17.7	138%	19.4	161%
Needle grasses	10.2	19.3	89%	23.8	133%
Sedges	13.7	16.7	22%	14.2	4%
Little bluestem	20.7	16.4	-21%	12.4	-40%
Big bluestem	15.6	9.6	-39%	8.2	-48%
Scurfpea	16.8	8.8	-48%	5.2	-69%





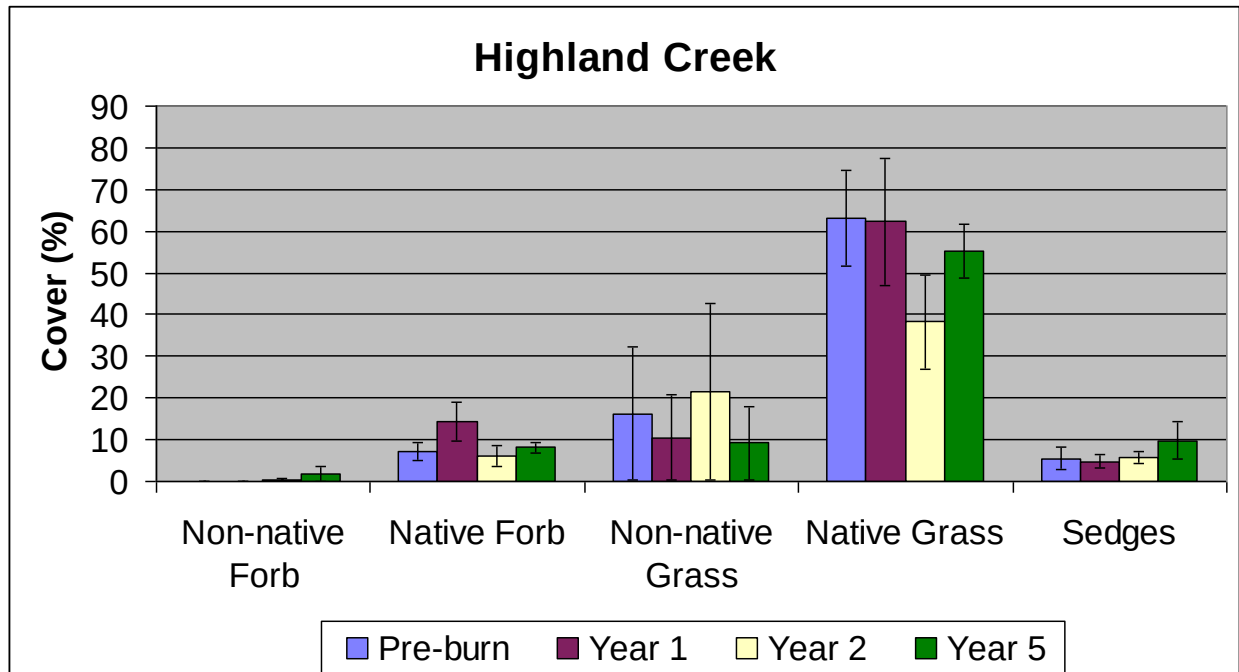
BISON FLATS					
tons/acre	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	7.3	5.8	-21%	6.9	-6%
Litter & Duff	4.7	2.2	-53%	2.7	-41%
Total	12.0	8.0	-34%	9.6	-20%

Tree density was reduced for both poles and overstory sized trees two years following the prescribed fire, but remained unchanged five years post-treatment.

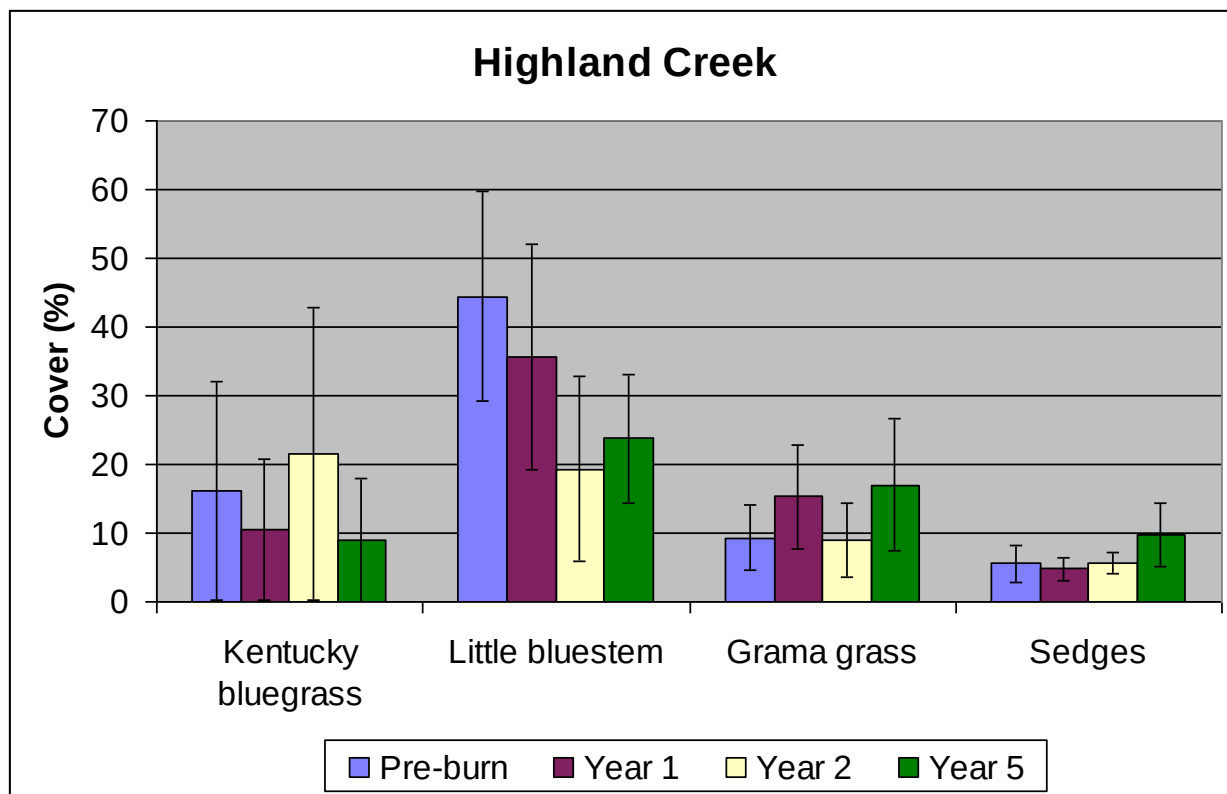
BISON FLATS					
stems/acre	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Poles	0.0	0.0	--	16.2	+
Overstory	105.2	101.2	-4%	97.1	-8%

Highland Creek

Three plots have been installed in Highland Creek, two native prairie and one ponderosa pine. Herbaceous vegetation data is summarized from all five plots in the two figures below.

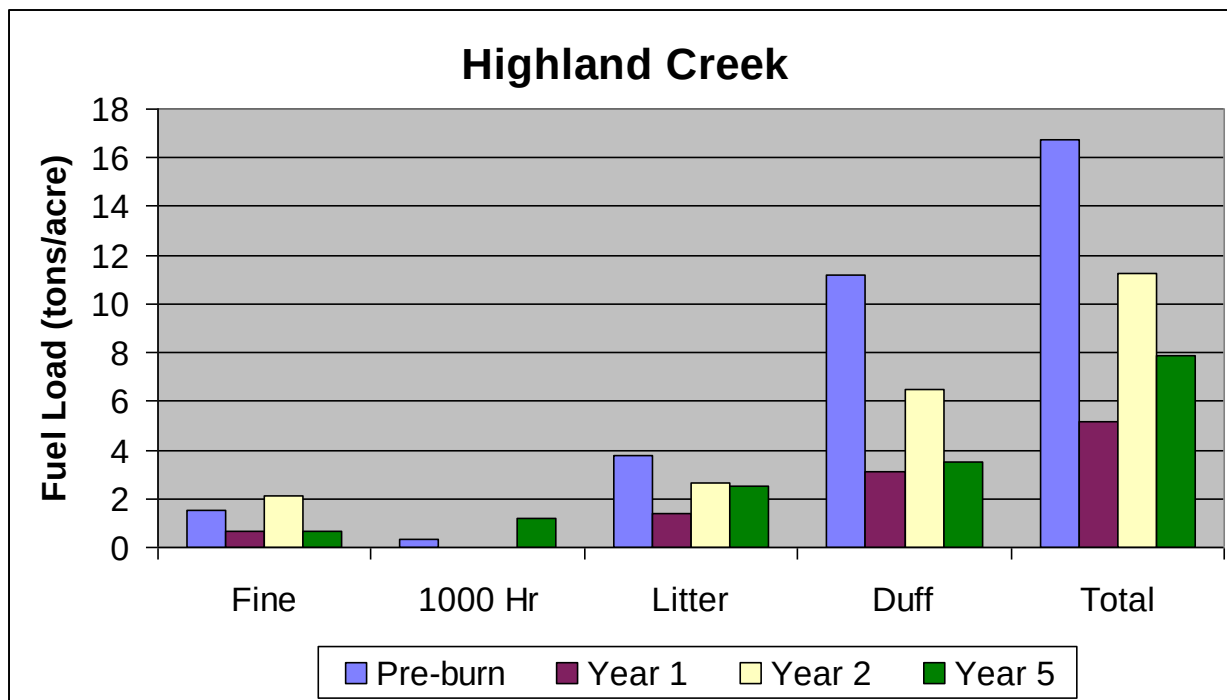


HIGHLAND CREEK					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	0.0	0.4	+	1.8	+
<i>Native Forb</i>	7.2	6.0	-17%	8.1	13%
<i>Non-native Grass</i>	16.2	21.5	33%	9.2	-43%
<i>Native Grass</i>	63.1	38.2	-39%	55.1	-13%
<i>Sedges</i>	5.5	5.7	2%	9.8	77%



HIGHLAND CREEK					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Kentucky bluegrass</i>	16.2	21.5	33%	9.0	-44%
Little bluestem	44.5	19.3	-57%	23.8	-46%
Grama grasses	9.4	8.9	-5%	17.0	82%
Sedges	5.5	5.7	2%	9.8	77%





HIGHLAND CREEK					
tons/acre	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	1.8	0.7	-64%	1.8	—
Litter & Duff	14.9	4.5	-70%	6.0	-60%
Total	16.8	5.2	-69%	7.9	-53%

Tree density was reduced for poles by two years post-treatment and additional mortality was observed five years after the prescribed fire. Acceptable levels of mortality was documented in overstory trees.

HIGHLAND CREEK					
stems/acre	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Poles	242.9	161.9	-33%	145.7	-40%
Overstory	93.1	76.9	-17%	72.8	-22%

Northwest

Three circular tree plots were installed in the Northwest unit to assess seedling mortality following prescribed fire. All the seedlings in the three plots were killed by the fire. Most of the unit was burned by head fire due to a wind switch shortly after ignition began.



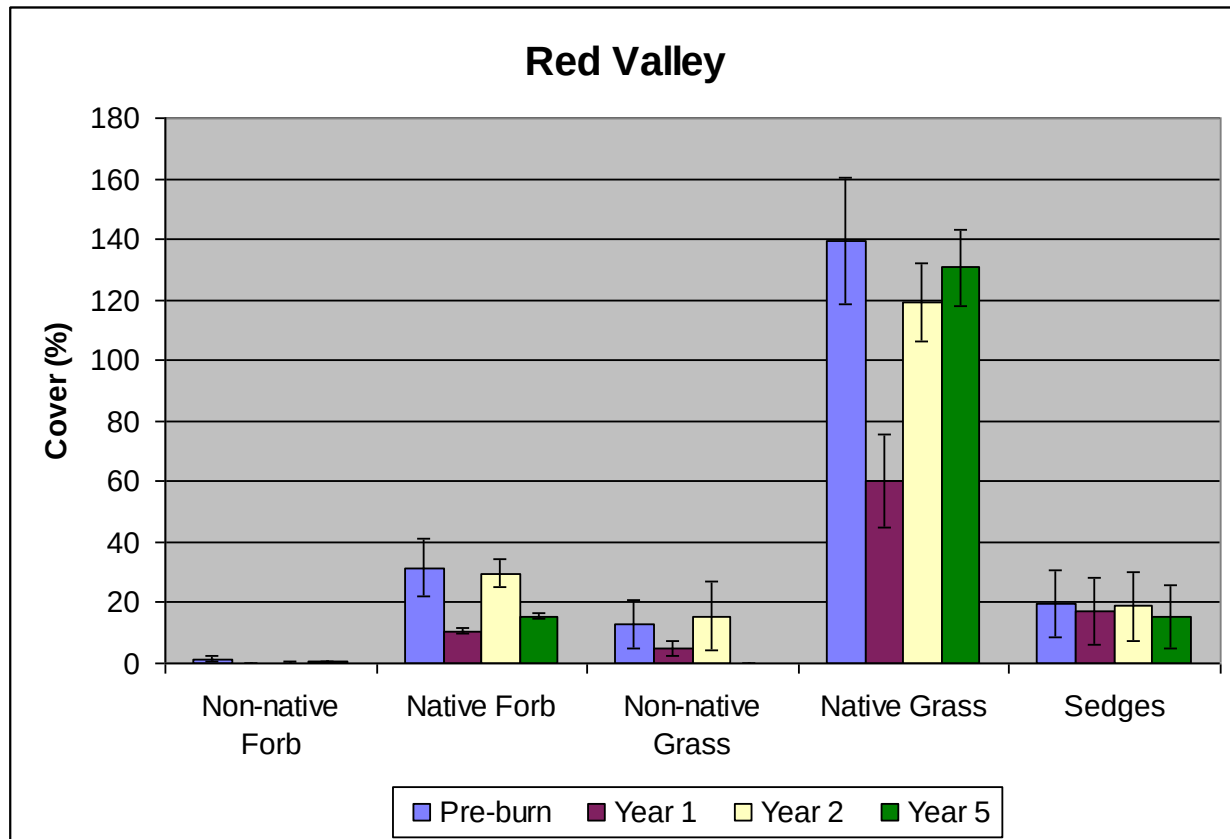
Pre-burn: March 31, 2004



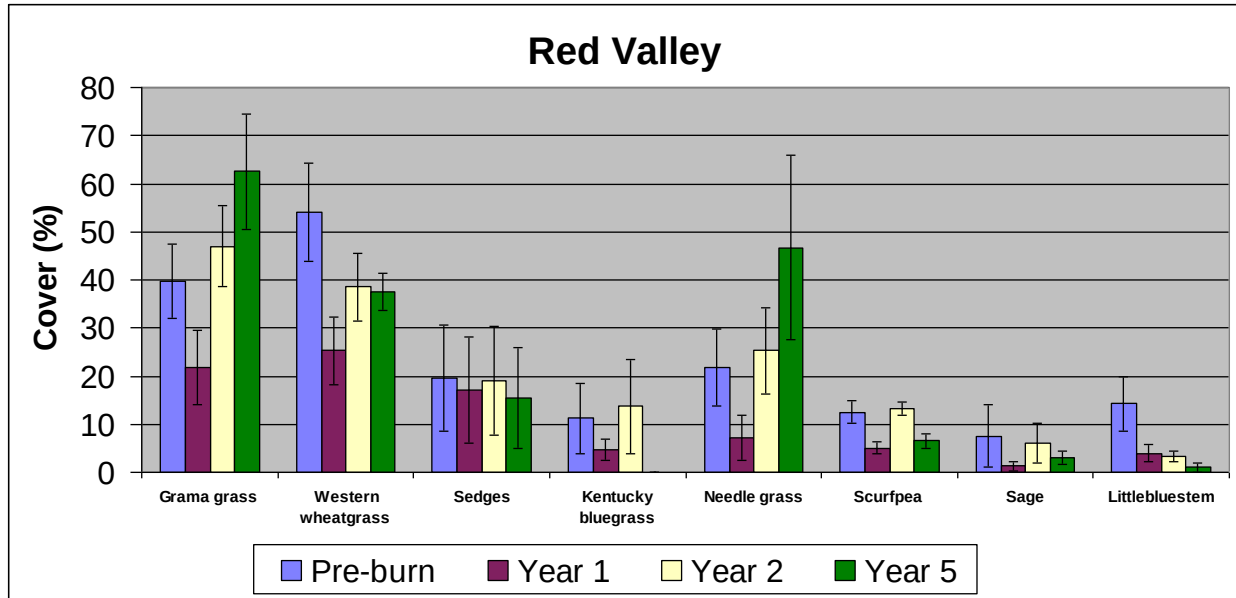
Post-burn: April 23, 2004

Red Valley

The following two figures includes data from three western wheatgrass plots and one Kentucky bluegrass plot.



RED VALLEY					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	1.5	0.3	-83%	0.5	-67%
Native Forb	31.5	29.8	-6%	15.5	-51%
<i>Non-native Grass</i>	13.0	15.5	19%	0.0	-100%
Native Grass	139.3	119.0	-15%	130.8	-6%
Sedges	19.5	19.0	-3%	15.5	-21%



RED VALLEY					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Grama grasses	39.8	47.0	18%	62.5	57%
Western wheatgrass	54.0	38.5	-29%	37.5	-31%
Sedges	19.5	19.0	-3%	15.5	-21%
Kentucky bluegrass	11.3	13.8	22%	0.0	-100%
Needle grasses	21.8	25.3	16%	46.8	115%
Scurfpea	12.5	13.3	6%	6.5	-48%
Sagewort	7.5	6.0	-20%	3.0	-60%
Little bluestem	14.3	3.3	-77%	1.0	-93%



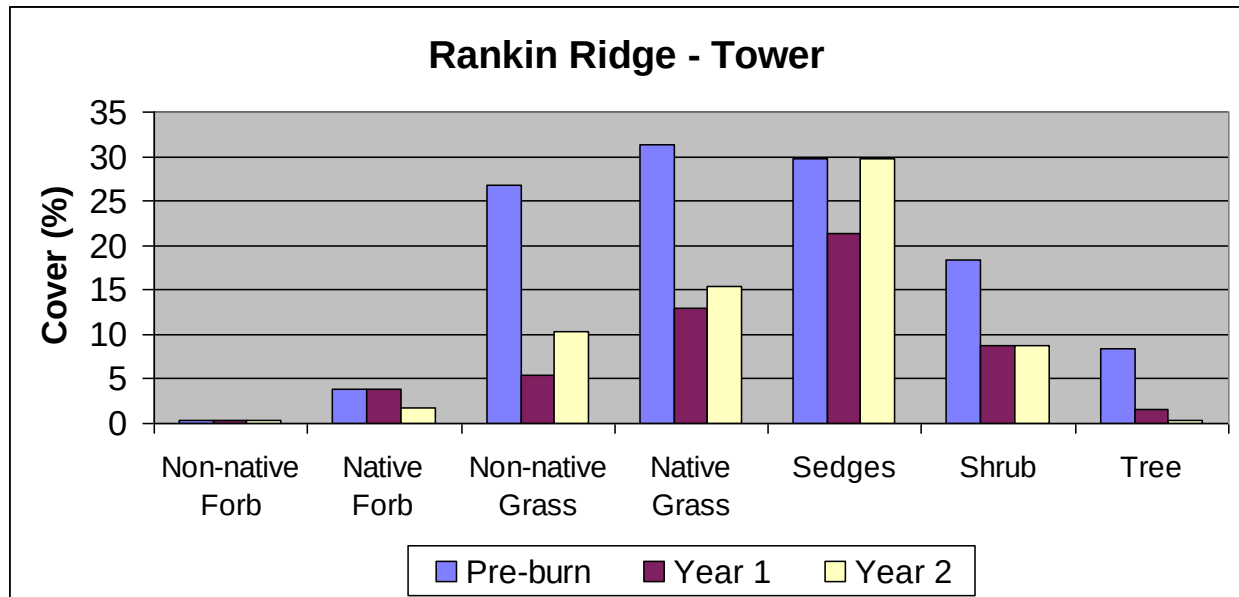
Four circular tree plots were installed in Red Valley to document seedling mortality following the prescribed fire. Seedling density was reduced by 93% after the fire.



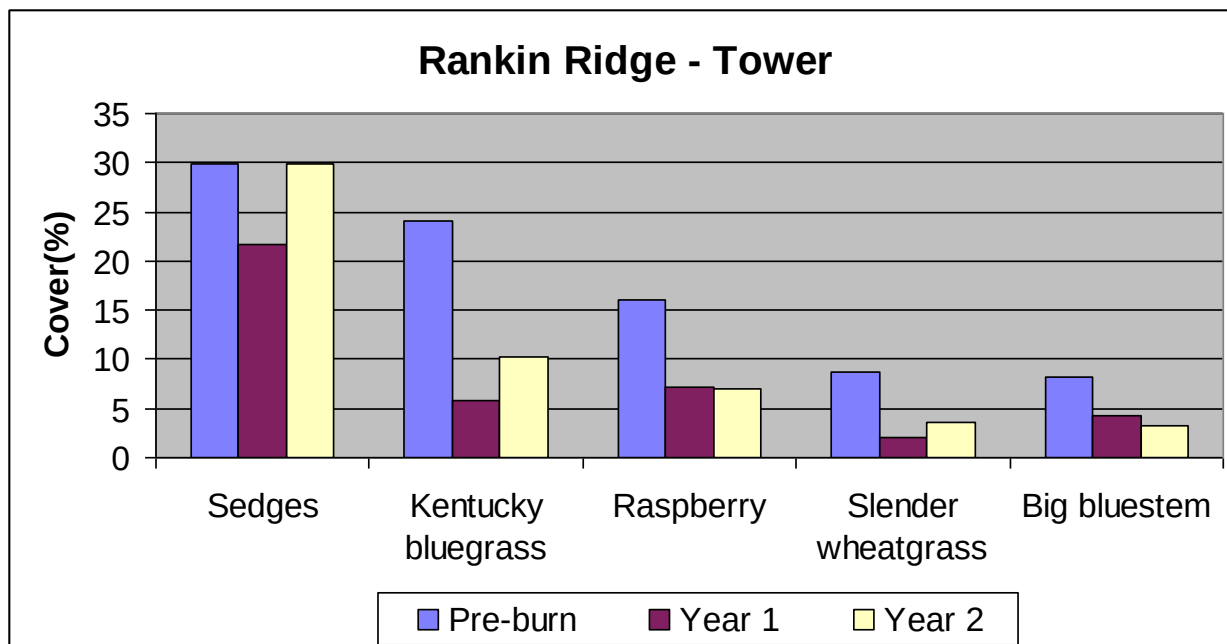
Post-burn: September 14, 2004

Rankin Ridge – Tower

Two forests plots have been installed in the Tower block of Rankin Ridge. Standard error bars were not added to the following figures because of the small sample size.

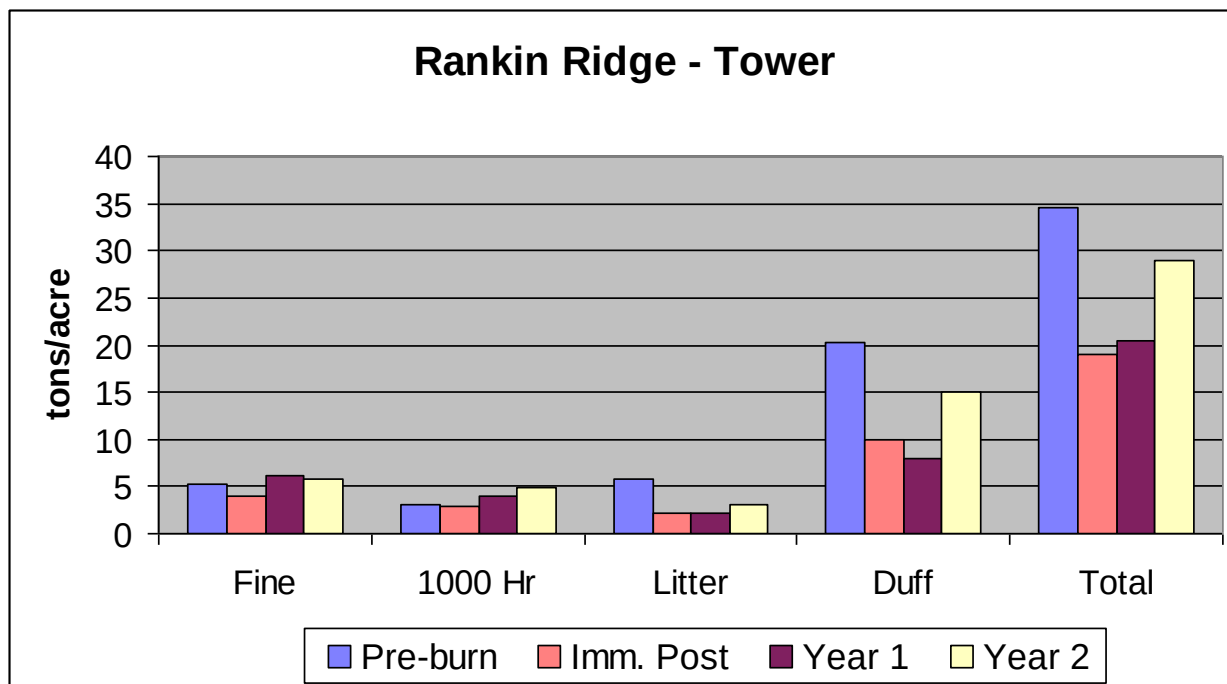


RANKIN RIDGE – TOWER			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	0.3	0.3	0%
Native Forb	3.9	1.8	-54%
<i>Non-native Grass</i>	26.8	10.2	-62%
Native Grass	31.3	15.4	-51%
Sedges	29.8	29.8	0%
Shrubs	18.4	8.7	-52%
Trees	8.4	0.3	-96%



RANKIN RIDGE - TOWER			
	Pre-burn Cover	Yr 2 Cover	Change
Sedges	29.8	29.8	0%
<i>Kentucky bluegrass</i>	24.1	10.2	-58%
Raspberry	16.0	6.9	-57%
Slender wheatgrass	8.7	3.6	-59%
Big bluestem	8.1	3.3	-59%



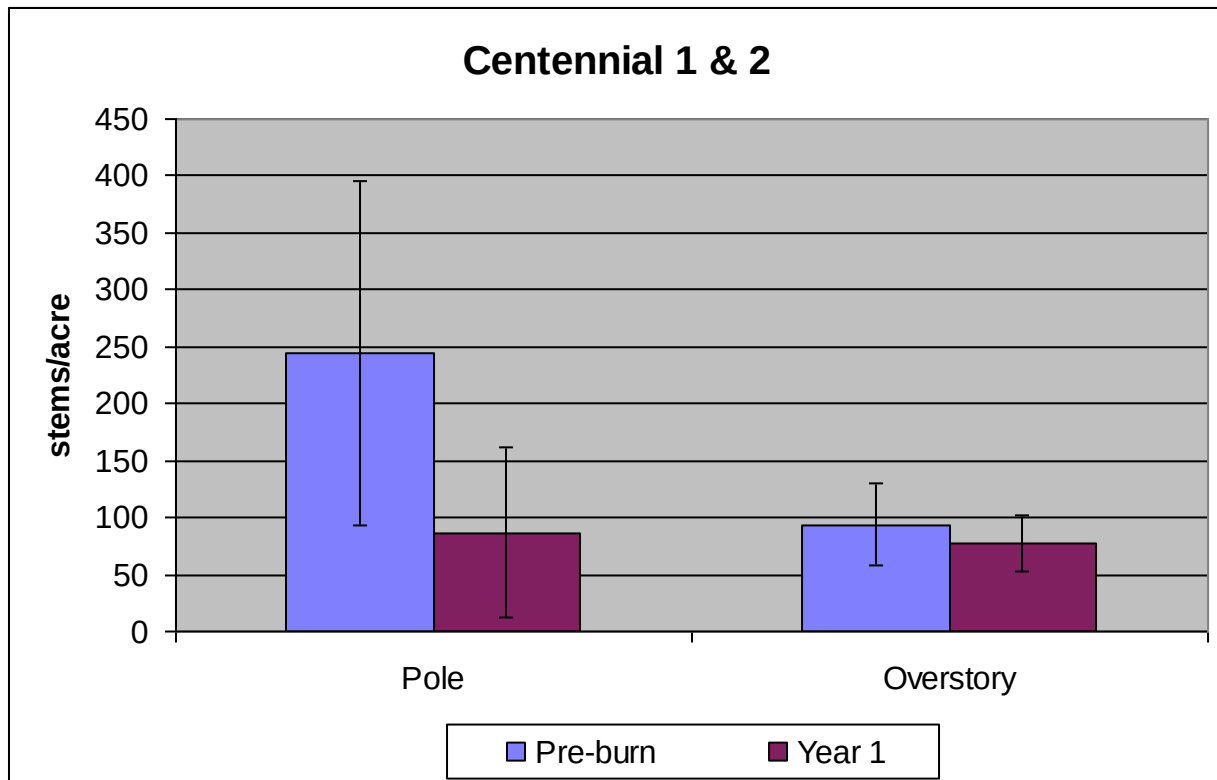


RANKIN RIDGE – TOWER			
tons/acre	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	8.4	10.3	22%
Litter & Duff	26.1	10.2	-61%
Total	34.5	20.5	-41%

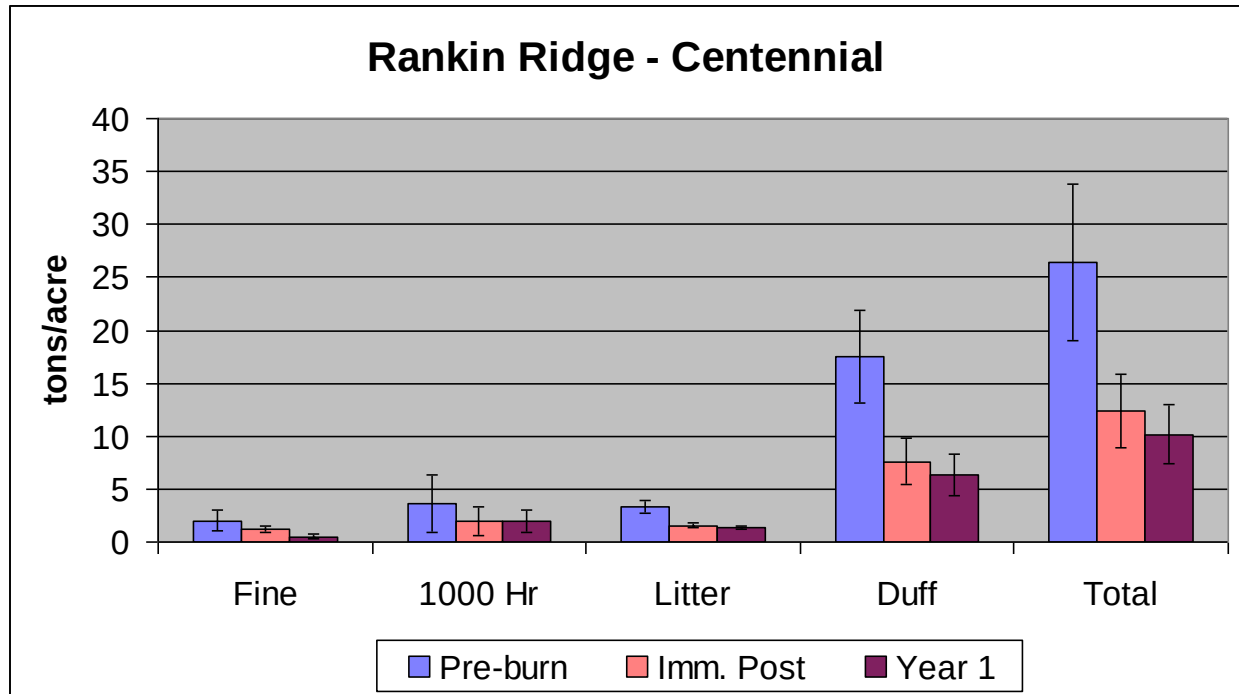
RANKIN RIDGE – TOWER			
stems/acre	Pre-burn Density	Yr 2 Density	Change
Poles	48.6	48.6	--
Overstory	178.1	178.1	--

Rankin Ridge – Centennial

Two FMH plots, 1 NGP plot, and 11 Forest & Fuels plots have been installed in the Centennial block of Rankin Ridge, but only four of the Forest & Fuels plots have burned. The following figures include data from these four plots.



RANKIN RIDGE – CENTENNIAL			
stems/acre	Pre-burn Density	Yr 1 Density	Change
Poles	244.7	87.0	-65%
Overstory	93.4	77.3	-17%



RANKIN RIDGE – CENTENNIAL			
tons/acre	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	5.6	2.4	-57%
Litter & Duff	20.8	7.7	-63%
Total	26.5	10.2	-62%

Campground

No plots were installed in the Campground unit.



Monitoring Units

Native mixed-grass prairie

Prescribed fire objectives

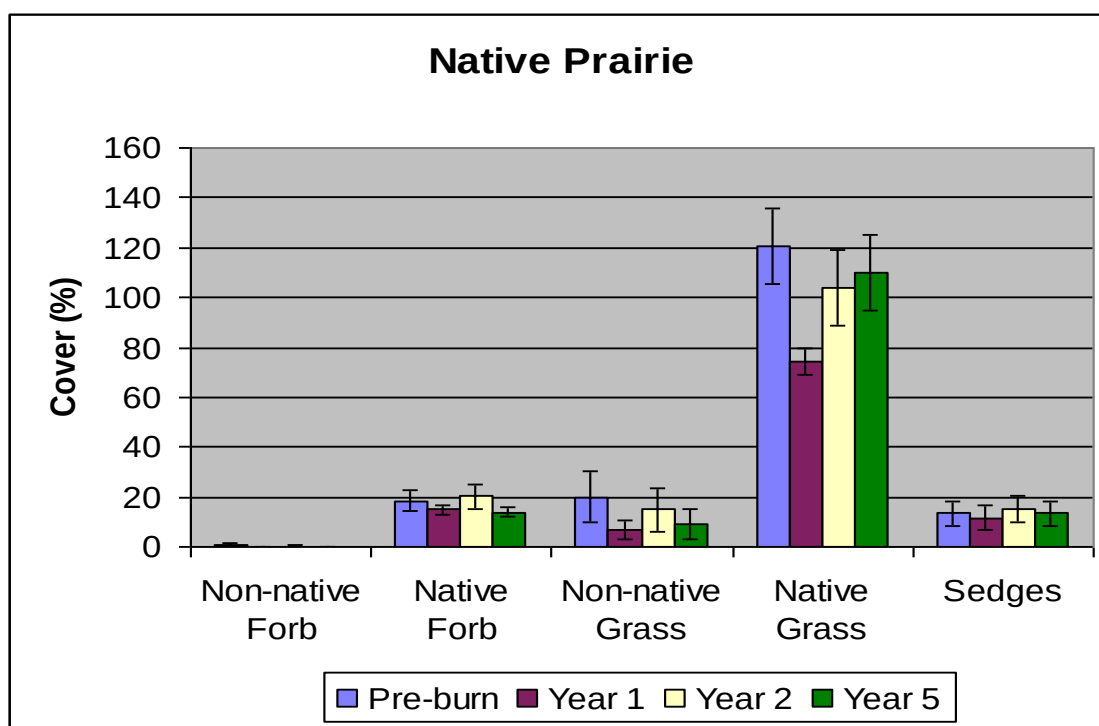
Immediate Post Burn

- Burn 60-80% of the burnable project area.

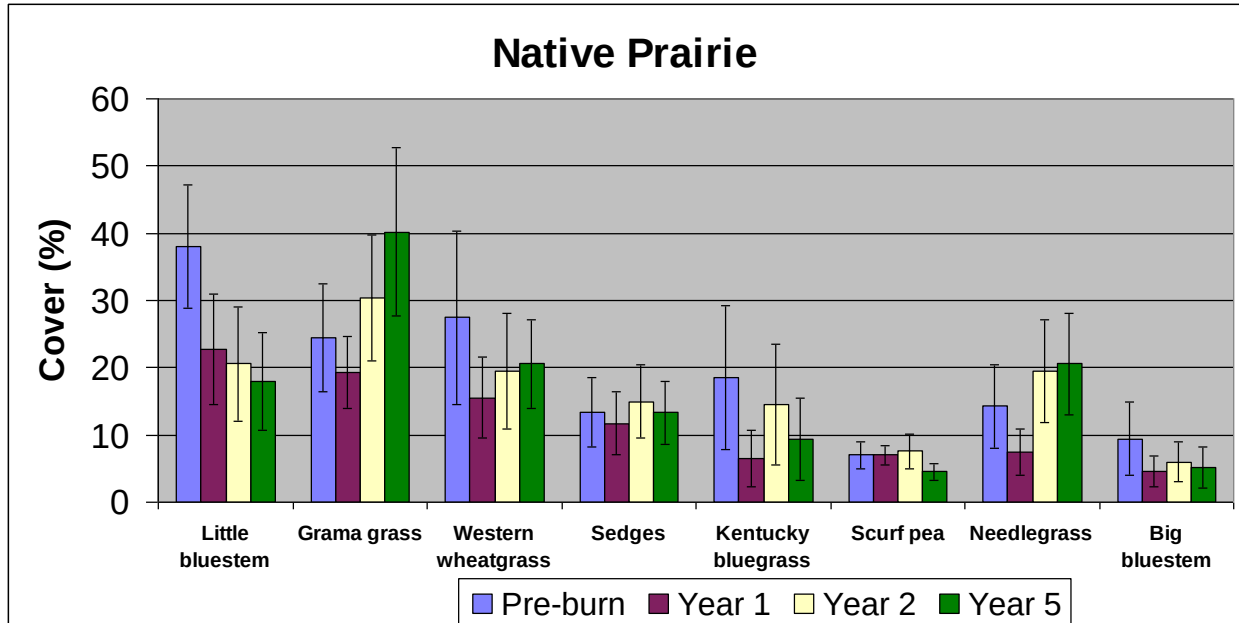
Two Years Post Burn

- Reduce cover of non-native grasses by at least 20%
- Increase cover of native grasses by at least 10%
- Increase cover of native forbs by at least 30%

Fourteen grassland plots have been installed in western wheatgrass and little bluestem vegetation types. Nine of these plots have burned and have been visited five years after prescribed fire. The figures below include data from seven plots because there are issues with pre-burn data from two of the plots. These were excluded from the analysis.



	NATIVE PRAIRIE				
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	0.6	0.4	-25%	0.3	-50%
<i>Native Forb</i>	18.6	20.3	9%	13.7	-26%
<i>Non-native Grass</i>	19.9	14.7	-26%	9.3	-53%
<i>Native Grass</i>	120.6	103.9	-14%	110.0	-9%
<i>Sedges</i>	13.4	15.0	12%	13.3	-1%
<i>Shrub</i>	3.7	3.1	-15%	1.4	-62%



NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
Little bluestem	38.0	20.6	-46%	18.0	-53%
Grama grass	24.4	30.4	25%	40.1	64%
Western wheatgrass	27.4	19.6	-29%	20.6	-25%
Sedges	13.4	15.0	12%	13.3	-1%
Kentucky bluegrass	18.6	14.6	-22%	9.3	-50%
Scurf pea	7.0	7.6	8%	4.6	-35%
Needlegrass	14.3	19.6	37%	20.6	44%
Big bluestem	9.4	6.0	-36%	5.1	-45%



Non-native prairie – Kentucky bluegrass

Prescribed fire objectives

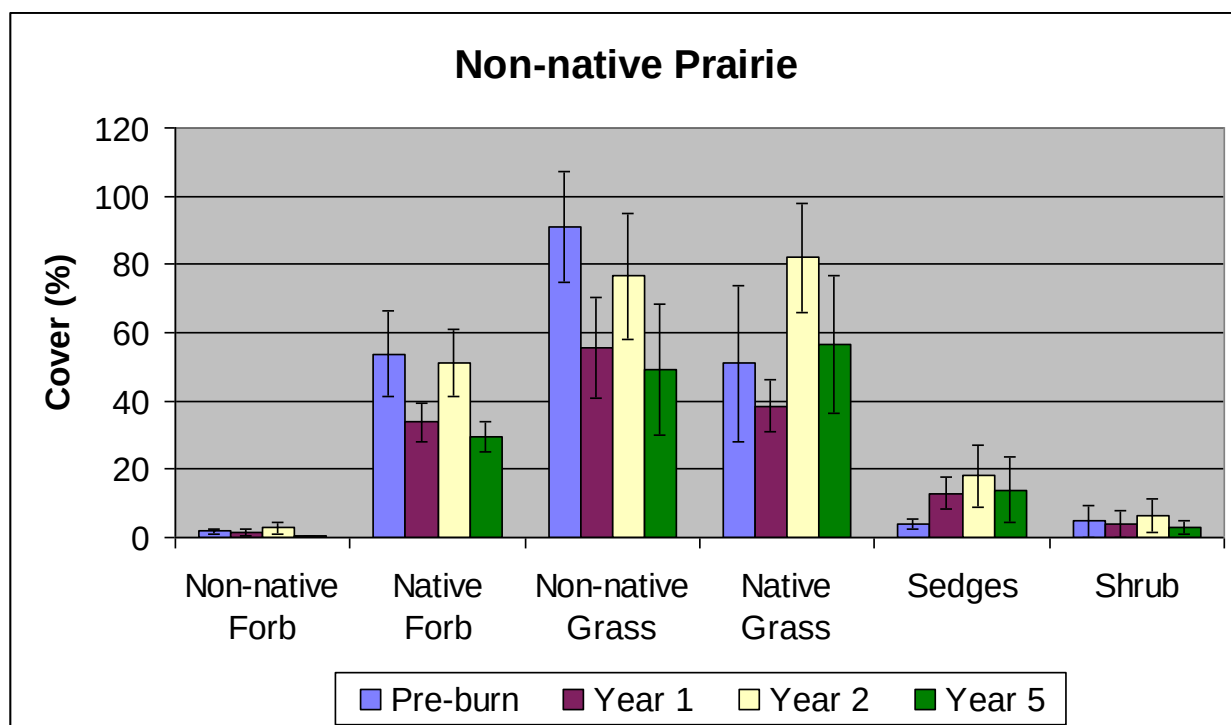
Immediate Post Burn

- Burn at least 60% of the burnable project area.

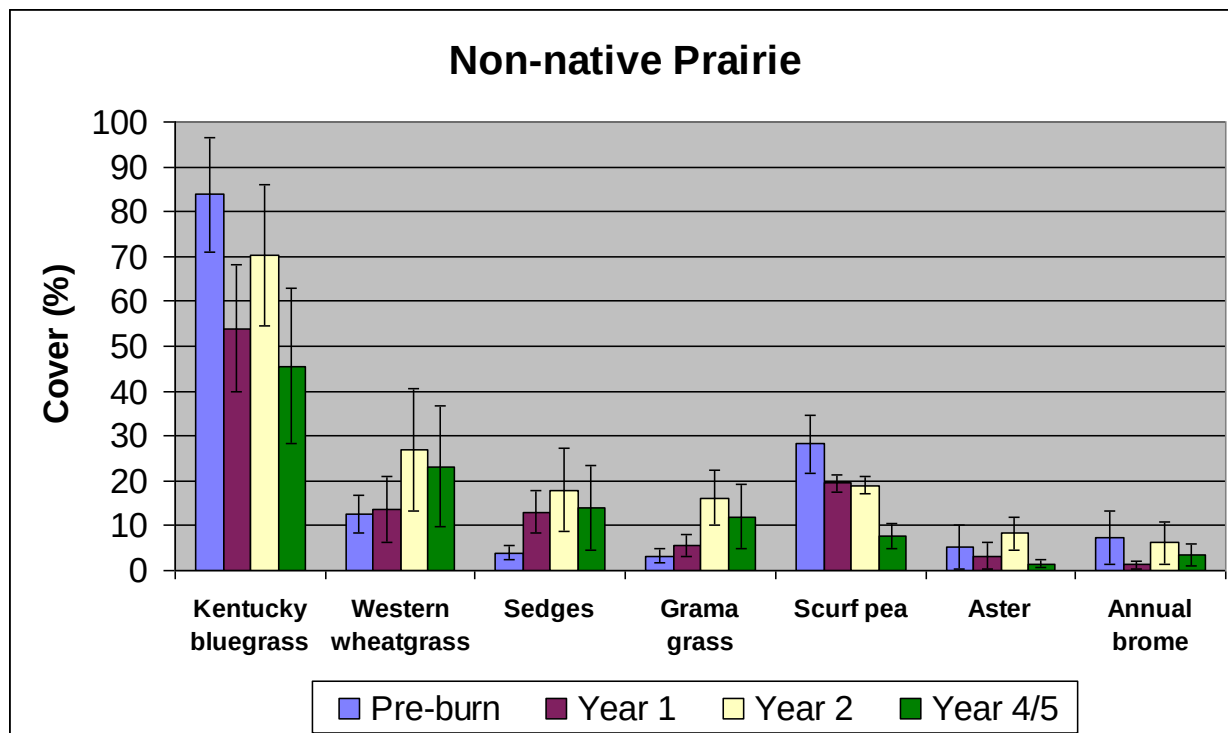
Two Years Post Burn

- Reduce *relative* cover of non-native grasses by at least 30%.
- Increase *relative* cover of native grasses by at least 20%.
- Increase *relative* cover of native forbs by at least 20%.

Five plots have been installed in Kentucky bluegrass dominated grasslands. All of these plots have burned, but only four have been visited 5 years post-burn. Data from the four plots have been summarized in the following two figures and tables.



NON-NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	1.8	2.8	57%	0.3	-86%
<i>Native Forb</i>	53.8	51.0	-5%	29.5	-45%
<i>Non-native Grass</i>	91.0	76.5	-16%	49.0	-46%
<i>Native Grass</i>	51.0	82.0	61%	56.5	11%
<i>Sedges</i>	4.0	18.0	350%	14.0	250%
<i>Shrub</i>	4.8	6.3	32%	3.0	-37%



NON-NATIVE PRAIRIE					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Kentucky bluegrass</i>	83.8	70.3	-16%	45.5	-46%
<i>Western wheatgrass</i>	12.5	27.0	116%	23.3	86%
<i>Sedges</i>	4.0	18.0	350%	14.0	250%
<i>Grama grass</i>	3.3	16.3	400%	12.0	269%
<i>Scurfpea</i>	28.3	19.0	-33%	7.8	-73%
<i>Aster</i>	5.3	8.3	57%	1.5	-71%
<i>Annual brome</i>	7.3	6.3	-14%	3.5	-52%

Ponderosa pine forest

Prescribed fire objectives

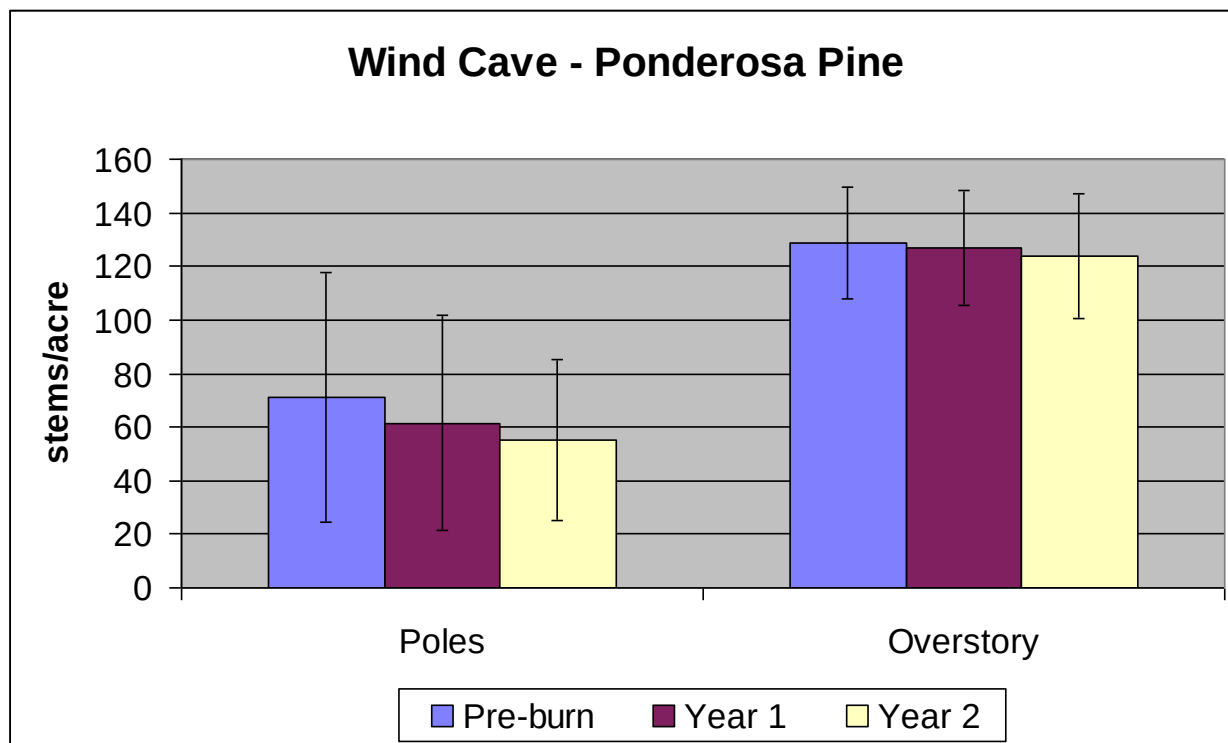
Immediate Post Burn

- Reduce dead and down fuel loading by at least 60%
- Burn at least 80% of the project area

Two Years Post Burn

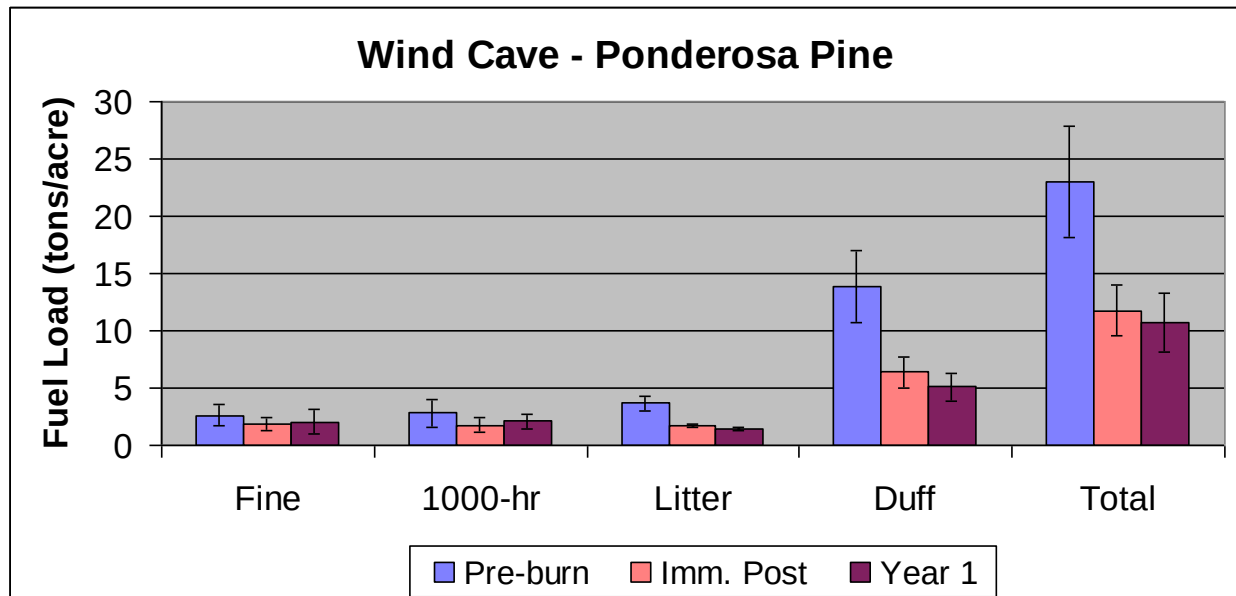
- Achieve at least 30% mortality in overstory ponderosa pine
- Achieve at least 50% mortality in pole-size ponderosa pine
- Achieve at least 70% mortality on seedling ponderosa pine
- Increase cover of native herbaceous species by at least 25%
- Reduce cover of non-native herbaceous species by at least 25%

Twelve FMH tree plots, one pilot NGP plot, and eleven Forest & Fuels plots have been installed at WICA. Nine of these plots (5 FMH, 4 Forest & Fuels) have burned in prescribed fires. Data from the 5 FMH plots were used in the summary of overstory trees, poles trees, and herbaceous vegetation since they have been visited two years following prescribed fire. All nine of the burned plots were used in the summaries of seedling trees and fuels.



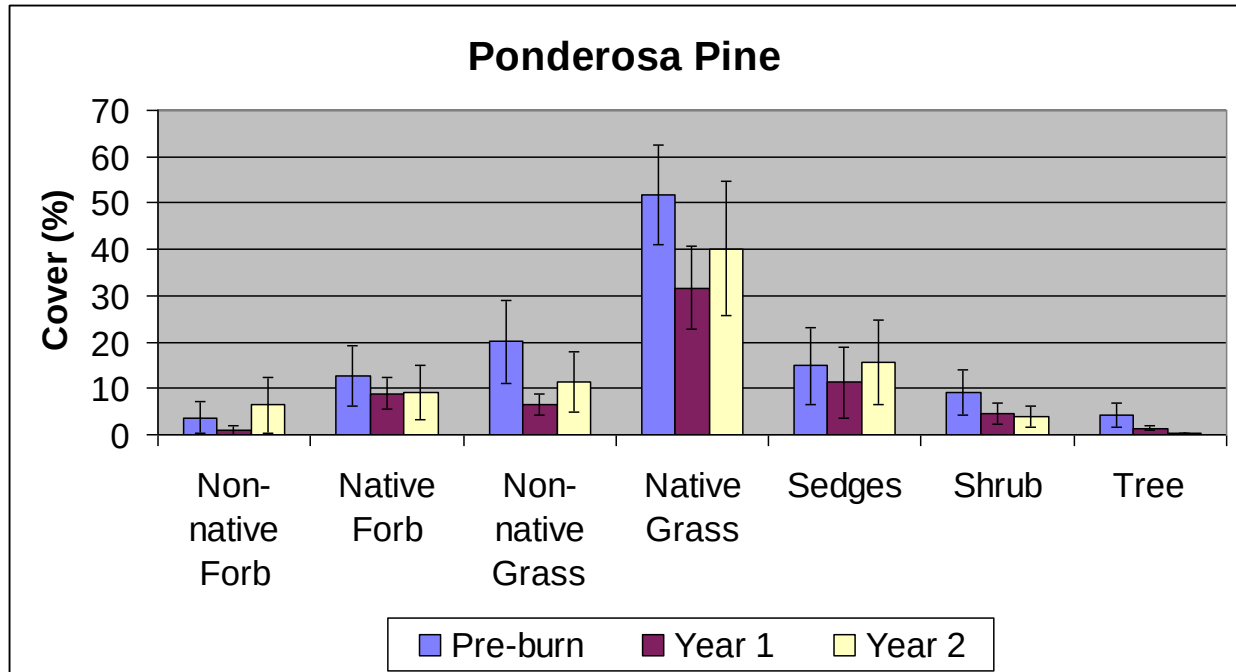
PONDEROSA PINE			
stems/acre	Pre-burn Density	Yr 2 Density	Change
Poles	71.2	55.0	-23%
Overstory	128.7	123.8	-4%

PONDEROSA PINE			
stems/acre	Pre-burn Density	Yr 1 Density	Change
Seedlings	6019.4	582.1	-90%

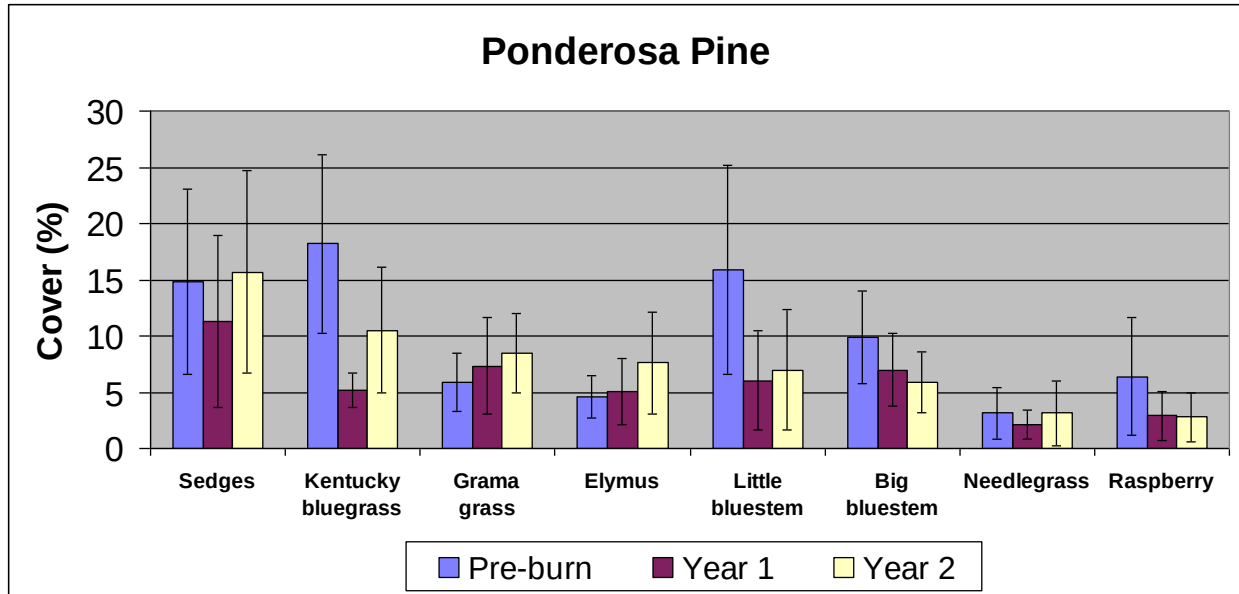


Ponderosa Pine			
	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	5.4	4.2	-24%
Litter & Duff	17.6	6.5	-63%
Total	23.0	10.7	-54%





PONDEROSA PINE			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	3.7	6.4	71%
Native Forb	12.6	9.0	-29%
<i>Non-native Grass</i>	20.1	11.4	-43%
Native Grass	51.8	40.1	-23%
Sedges	14.8	15.7	6%
Shrub	9.2	4.0	-57%
Tree	4.2	0.2	-94%

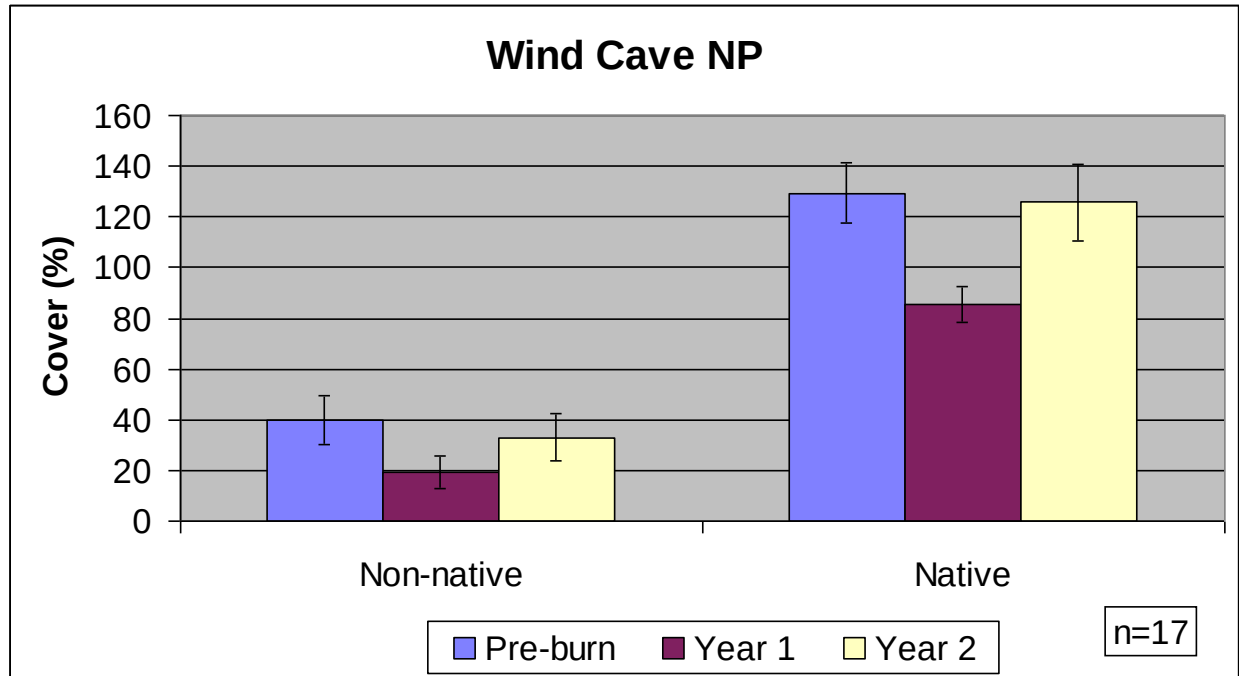


PONDEROSA PINE			
	Pre-burn Cover	Yr 2 Cover	Change
Sedges	14.8	15.7	6%
<i>Kentucky bluegrass</i>	18.2	10.5	-42%
Grama grass	5.9	8.4	43%
Elymus spp.	4.6	7.6	66%
Little bluestem	15.9	7.0	-56%
Big bluestem	9.9	5.9	-40%
Needlegrass	3.1	3.1	0%
Raspberry	6.4	2.8	-57%

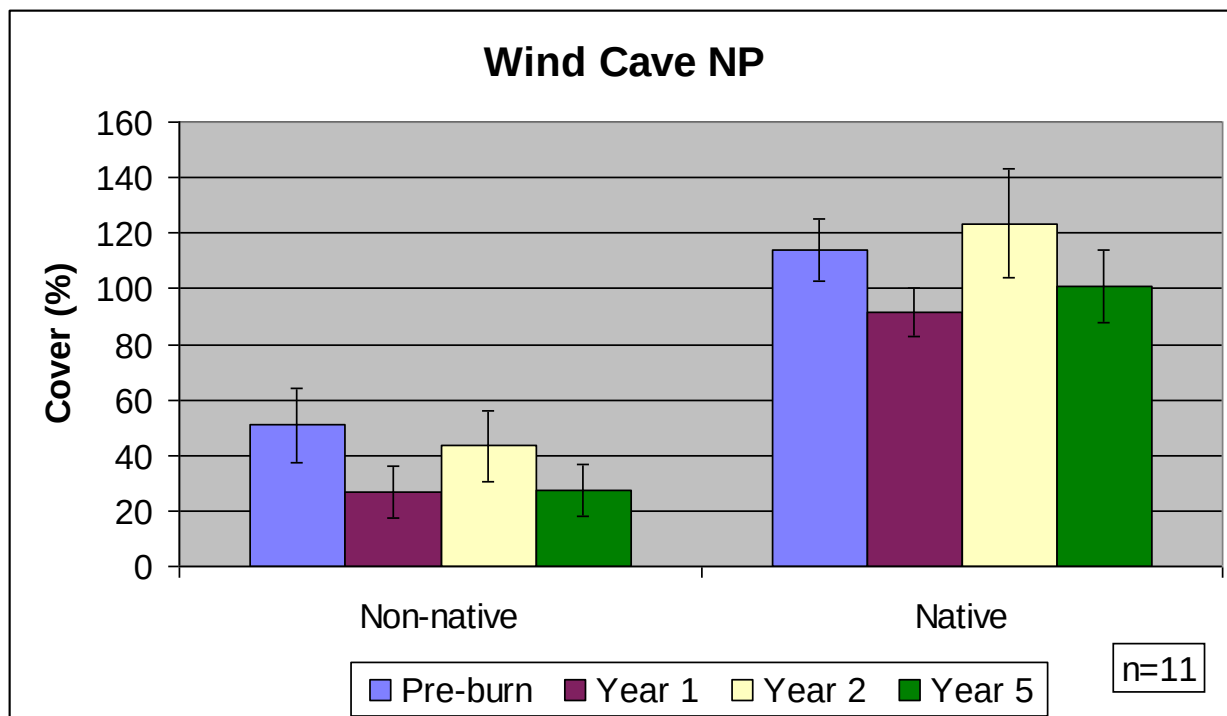


Park-wide Summary

Twenty-seven FMH plots have been installed at Wind Cave National Park. Two of these plots have been excluded from this analysis because there are issues with the data that were collected when the plots were installed in 1997. Of the remaining plots, seventeen have burned in prescribed fires. These plots have all been visited two years after fire. Eleven of these plots have been visited five years after fire. The two- and five-year summaries are shown in the following figures and tables.

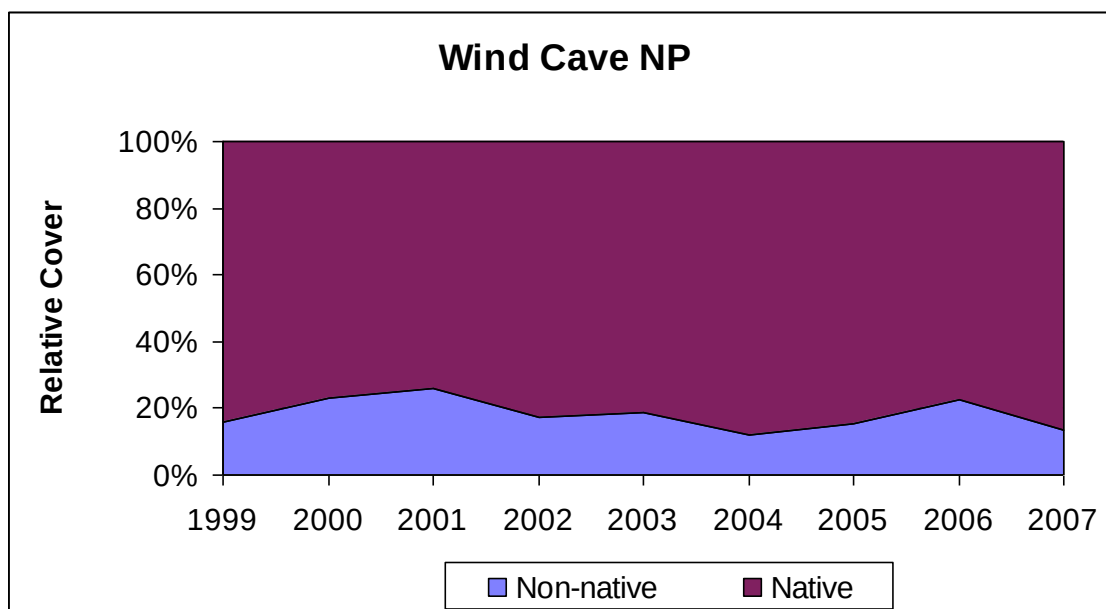


WIND CAVE NP			
	Pre-burn Cover	Yr 2 Cover	Change
Non-native	39.5	33.0	-17%
Native	129.5	125.9	-3%



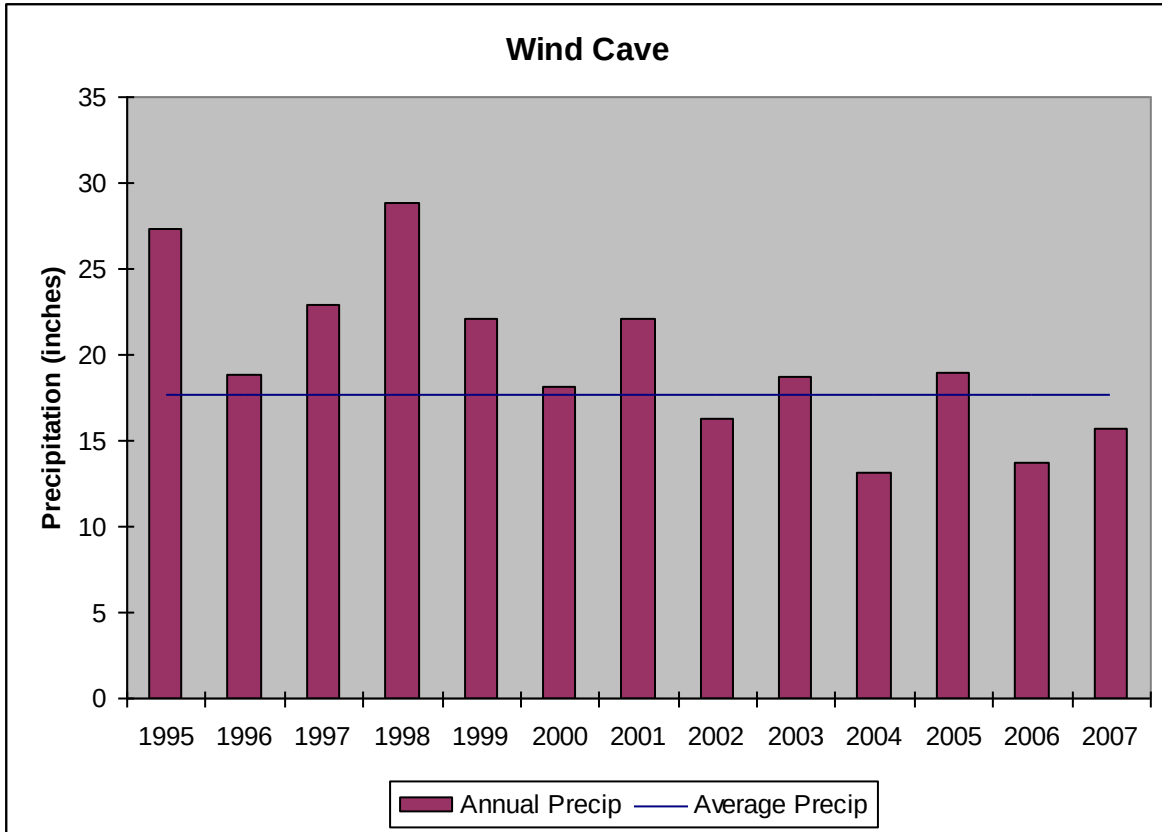
WIND CAVE NP					
	Pre-burn cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native</i>	50.8	43.3	-15%	27.4	-46%
Native	114.0	123.4	8%	101.0	-11%

The figure below is a summary of relative cover on all plots visited by year. One caveat regarding this summary is that sample size changed by year, varying from four plots visited in 2000 to twenty plots in 2003. The hope is to assess relative cover by year, regardless of plot treatment status.



PRECIPITATION

Data from manual weather station at Wind Cave National Park. Data on file with Wind Cave Resource Management.

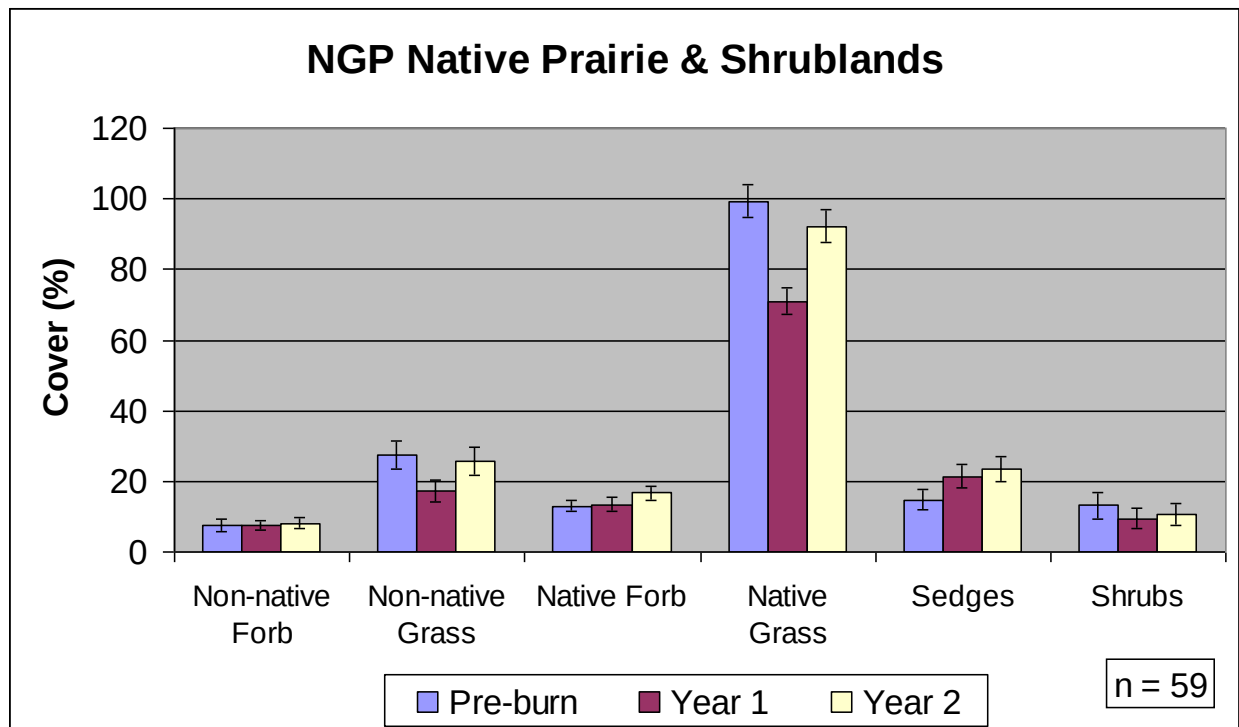




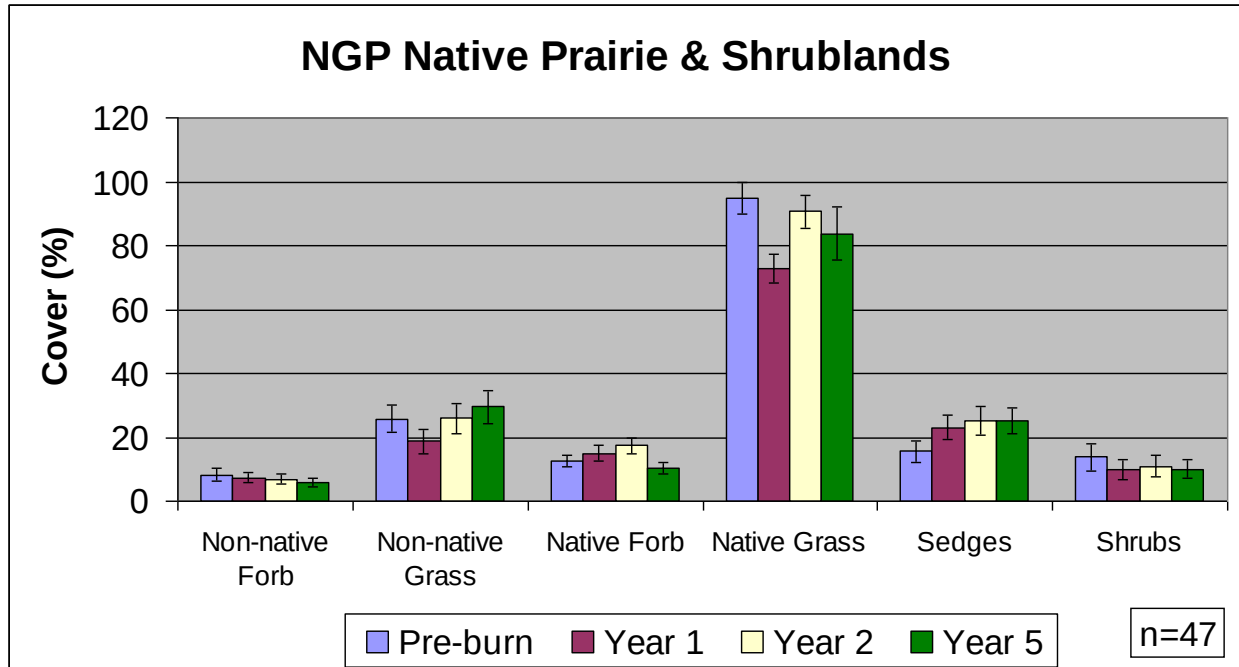
MULTI-PARK SUMMARY

NATIVE PRAIRIE & SHRUBLANDS

Monitoring plots have been installed and burned in native prairie and shrublands in 5 Northern Great Plains park units. Fifty-nine of these plots have been visited two years post-fire and 47 have been visited five years post-fire.



NATIVE PRAIRIE & SHRUBLAND			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	7.6	8.1	7%
<i>Non-native Grass</i>	27.6	25.8	-7%
<i>Native Forb</i>	12.9	16.7	29%
<i>Native Grass</i>	99.4	92.3	-7%
<i>Sedges</i>	14.8	23.4	58%
<i>Shrub</i>	13.2	10.7	-19%

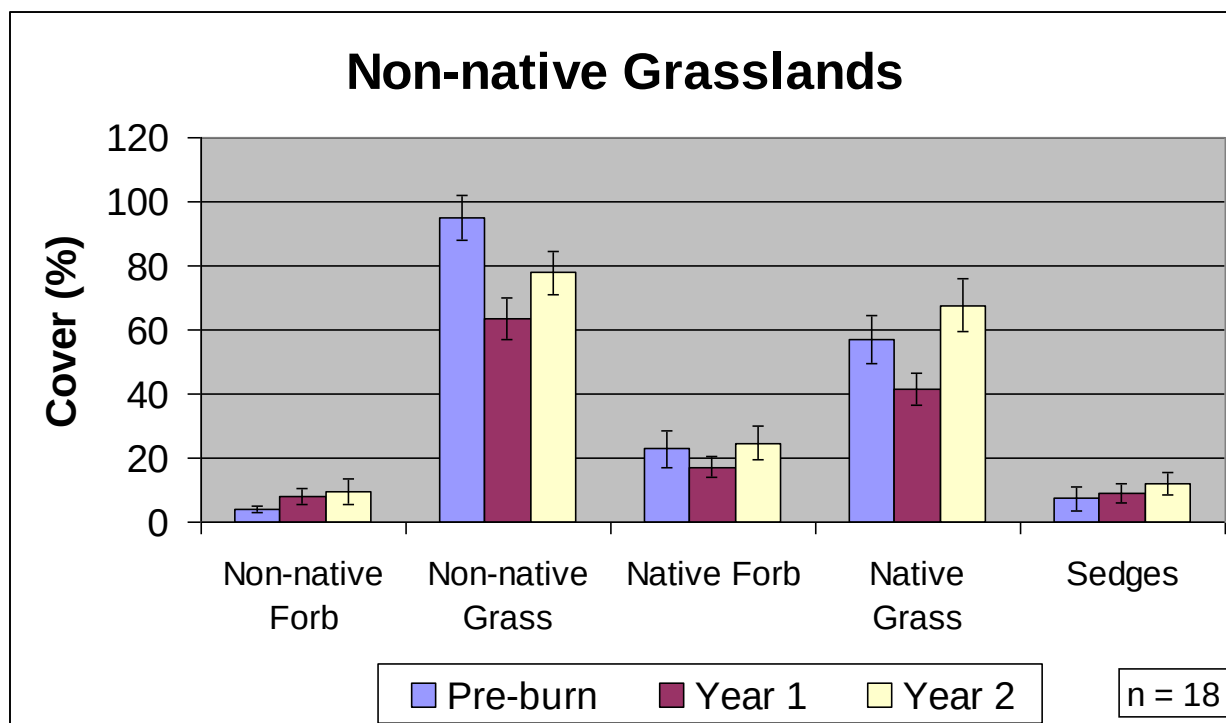


NATIVE PRAIRIE & SHRUBLAND					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	8.3	7.0	-16%	5.8	-30%
<i>Non-native Grass</i>	25.7	25.9	1%	29.4	15%
<i>Native Forb</i>	12.6	17.3	38%	10.4	-17%
<i>Native Grass</i>	94.7	90.7	-4%	83.8	-12%
<i>Sedges</i>	15.5	25.2	62%	25.2	62%
<i>Shrub</i>	13.8	11.0	-21%	10.0	-27%

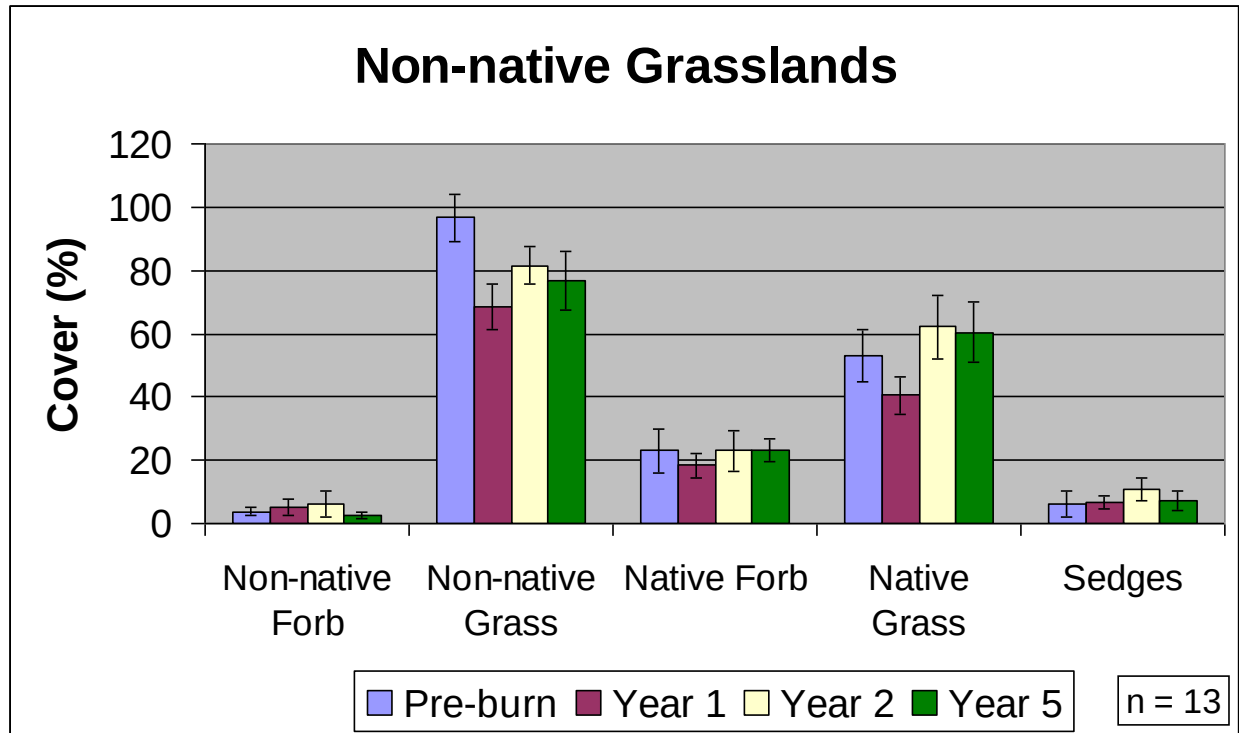


NON-NATIVE GRASSLANDS

Twenty-four plots have been installed in non-native grasslands across five NPS units. Eighteen plots have burned and have been visited two years after fire, while 13 of the plots have been visited five years after fire.

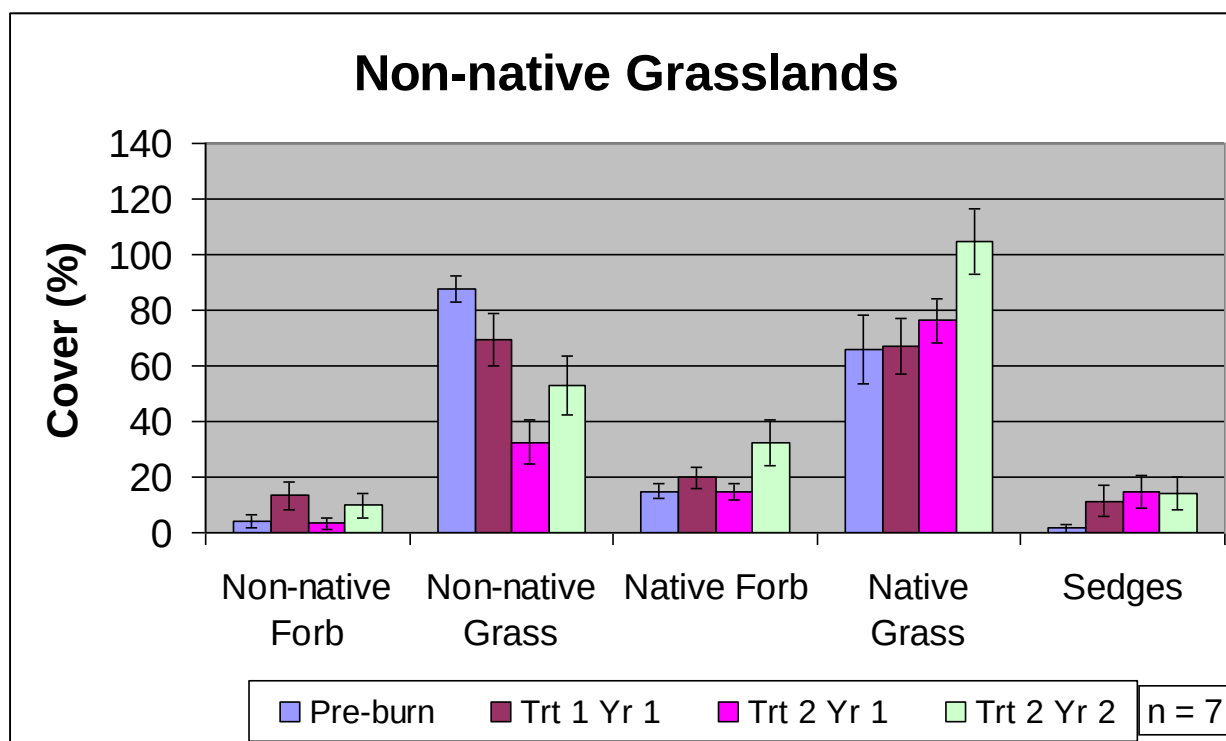


NON-NATIVE GRASSLANDS			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	4.1	9.6	137%
<i>Non-native Grass</i>	95.0	77.8	-18%
Native Forb	22.8	24.7	9%
Native Grass	56.8	67.7	19%
Sedges	7.3	11.9	63%



NON-NATIVE GRASSLANDS					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	3.8	6.3	67%	2.5	-33%
<i>Non-native Grass</i>	96.6	81.4	-16%	76.9	-20%
<i>Native Forb</i>	22.9	22.9	0%	23.3	2%
<i>Native Grass</i>	53.0	62.2	17%	60.4	14%
<i>Sedges</i>	6.2	10.8	75%	7.2	16%

Seven plots at Badlands, Devils Tower, and Theodore Roosevelt have burned twice and visited two years after fire. All seven of these are Kentucky bluegrass plots. A summary of these plots is included in the figure and table below.

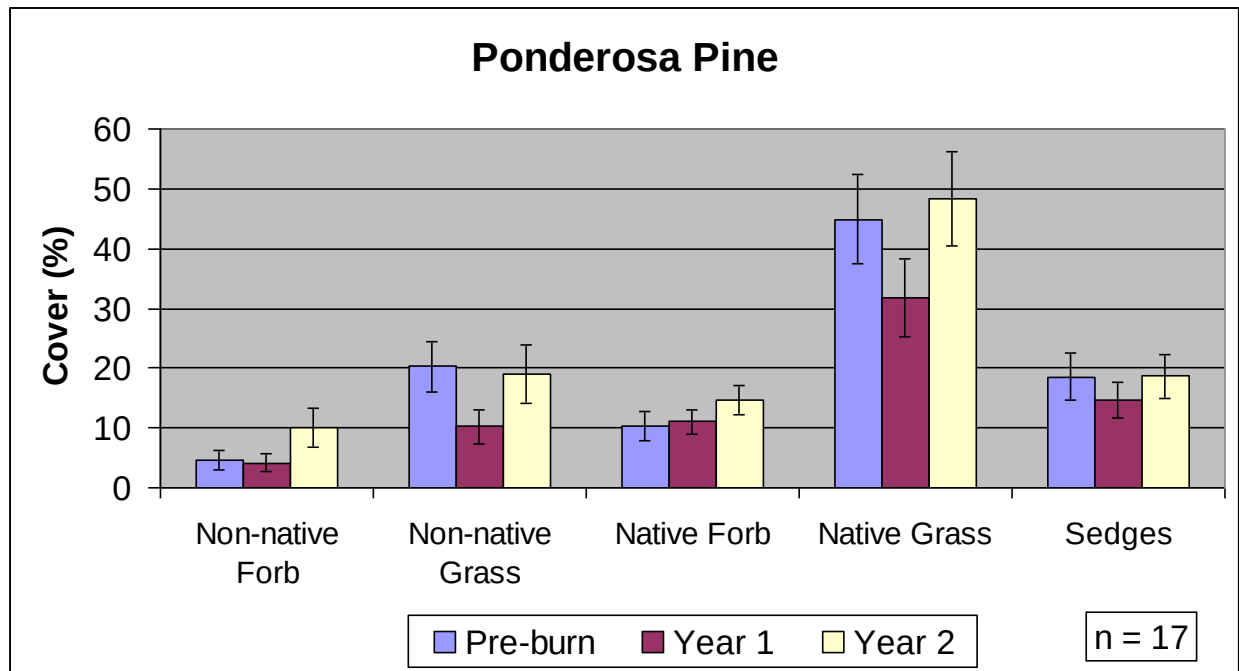


NON-NATIVE GRASSLANDS			
	Pre-burn Cover	Trt 2 Yr 2 Cover	Change
<i>Non-native Forb</i>	4.1	9.9	138%
<i>Non-native Grass</i>	87.9	53.1	-40%
Native Forb	15.0	32.3	115%
Native Grass	65.7	104.9	60%
Sedges	1.6	14.3	809%

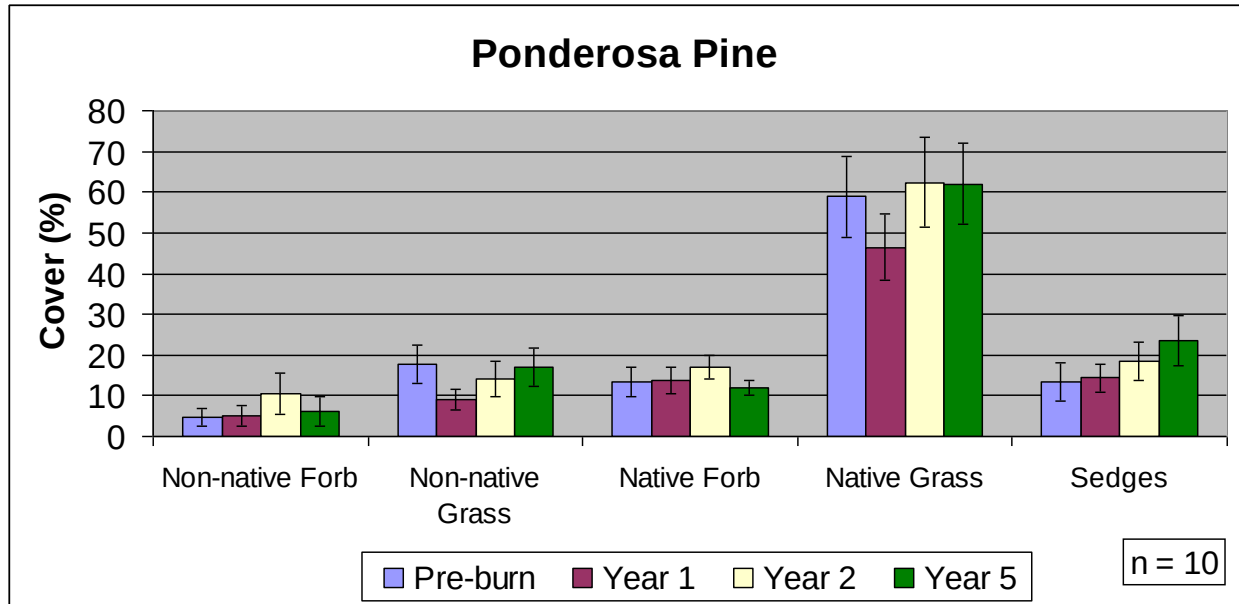
PONDEROSA PINE FOREST

Herbaceous Vegetation

Twenty-five ponderosa pine plots have been installed at Wind Cave and Devils Tower. Seventeen of these plots have been visited two years after fire while 10 have been visited 5 years after fire. The following figures and tables include summaries from these plots.



PONDEROSA PINE FOREST			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	4.6	10.0	116%
<i>Non-native Grass</i>	20.2	19.0	-6%
<i>Native Forb</i>	10.2	14.6	43%
<i>Native Grass</i>	44.8	48.3	8%
<i>Sedges</i>	18.5	18.7	1%

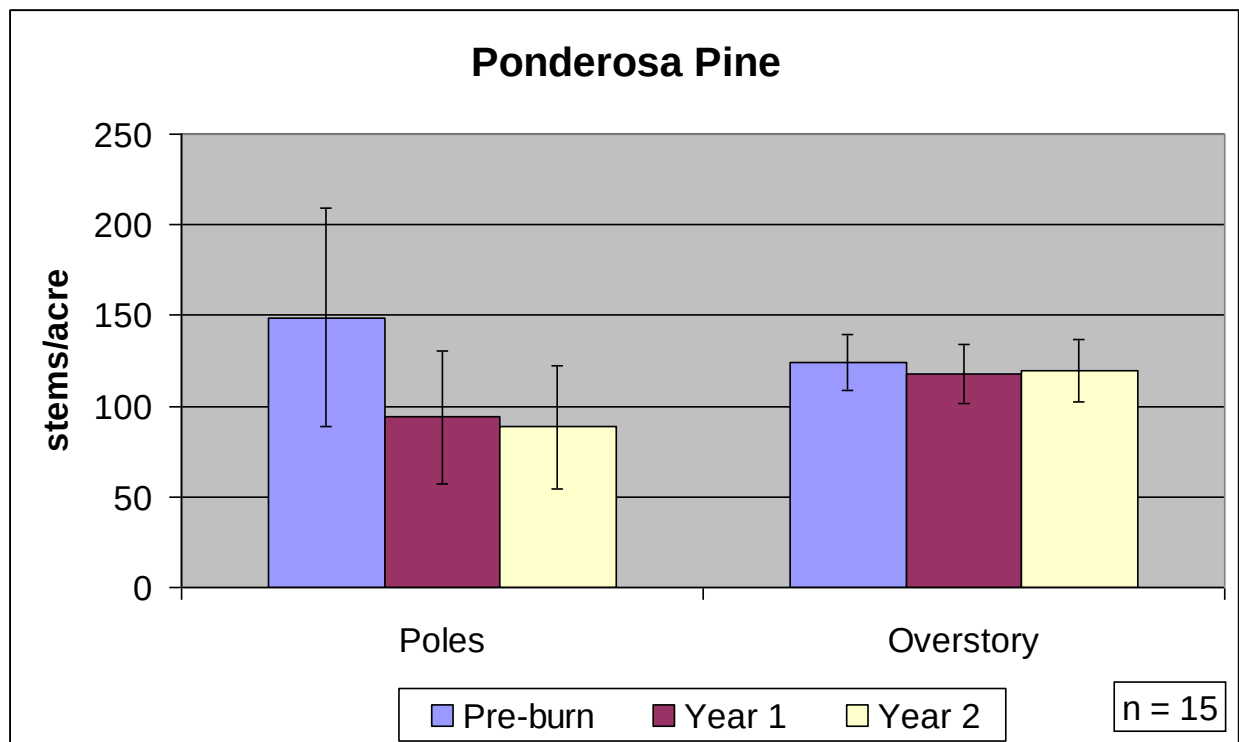


PONDEROSA PINE FOREST					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	4.8	10.5	122%	6.3	32%
<i>Non-native Grass</i>	17.8	14.2	-20%	17.0	-4%
<i>Native Forb</i>	13.4	17.0	27%	12.0	-10%
<i>Native Grass</i>	59.0	62.4	6%	62.0	5%
<i>Sedges</i>	13.3	18.3	38%	23.7	78%

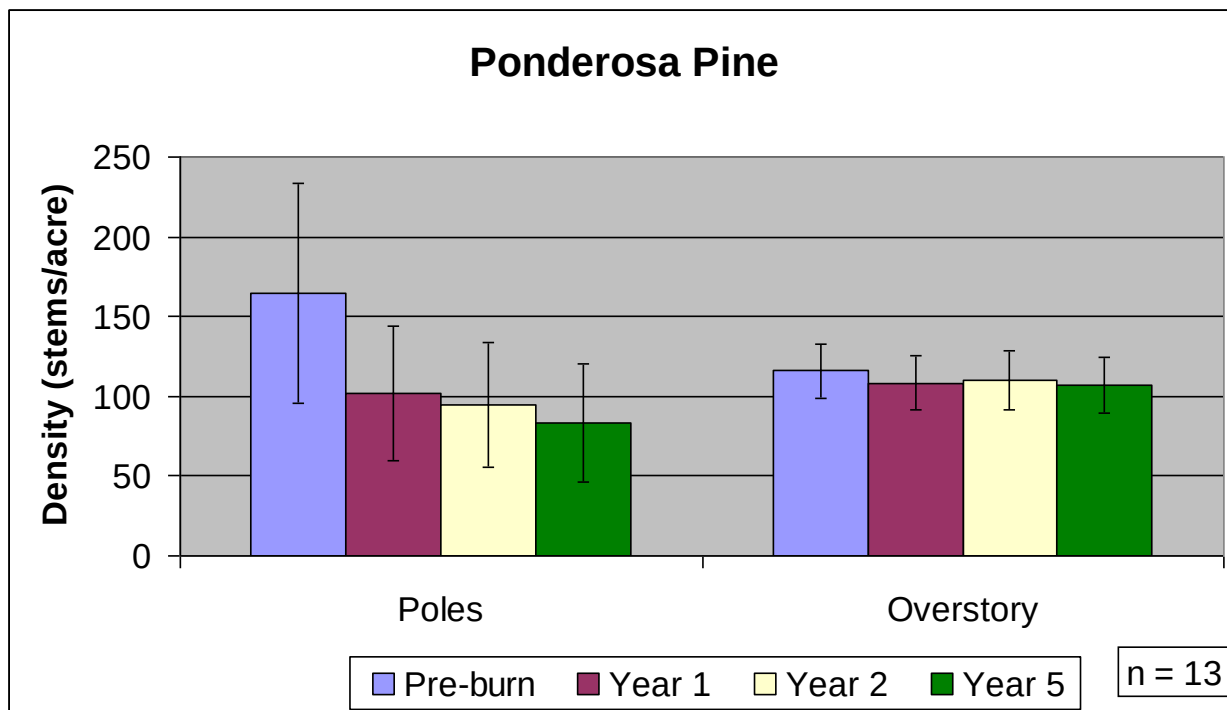


Tree Density

The following figures and tables include data from Wind Cave, Devils Tower, and Jewel Cave. This analysis does not include plots installed in the North Terrace unit at Devils Tower because these plots were mechanically thinned. For the purposes of this analysis, post-treatment data from the three plots at Jewel Cave were collected following the Jasper fire. These plots actually burned twice, first in a prescribed fire and then in the Jasper fire. The impact on the trees in these plots was primarily from the prescribed fire because they were very lightly burned during the Jasper fire but the timing was such that the post-treatment plot visits were used after the Jasper fire.



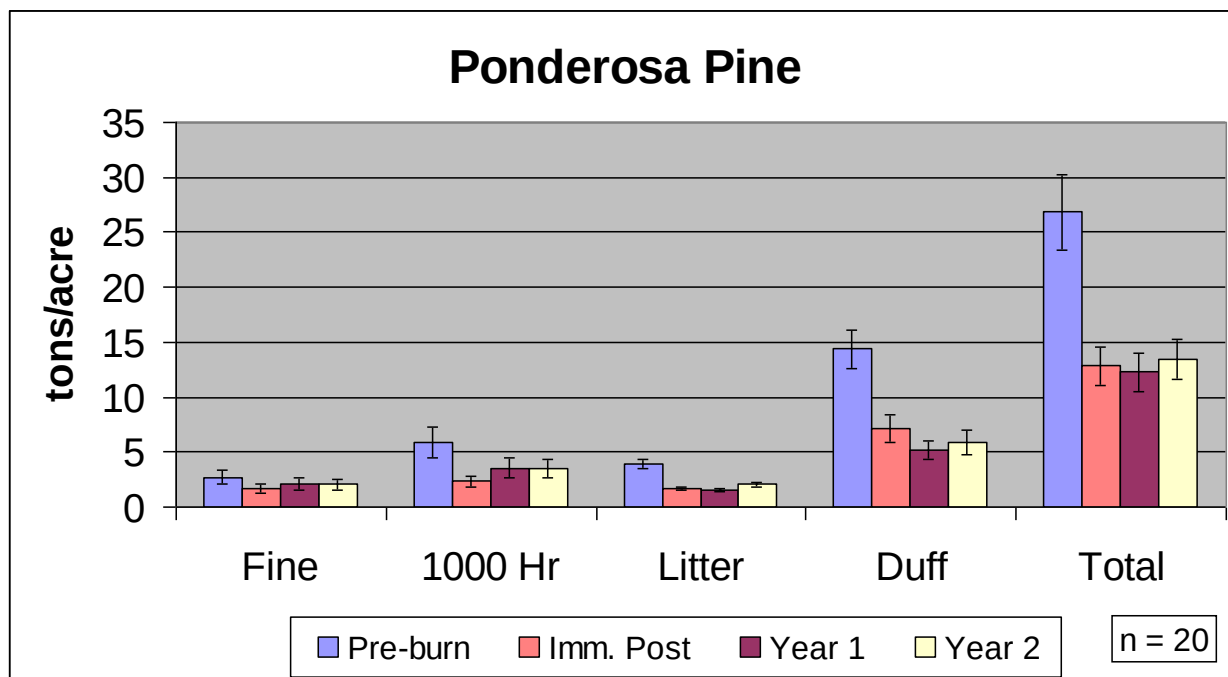
PONDEROSA PINE			
stems/acre	Pre-burn Density	Yr 2 Density	Change
Poles	148.9	88.5	-41%
Overstory	124.1	119.5	-4%



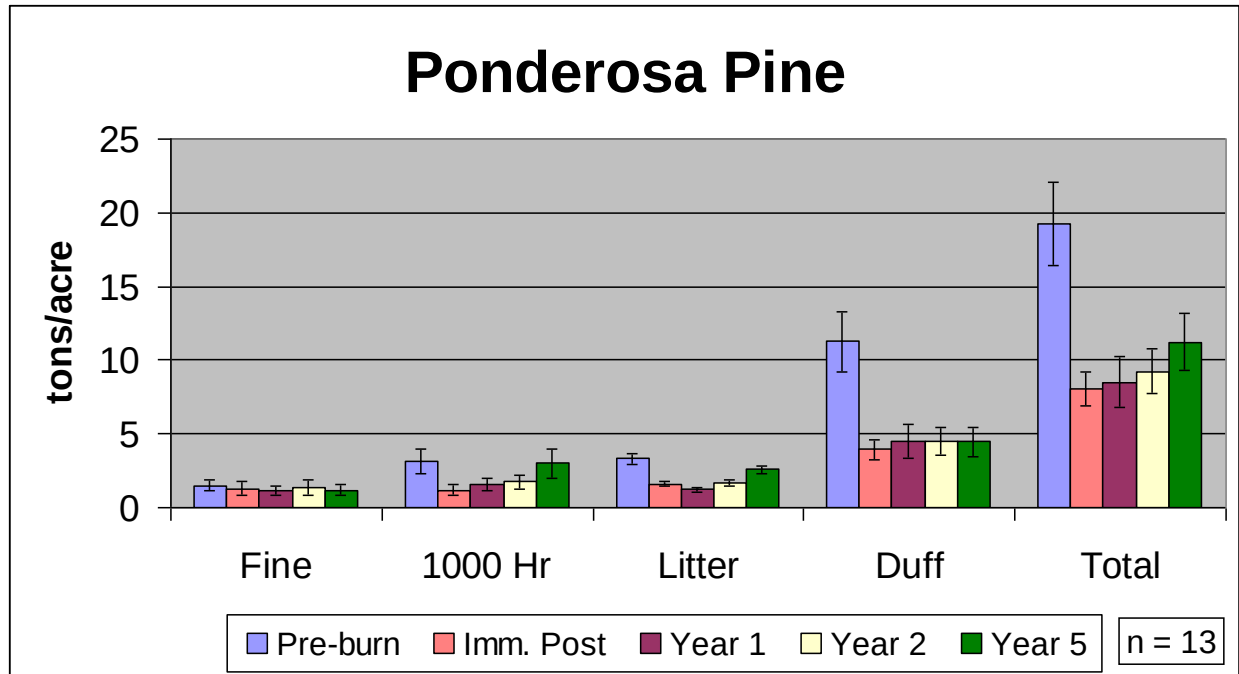
PONDEROSA PINE					
stems/acre	Pre-burn Density	Year 2 Density	Change	Year 5 Density	Change
Poles	164.4	94.6	-42%	83.4	-49%
Overstory	115.8	110.5	-5%	107.2	-8%

Fuel Load

This summary includes data from Wind Cave, Jewel Cave, and Devils Tower. Plots from the North Terrace unit at Devils Tower are included. The pre-treatment data is from the pre-thinning plot visit, while the post treatment data were collected following the prescribed fire. Some of the fuel may have been removed when the piles were burned, but that would also be reflected in the post-prescribed fire data. Pre-burn data for the three Jewel Cave plots were collected before the prescribed fire and the immediate post-burn data were collected after the prescribed fire. The Years 1, 2, and 5 data were collected during the visits following the Jasper fire.

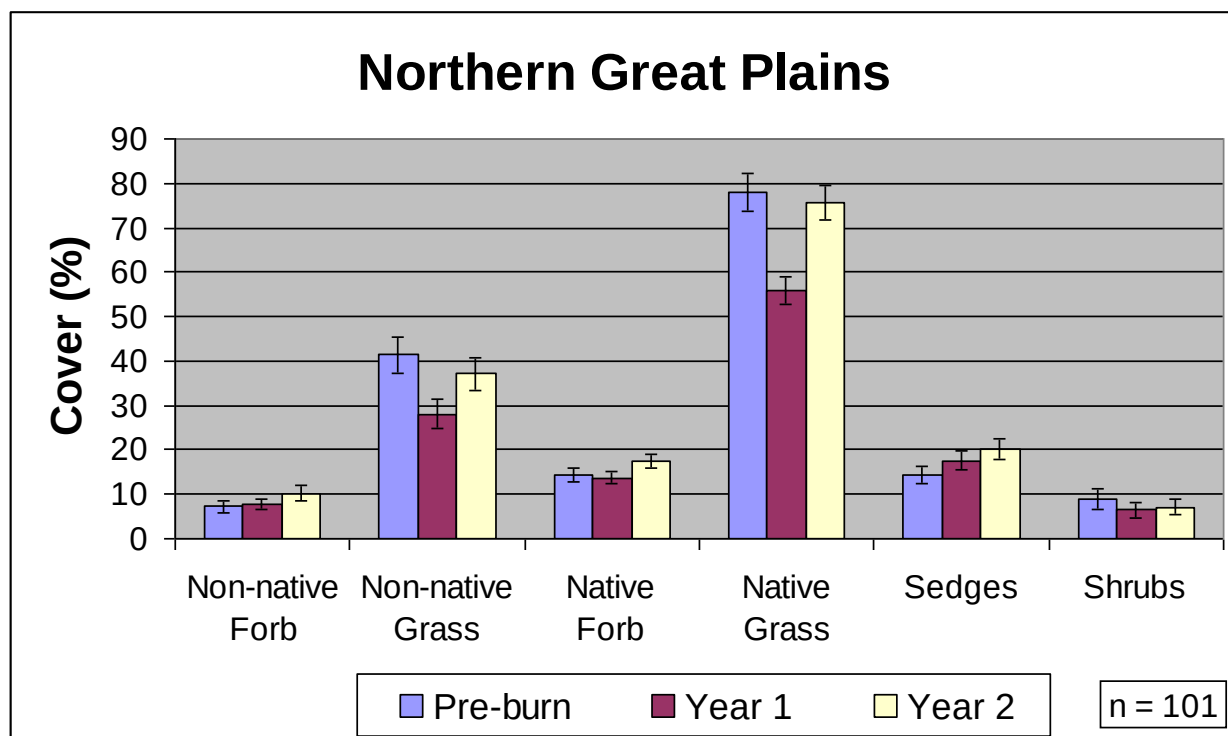


PONDEROSA PINE			
tons/acre	Pre-burn Fuel Load	Yr 1 Fuel Load	Change
Woody Fuels	8.5	5.6	-34%
Litter & Duff	18.3	6.7	-64%
Total	26.8	12.3	-54%

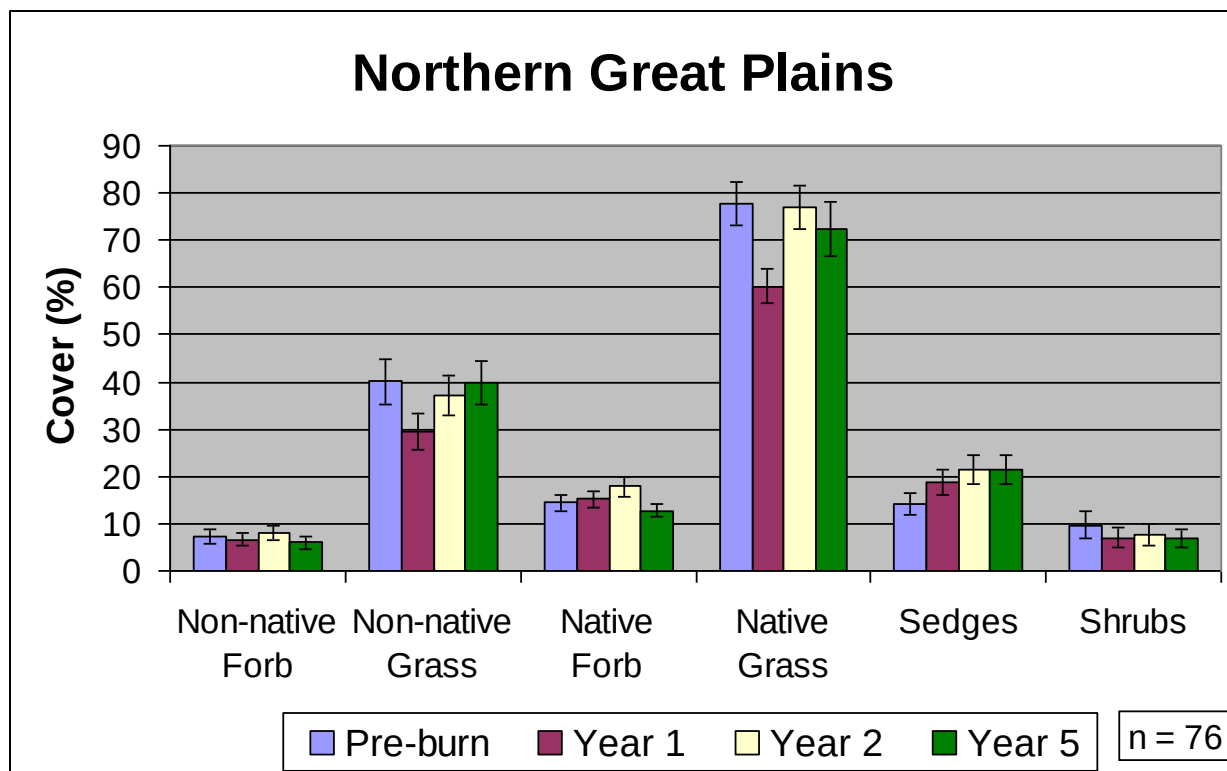


PONDEROSA PINE					
tons/acre	Pre-burn Fuel Load	Year 1 Fuel Load	Change	Year 5 Fuel Load	Change
Woody fuels	4.7	2.7	-41%	4.2	-10%
Litter & Duff	14.6	5.8	-61%	7.0	-52%
Total	19.3	8.5	-56%	11.2	-42%

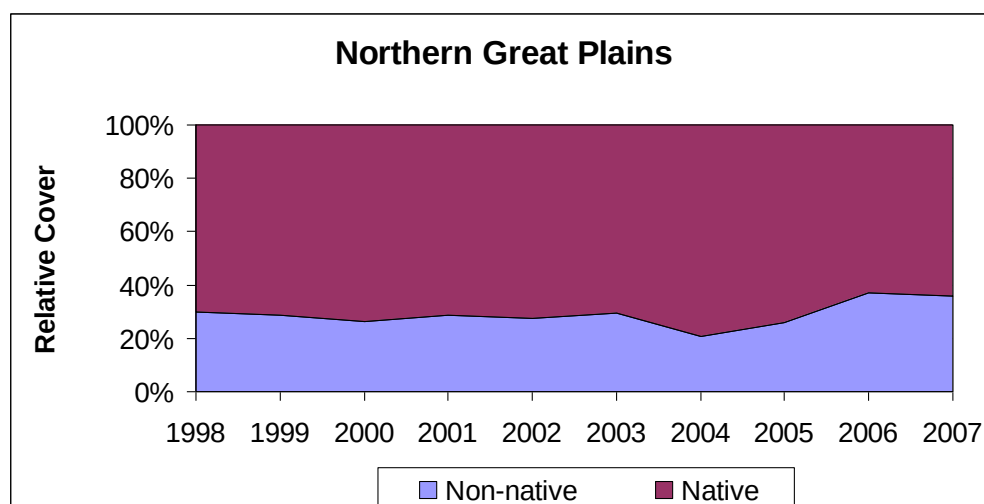
ALL PLOTS



NORTHERN GREAT PLAINS			
	Pre-burn Cover	Yr 2 Cover	Change
<i>Non-native Forb</i>	7.3	10.2	41%
<i>Non-native Grass</i>	41.4	37.2	-10%
Native Forb	14.2	17.5	23%
Native Grass	77.9	75.7	-3%
Sedges	14.4	20.1	40%
Shrubs	8.9	7.1	-21%



NORTHERN GREAT PLAINS					
	Pre-burn Cover	Yr 2 Cover	Change	Yr 5 Cover	Change
<i>Non-native Forb</i>	7.2	8.2	14%	6.0	-16%
<i>Non-native Grass</i>	40.1	37.1	-8%	39.9	-1%
Native Forb	14.4	17.8	24%	12.8	-11%
Native Grass	77.9	76.9	-1%	72.3	-7%
Sedges	14.2	21.4	51%	21.4	51%
Shrubs	9.7	7.7	-20%	7.0	-28%





CONCLUSION

This is the most comprehensive data analysis completed since fire effects data collection began in the Northern Great Plains park group. We hope that this comes at an important milestone for the program. The fire ecology program is currently collaborating with the NGP Inventory & Monitoring Program regarding the future of vegetation monitoring in NGP parks. Hopefully the results presented in this document can be referred to as a guide in the development of new goals and objectives, for making adjustments to monitoring protocols, and guiding the program into the future.

GENERAL OBSERVATIONS

We have found the response of vegetation cover to precipitation very interesting. This has been most dramatic at Badlands, but there have been similar responses at most of the parks. It is generally hard to tease out of our data because of our study design and lack of control plots, but precipitation appears to have as large, if not a larger, influence on changes in vegetation cover than fire does.

The response in upland sedge cover has been noteworthy because it seems to be fairly consistent across the parks. The sedges have tended to respond favorably to fire and in some cases remarkably so (at least in terms of percentage change). It also appears to be resistant to drought. In cases where other species appeared to decrease in cover as response to decreases in precipitation, the sedges maintained cover. We also noticed that in units where the prairie has been tilled or disturbed but is now in some stage of restoration, the upland sedges are absent. They seem to be sensitive to this type of disturbance. This may mean that the sedges would be a good indicator for the condition or health of prairie areas.

In general, Kentucky bluegrass is negatively affected by fire. There are several examples where Kentucky bluegrass cover has decreased following both spring and fall prescribed fire. The one striking example where this pattern does not hold is at Knife River. It would require further investigation to explain why we've seen such a different response there. The plots were predominately native when they were installed, but after two prescribed fires the native cover has decreased significantly while the non-native grasses have increased. There may be some problems with the plot locations--they are all clustered in one corner of the unit--so it is hard to make inferences about the burn unit. It doesn't seem to be a result of seasonality of fire because one was a spring fire and one was a fall fire. The response may be a result of the lack of grazing, but it is likely the interaction of several variables.

Some of our greatest and most visually dramatic successes have been in the ponderosa pine forests. Prescribed fires reduce the fuel load, kill the smaller trees, and open the canopy. This has been especially evident on treatment units where mechanical treatments have been followed by fire. Though the costs and challenges of burning in the forest are high, the monitoring results confirm that prescribed fire positively impacts the condition of ponderosa pine stands.

RECOMMENDATIONS

We have been very successful reducing fuel loads, seedling density, and to some extent pole density with prescribed fire in ponderosa pine stands. The majority of the fuel load in stands that

have not burned in many years or in some cases decades tends to be found in the litter and duff. After several fires in pine stands, we have reduced average litter and duff load by more than 50%. In our opinion, these fuels should be the target in stands that have not seen fire in many years. With that in mind, the litter and duff moisture should be taken into consideration when determining fire prescriptions for these stands. Further analyses will need to be completed to provide guidelines regarding the relationship of fuel moisture and fuel load reduction.

We are often asked for recommendations about seasonality of prescribed fire. We generally recommend late summer or fall for prescribed fire in park units of the NGP, especially in areas dominated by native species. Native species generally respond well to fire and fires historically occurred late in the growing season or in the fall. In areas where cool-season non-native grasses dominate it is preferred to burn in the spring to reduce their abundance. This strategy has been most successfully in reducing Kentucky bluegrass with mixed results for other species.

With regard to grasslands and prairies, we have not seen many significant changes in species composition resulting from fire. In the native prairie, fire has had little impact on species composition. We view this as a good thing, because we really don't want to see changes—they are already primarily native and we would like them to stay that way. In the non-native grasslands, we've seen some modest decreases in non-native grass cover coupled with modest increases in native grass cover. This evidence comes from a relatively small number of plots, so we would hesitate to draw definitive conclusions. We have seen some indications of positive change in species composition in Kentucky bluegrass plots that have burned twice. These data are from a very small sample size, but there does appear to be substantial reduction in non-native grass cover and an increase in native grass cover following two prescribed fires in areas with high cover of Kentucky bluegrass before treatment.

In areas where non-native species form a near monoculture (e.g. smooth brome), prescribed fire alone will not restore the area to native species. If restoration of areas such as this is desirable, treatments should include some combination of native seeding, fire, and/or herbicide. We would not usually recommend tilling, but in some cases that may also be a realistic option to include as a restoration treatment.

ACKNOWLEDGEMENTS

Jessyca Wilcox, Kevin Rehman, Bob Kobza, Martha Jakobek, Julie (Query) Larson, Katie Johnson, Phil Graeve, Daniel Dyer, Andrea Holmquist, Keith Mitchell, Marcus Lund, Lindsey Barney, Mike Bynum, Laura Drake, Tyler Schmitt, Andrea Powers, Rene Ohms, Kelly Mathis, Joanne Vokoun, Kara Paintner, and many park staff that have assisted with field work over the years.

Bill Adams, Bill Gabbert, Doug Alexander, Jim McMahonill, Gary Kemp, Mike Beasley, Dan Morford, Karri Fischer, and Steve Ipswitch have all played important roles in the NGP Fire Management office over the past 10 years. They have been responsible for implementation of prescribed fire and mechanical projects that have given us something to monitor.

Special thanks to Linda Kerr and Amy Symstad for providing helpful comments on an earlier draft of this report.