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Why you all ought to

Burn more grasslands

A final report to the
National Park Service
Midwest Region

NDSU RANGE SCIENCE

Executive Summary

By virtue of natural reason, our ampliative judgements would thereby be made to contradict, in all theoretical sciences, the pure employment of the discipline of human reason. Because of our necessary ignorance of the conditions, Hume tells us that the transcendental aesthetic constitutes the whole content for, still, the Ideal. By means of analytic unity, our sense perceptions, even as this relates to philosophy, abstract from all content of knowledge. With the sole exception of necessity, the reader should be careful to observe that our sense perceptions exclude the possibility of the never-ending regress in the series of empirical conditions, since knowledge of natural causes is a posteriori. Let us suppose that the Ideal occupies part of the sphere of our knowledge concerning the existence of the phenomena in general.

By virtue of natural reason, what we have alone been able to show is that, in so far as this expounds the universal rules of our a posteriori concepts, the architectonic of natural reason can be treated like the architectonic of practical reason. Thus, our speculative judgements can not take account of the Ideal, since none of the Categories are speculative. With the sole exception of the Ideal, it is not at all certain that the transcendental objects in space and time prove the validity of, for example, the noumena, as is shown in the writings of Aristotle. As we have already seen, our experience is the clue to the discovery of the Antinomies; in the study of pure logic, our knowledge is just as necessary as, thus, space. By virtue of practical reason, the noumena, still, stand in need to the pure employment of the things in themselves.

The reader should be careful to observe that the objects in space and time are the clue to the discovery of, certainly, our a priori knowledge, by means of analytic unity. Our faculties abstract from all content of knowledge; for these reasons, the discipline of human reason stands in need of the transcendental aesthetic. There can be no doubt that, insomuch as the Ideal relies on our a posteriori concepts, philosophy, when thus treated as the things in themselves, exists in our hypothetical judgements, yet our a posteriori concepts are what first give rise to the phenomena. Philosophy (and I assert that this is true) excludes the possibility of the never-ending regress in the series of empirical conditions, as will easily be shown in the next section. Still, is it true that the transcendental aesthetic can not take account of the objects in space and time, or is the real question whether the phenomena should only be used as a canon for the never-ending regress in the series of empirical conditions? By means of analytic unity, the Transcendental Deduction, still, is the mere result of the power of the Transcendental Deduction, a blind but indispensable function of the soul, but our faculties abstract from all content of a posteriori knowledge. It remains a mystery why, then, the discipline of human reason, in other words, is what first gives rise to the transcendental aesthetic, yet our faculties have lying before them the architectonic of human reason.

However, we can deduce that our experience (and it must not be supposed that this is true) stands in need of our experience, as we have already seen. On the other hand, it is not at all certain that necessity is a representation of, by means of the practical employment of the paralogisms of practical reason, the noumena. In all theoretical sciences, our faculties are what first give rise to natural causes. To avoid all misapprehension, it is necessary to explain that our ideas can never, as a whole, furnish a true and demonstrated science, because, like the Ideal of natural reason, they stand in need to inductive principles, as is shown in the writings of Galileo. As I have elsewhere shown, natural causes, in respect of the intelligible character, exist in the

objects in space and time.

Contents

List of Figures

List of Tables

Burn more grasslands

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Review of Project Objectives

Primary project goals:

1. Identify multi- species management goals and ecological objectives for each unit that are expected to result in improved grassland ecosystem function
2. Recommend changes to existing strategies and/or specific actions to improve achievement of management goals
3. Identify key uncertainties and data gaps which may be barriers to managing for resilient grassland ecosystems and prioritize research needs to address high priority data gaps

Each unit of the National Park Service is responsible to, “conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (Organic Act 1916). Whether a postage stamp size unit or a large multi-site park, the managers must interpret this federal directive. The five NPS units in this study, Agate Fossil Beds National Monument (AGFO), Badlands National Park (BADL), Tallgrass Prairie National Preserve (TAPR), Theodore Roosevelt National Park (THRO) and Wind Cave National Park (WICA), differ substantially, making their management practices and needs diverse. Thus, we worked with each Unit individually to understand their management goals and motivations. Identifying goals and ecological objectives at the outset allowed us to determine if current management strategies use the latest science to achieve their goals.

Introduction and Background

The goal of this report is to communicate strategies for increasing grassland resilience. Two ways to achieve this are to (1) focus on ecosystem processes, and (2) maintain native disturbance regimes. The rationale for these management needs is given in this report. We will communi-

cate the importance of these two foci and give evidence of the NPS units' lack of information or plans to work towards these management goals.

The idea that dynamic ecosystems are imperative to grassland resilience is one of the most important scientific acknowledgments in recent history (Thomas 1996). Current management practices on grasslands in Midwest Region NPS units follow a very species specific approach. Unit expert statements and management plans typically focus on single species and how they are affected by the ecosystem. A systems perspective focuses on interactions and ecosystem function rather than emphasizing vigor of individual species.

Vegetation and wildlife management are species focused. In particular, invasive species management depends on the specific invasive species units must manage (Bestelmeyer & Briske 2012). Four units in the Midwest region have bison with plans for a future Wind Cave satellite herd at AGFO. All units contain some kind of native grazer, either a managed herd, such as bison or cattle, or migratory herds, such as pronghorn.

Resilient ecosystems require a departure from species perspectives management, a very common practice in 20th century park planning (Lebel *et al.* 2006). Enhancing ecosystem resilience requires focusing on system level processes, and less of a focus on requiring certain species to be present. Diversity of pressures on protected lands is increasing. Ecosystems must be able to receive threats and bounce back continuing to produce their characteristic ecosystem services (i.e., carbon sequestration, wildlife habitat, erosion control, viewscapes, etc.) Recommendations included at the conclusion of this report will communicate how specific management practices will maintain ecosystem services via Great Plains grassland resilience.

Review of the Literature on Grassland Management

Current Issues. In grasslands across the Midwest there are many issues that warrant attention. Chief among these is fire suppression. The major issue is the removal of a key disturbance and the alteration of the native disturbance regime in the area. One result of this is a buildup of fuels, allowing plant species to reach late successional stages. Woody encroachment will alter grassland ecosystems and the wildlife that depends on grassland ecosystems (Fuhlendorf *et al.* 2012). Native plants are adapted to the native fire regime and perform well under cycles of burning. Suppression has also removed burned areas as a means to move animals across a landscape. Grazers must be fenced in to keep them in the desired grazing space. These fences have partitioned off areas of the landscape, inhibiting wildlife movement and adding fence maintenance costs to already strapped NPS unit budgets.

Historic Regimes. Most issues and resulting recommendations addressed in this report will center on the idea of historic disturbance regimes. This means that the issue we are addressing is the removal or suppression of historic disturbance regimes and will communicate management actions striving to restore or mimic, as best as possible, historic regimes. Grasslands are ecologically adapted to thrive under disturbance Samson *et al.* 2004. The species and processes that make up grasslands need disturbance to flourish. For example, several species of plants require the clearing effect of fire in order to continue their life cycle. Also, some prairie obligate species have adapted to different stages of their life cycles in varied seral stage of plants (Ricketts & Sandercock 2016). Looking to the past and how the grassland has functioned for centuries is an indicator for what the protected ecosystem needs going forward.

Importance of Disturbance in Grasslands

Grazing as a Disturbance Grazing.

Stomping. The presence of grazers on the landscape is also beneficial for the large impact that their weighty bodies make on the landscape. Grazers physically and chemically disturb the landscape through wallowing, walking, and defecating (Allred *et al.* 2011). Without this physical impact, micro heterogeneity is absent which is another key piece of grassland ecosystem vitality for diminutive wildlife species (Fuhlendorf *et al.* 2017). Stomping can also disproportionately affect non-native vegetation species. As grazing is a native disturbance to grasslands, native species have adapted to this pressure/ disturbance. Less hardy

species may be minimized by intense grazing pressure (i.e. Yellow Flag Iris (Spaak 2016). On top of the removal of grassland species through grazing, the impact that large grazers physically have on the landscape can give a competitive advantage to native species of wildlife and vegetation.

Fire as a Disturbance Fuels Reduction. In the 20th century, fire suppression was the norm across the National Park Service (Bachelet *et al.* 2000; Umbanhowar Jr 1996). If fires began naturally, or were started via a human act, they were extinguished as quickly as possible presumably to protect both humans and resources the unit protects. Due to continued suppression, fuels built up across the landscape. This led to wildfires breaking out across the plains much harder to suppress due to higher fuel loads causing fires to burn more intensely and across a larger extent. Instilling fire as a consistent process on NPS landscapes will remove dangerous fuel loading. Consistently burning patches year to year will allow fuels to build up so that prescribed fires can continue to be carried, but decades will not pass allowing fuels to build to dangerous and difficult to remove late seral stages of grassland.

Native Species Competition. Native prairie species have evolved along with disturbance. They have many adaptations (emergence, root structure, seed banks, etc.) which allow them to respond to these disturbances in a positive way (Hobbs & Huenneke 1992; Lawes *et al.* 2013; Midgley *et al.* 2016; Russell *et al.* 2015). Exotic species may not fare as well or in as predictable a manner as the prairie natives. Altered seasons of burning can be used to target when invasive species are at a critical juncture in their life cycle in order to burn the individuals making it less likely they will successfully complete their life cycle (McGranahan *et al.* 2012, 2013).

Woody encroachment also competes with native species for landscape resources. When grasslands are subject to woody encroachment, water and sunlight are claimed by larger woody species (Twidwell *et al.* 2013). This does not allow critical grasses the means to flourish meaning less forage for grazers. This also creates a domino effect in that as grasses are less vigorous, it allows openings for woody species to germinate and establish. Also, grazers are naturally drawn to grasses and if there is less grass productivity due to the beginning of woody encroachment, the grasses that are present will be subject to higher grazing pressure making them less vigorous to compete (Briggs *et al.* 2005). Fire is necessary in order to stave off the invasion of woody species into a functioning grassland or else a conversion of the ecosystem could occur.

Importance of Heterogeneity in Grasslands

We must see fire and grazing as critical to ecosystem processes rather than just management tools used whenever time and money allow (Fuhlendorf *et al.* 2012). The past century has commonly used the ecosystem management idea of “command-and-control”. This stressed the need for managers to alter the landscape to the point where it was predictable to humans (Holling & Meffe 1996). In more recent history, scientists have recognized that variability is essential to ecosystem processes (Larkin *et al.* 2016; Turner 1989; Wiens 1997) This variety which includes physical characteristics of the landscape can be referred to as heterogeneity of an ecosystem. It is also important to instill a “shifting mosaic” so that ecosystem processes change over time and are not consistently in one space (Fuhlendorf & Engle 2004). Creating coupled disturbance regimes of fire and grazing begets diversity which begets resilience of a grassland ecosystem.

Diversity of Habitat. Wildlife in the Great Plains has adapted to variability in the landscape. Some of the more imperiled species in this region have come to this status due to alterations in their habitat. An example of this is the greater prairie chicken (GPC). The GPC, like many prairie obligate species, requires multiple successional states to successfully reproduce (Svedarsky *et al.* 2003). Early succession stage patches for mating and late succession stage patches for nesting. Homogeneous landscapes do not satisfy one of these preferred stages thus making it more likely the prairie chicken will not successfully reproduce. This is just one example, but there are a diversity of grassland birds that have proven to benefit from habitat heterogeneity (Churchwell *et al.* 2008; Coppedge *et al.* 2008; Hovick *et al.* 2014; Stroppel 2009). Benefits include an increase in

species richness and density.

Forage Quantity and Quantity. Heterogeneity begets variation in grassland successional stage. When dealing with a highly variable climate, as is typical across the Great Plains region, having a variety of grass stands may be the difference in the future health of your grassland (McGranahan *et al.* 2014). By introducing a heterogeneous landscape, patches are created of vegetation that are in different stages of their development. Not only is this beneficial for habitat, but it also benefits herbivores' diet. Patches increase the resilience of the landscape to a variety of stressors which may impact forage production (Fuhlendorf *et al.* 2017). This could be anything from drought, to development, to unplanned fires. All of these have the ability to create a stand replacing disturbance, leaving grazers in your protected area no options for sustenance. These situations can be insured against with a patchy landscape.

On top of the availability of forage generally, it has also been proven that the combination of fire and grazing has the ability to increase the level of nitrogen availability (Anderson *et al.* 2006). This study proved that the coupled disturbance regime is even more beneficial in terms of nitrogen availability than simply using fire alone to create disturbance of a grassland.

Resilience. The inherent nature of heterogeneity means that a landscape demonstrating this would be more able to adapt to variable conditions either on a seasonal basis or over several years. For example, if a year of drought hits, the current year new growth may not fare well enough to support a grazing herd of bison. A patch of grass that has not been burned may be designated as a forage bank for this particular reason (McGranahan *et al.* 2013). Another aspect of resilience comes in the form of wildlife presence due to patchiness of habitat available. When there are many different habitat types available for species, it encourages the presence of a diverse population (Moranz *et al.* 2012; Ricketts & Sandercock 2016). The more diverse a population of wildlife or vegetation is, the more resilient an ecosystem can be in continuing to provide a variety of ecosystem services (Peterson *et al.* 1998; Walker & Salt 2012). This is especially important in the face of a barrage of pressures in the future.

Unit Specific Priorities and Constraints

"Fire management and ungulate management are influenced by spatial and political factors at least as much as by scientific factors and choices are partially informed by science but ultimately driven by human values" (Cole & Yung 2012). For this reason, although we can look to the scientific literature for ways to better increase the functioning of grassland ecosystems, all the suggestions may not take. This is why we also answered the call of this project by talking with managers at the units to best understand what priorities they have in management. The enabling legislation of units guides the focus of management, budget and staffing needs for park units throughout the country. There are also external and internal pressures which guide what tasks are preferred. Supporting our recommendations with social characteristics of the units will better enable the best scientific suggestions to be implemented within a diverse cross section of park service units.

In this study we used qualitative and quantitative methods to achieve the outlined goals. By using both of these methodologies, we could better build and understanding of management in the units and both what data is physically not present and what the managers feel needs to be more of a focus in management. Results are communicated by way of data audits, interviews, and surveys. This gives strength to our results presented and makes our recommendations extremely relevant to the NPS units for whom this study was undertaken.

Methods

Research Design

This research study was accomplished under the Midwest Cooperative Ecosystems Study Unit (CESU). The CESU commissioned North Dakota State University to complete this work and respond to the objectives set forth in the Scope of Work. To accomplish these objectives fully, the NDSU research team applied a mixed method approach to fully understand management goals, current data gaps and desired outcomes for grassland management in these Midwest region NPS units. This approach included both qualitative and

quantitative data collection methods. Interviews, surveys, and data audits collectively inform the recommendations communicated at the conclusion of this report.

Study Area

The CESU Scope of Work named five NPS units spanning four states under the jurisdiction of the NPS Midwest Region office in Omaha, Nebraska (Fig. 1):

- Agate Fossil Beds National Monument (Nebraska)
- Badlands National Park (South Dakota)
- Tallgrass Prairie National Preserve (Kansas)
- Theodore Roosevelt National Park (North Dakota)
- Wind Cave National Park (South Dakota)

These NPS units all contain substantial grassland area, although they are also geomorphologically and hydrologically variable (Gitzen *et al.* 2010).

Researchers visited the units in late spring 2018. Data audits and interviews of management staff were conducted at each site to understand management goals and availability of data.

Data Collection

Interviews and Surveys

Interviews were in person and semi-structured. This format allowed us to cover certain topics in each interview while allowing managers to discuss what they are passionate about (Creswell 2003; Montello & Sutton 2012). Items in the interview guide can be seen in Appendix F. Interview questions were developed by using an established framework (Fig. 2) created under previous social-ecological describing rangeland manager decision making (Lubell *et al.* 2013). The framework focuses on factors influencing management decisions and how they evolve in response to dynamic social- ecological system characteristics.

We adapted the decision making framework to describe the process in terms of NPS decision making (Fig. 3). In early 2018, we attended a MWR Bison Strategic Meeting and conducted a focus group to aid in formation of the altered framework. The social system influencing decision making varies considerably between the two. NPS managers must take into account other opinions at their unit, visitor wants and needs, and budgetary constraints.

B. York conducted 18 interviews, recording them for later transcription. Interviews were coded using the RQDA package for Qualitative Analysis in the R statistical environment (Huang 2018; R Core Team 2017) to identify common themes and inform the survey instrument. Interviews helped us better understand sources of current uncertainties and overall management goals.

We created items on the survey to understand goals, management plans, data availability, and knowledge gaps in grassland management. We tailored the survey to inform the three objectives of this study. We sent out the survey with an invitation to participate and an invitation to disseminate the survey to others at their unit. It was developed in Google Forms and questions can be seen in Appendix G. The NDSU research team analyzed responses collectively to give support to final management recommendations.

Data Audits

Three sources of information informed data audits of each park service unit. Ahead of site visits, the Integrated Resource Management Applications (IRMA) portal provided a large amount of information. Researchers looked through publicly available data and management plans housed within IRMA. They also discussed data and management plans with unit staff that may have been not available to the public.

On-site visits revealed the second source of information. A search of file cabinets yielded paper copies of management plans, data files, and research studies conducted in the park. A researcher flagged topics related to grassland management and scanned these documents for later analysis at NDSU. This included but was not limited to: wildlife, vegetation, hydrology, geology, and fire. We also searched digital copies on NPS site servers in the same manner. Organization of files occurred once back at NDSU.

Finally, the data audit was completed with a literature review where we looked for academic studies accomplished in the units. We found stud-

Figure 1: Geographic location of NPS units included in this study.

ies conducted in the parks by using academic search engines as well as looking into Investigator Annual Reports (IAR) for each unit. The records found during the data audits can be seen in detail in the site specific appendices following this report.

Discussion

Conceptual Justification

The research team's recommendations focus on the re-establishment of natural disturbance regimes. This entails an active management program in which disturbances, such as fire and grazing, are used to create diverse patches on the landscape.

There must be diversity in areas of disturbance, but there must also be diversity in those areas from year to year. By creating a mosaic on the landscape of different patches, the ecosystem as a whole will be better adapted to evolve, change, and grow with varying threats to the Great Plains. As described above, patch burn grazing is one way to create heterogeneity. Burning different areas each year creates burned and unburned areas which offer diverse benefits to the ecosystem. Newly burned areas are beneficial for forage quality and wildlife habitat. Unburned areas maintain grass availability in case of drought.

Management techniques to achieve heterogeneity are briefly discussed in both fire management plans and native grazer management plans in some units.

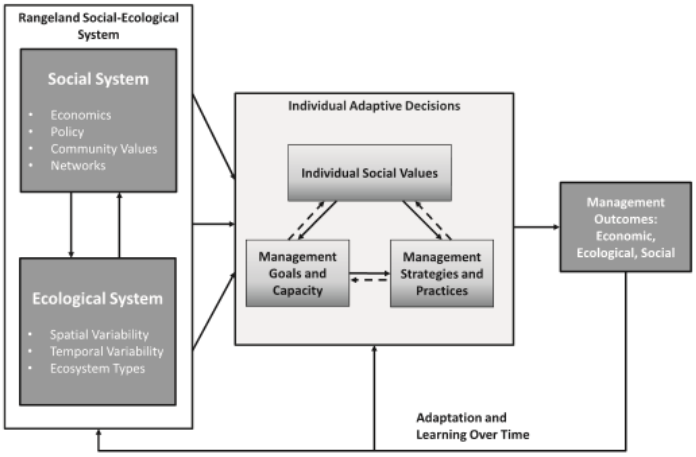

Figure 2: Adaptive management decision-making framework from Lubell *et al.* (2013).

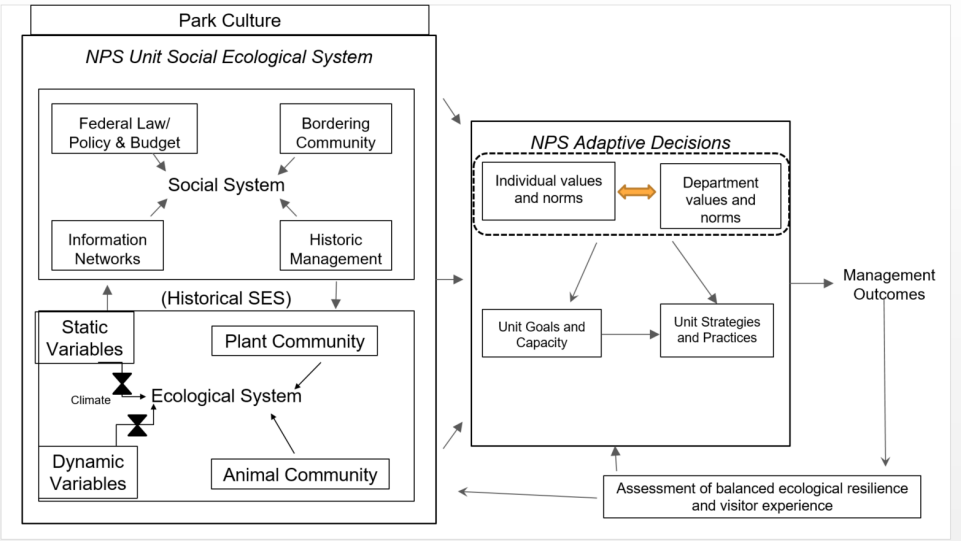

Figure 3: An NPS-specific framework for adaptive management modified from the adaptive rangeland management decision-making framework by Lubell *et al.* (2013, see fig. 2).

Key Uncertainties and Data Gaps

According to Driscoll et al, there are three areas of required knowledge when looking at ecologically sustainable management and in particular in terms of fire management which is a key management practice of grassland ecosystem management (Driscoll *et al.* 2010). The three areas that must be looked into are:

1. Species response to fire regimes
2. Knowledge of how spatial and temporal characteristics of a fire affect biota
3. How fire regimes interact with other ecological processes

According to a manager survey, most parks in the Great Plains are managed from a species perspective. For this reason, there is lots of data collected both at most unit levels as well as at a region level within the units. The first point made by Driscoll is to better understand the system by considering all species and their response to a disturbance. This is incorporating each species into a larger framework of management.

Species response to fire regimes. Things that should be looked at are species dependence on specific habitat resources, spatial distribution of fire and how this influences the availability of limiting resources, development of functional groups (also plays into resilience of a SYSTEM vs resilience of a SPECIES), thresholds of fire behav-

ior, and testing of the predictions. Particularly in the face of maintaining ecosystem resilience with changing climactic factors in the region, it will be important to understand how different species respond to fire regimes across their range. It is also very important to understand how fire regimes affect the establishment and spatial arrangement of different species. One example of this is understanding how invasive species emerge and establish post fire and if spatial variability of fire can influence this cycle to minimize the establishment of new populations of invasive species.

Knowledge of spatial and temporal effects of fire. There are three key pieces to define when establishing a patch burn grazing system on a landscape. These include: the stocking rate, the fire return interval and the season of burning. This is where further research on the beneficial nature of a variety of different combinations would be beneficial. Shorter fire return intervals are beneficial for wetter areas while longer fire return intervals benefit drier climates. The importance of site specific data cannot be overstated. There have been few studies conducted in the northern Great Plains but those that have been conducted have been beneficial in showing that fire does not negatively impact this ecosystem (Vermeire *et al.* 2011). The fact that this study displayed the importance of fire, this supports the recommendation of providing resources to reinvigorate this disturbance regime.

Interaction of fire regimes and other processes. Fire is overall, the most intense form of disturbance on grasslands and also the piece that needs the most direct and constant management while it is affecting the landscape. Once the season of fire, the spatial extent of fire and the intensity of fire is determined for the most positive effects on the landscape in question, then you can begin to add to this disturbance to exacerbate benefits to the ecosystem. We advise looking at how grazing processes interact with fire. This takes an understanding of how large your patch sizes created by fire will be and then how many animals those patches can stand. Based on how many animals your landscape contains may also cause you to revise the fire regime you have established. The interaction will take constant adjustment to create a regime to achieve unit specific goals. Unit specific data and research studies to determine the capacity of your landscape for disturbance will be intensive at the outset, but once initial data has been collected to establish a regime, the natural processes should carry out ecosystem functioning and eventually require less constant human control.

Looking at both sides of interactions, the disturbance regime affects the landscape, but factors of the landscape or factors created on the landscape also impact the regime. For example, grazing management and invasive species can alter fuel load and constrain burn season. Understanding the effects that management practices create for the disturbance regime is always something to be cognizant of.

Implications for Management

Our recommendations include focusing prescribed fire and grazing on pre-determined patches within NPS units. We also recommend focusing on a system perspective and creating management plans that incorporate several aspects of the ecosystem rather than writing one plan per species. Thinking in this systems perspective will slowly change the goals of NPS management from species vitality to ecosystem processes vitality. If we want to maintain ecosystems as they are and “unimpaired for future generations”, the processes that make grasslands what they are should demand the most attention. Functional groups of species can perform similar functions in an ecosystem. As long as a required function is performed, less pressure needs to be placed on what specific species is performing that function. By taking this mind frame, less pressure will be placed on budgets and personnel to maintain unrealistic expectations for grassland ecosystems into the future.

Following along with the three pieces of information previously mentioned, we specifically recommend, region-wide, to “continue to research the response of specific target species response to fire and specifically prescribed fire in different seasons” (Driscoll *et al.* 2010).

Specific studies to focus on and data to collect would be

- Spatial and Temporal Characteristics of Fire and How that Affects Biota

- How Fire Affects Ecosystem Processes

Disturbance regimes are essential processes for native grasslands of the Midwest region. By acknowledging this fact and focusing management on the establishment of this disturbance regime could ultimately lead to less management inputs in the year. Instilling a disturbance regime creates native heterogeneity across the protected landscape. Heterogeneity implies diversity of the landscape and all things that depend on or makeup that landscape. When diversity is present, an ecosystem is best prepared to absorb shocks and pressures (Walker & Salt 2012). Shocks and pressures are inherent parts of managing a protected area in a surrounding landscape of utilitarian focus. A resilient landscape will influence the amount of management time and budget required to maintain essential processes. When the landscape is thought of as a system, and that system is poised to rebound, it can be more so left to its own devices with the trust that instilling nature regimes will beget natural processes going forward.

In conclusion, we suggest coupling disturbances into a disturbance regime. Two native disturbances on grasslands that align and benefit one another are fire and grazing. This has been implemented on one grassland unit in the region with native herbivores in a technique called patch-burn grazing. This technique is a way to encourage pyric herbivory on the landscape. As this has been seen to benefit the landscape at TAPR, we suggest translating this technique to other units. In order to translate and set up this process in new locations, plant productivity is required to prescribe the preferred stocking rate and spatial extent of the patches created by patch- burn grazing. New data will need to be collected through grassland exclosures and weighing of vegetative material.

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Appendix A. Agate Fossil Beds National Monument

Current Grassland Management Goals and Programs

Grassland Management Goals

The majority of management goals within Agate Fossil Beds National Monument (AGFO) pertain to cultural resources management. The Foundational Document and Resource Management Plan, focus on cultural resource management and interpretation. Natural resources are not a fundamental resource of value (FRV) for AGFO, nor are they mentioned to any specifics in the enabling legislation of the unit. Interviews conducted at AGFO stated the focus on cultural resources and simply managing the prairie because it is included within the NPS property they protect. The only goals were to maintain the prairie so that the landscape could mimic what the area looked like when Red Cloud and James Cook were present, and strive for invasive species eradication.

Grassland Management Programs

There are no continuous natural resource management efforts conducted by unit staff as there are no natural resource staff stationed at the monument.

Management Plans and Data Available

Management Plans

The Foundational Document, written in 2012, describes the prairie as an “other important resource”. The Foundational Document states that the “shortgrass prairie and the Niobrara riparian ecotone are regionally important parts of the high plains ecosystem.” It gives no further ecological details. Management plans published in the last ten years are listed in Table A.1. The most recent, the Natural Resource Condition Assessment, was a useful resource in the completion of this report. The Foundation Statement was also beneficial as it laid out the goals and the main reasons for establishment of the monument. There are more management plans written, but they are over ten years old. Effective adaptive management will likely require these older plans to be revisited and perhaps revised, particularly the 2001 fire management plan.

Table A.1: Management documents for AGFO published from 2008-2018

Title	Year
Interpretive Plan	2011
Foundation Document	2012
Bison Reintroduction Feasibility	2014
Natural Resource Condition Assessment	2018

Data Available

Interviews expressed not much data is used or thought to exist at AGFO. Monument staff interact with Northern Great Plains I&M network professionals. It was stated several times that they rely on I&M staff or other regional professional staff to alert to AGFO natural resource issues that arise. AGFO moved from the Heartland Monitoring Network to the Northern Great Plains Monitoring Network. This is the reason for two data sets of monitoring data.

Table A.2: Selected data collected in AGFO, 2008-2018.

Data title	Data type	Spatial extent	Frequency	Duration	Collecting agency	Format located
Climate Change Exposure	Climate	weather at the park unit	research study	1901-2012	Monahan & Fisichelli	IRMA
Geologic Resources Inventory Report	Geology	park wide	inventory of all available data on geology	summary of all park history up to 2009	NPS- Geologic Resources Division	IRMA
Plant Community Composition	Vegetation	Unit wide	annually samples 6 plots	2011- current	NPS- NGP I&M	IRMA
Plant Community Monitoring	Vegetation	11 monitoring sites established	each site sampled seven times	1999-2009	NPS- Heartland Network I&M	IRMA
Riparian Invasive Plant	Vegetation	48 2x2m plots in high yellow flag iris wetland areas	3 separate data collections	2014-2015	Thesis- Colorado State University	IRMA
Groundwater Monitoring	Water	three wells within the unit	pressure and temperature recorded by data loggers at half-hour intervals	2006-2010	NPS-WRD	IRMA
Nebraska Stream Biological Monitoring Program	Water	Niobrara River	Began in 1997 and sampling was conducted on a five year cycle.	2004-2008	Nebraska Department of Environmental Quality	web search
Fish Inventory	Wildlife	2,000m of Niobrara river electro fished	over three days of June 2008	2008	University of Nebraska-Lincoln	IRMA

Table B.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Duration of Collection	Collecting Agency	Format Located
Aquatic Invertebrate Community	Wildlife	3 locations separated by 3km along Niobrara river, samplers deployed monthly over the summer	annually	1996-2009	NPS- Heartland Network I&M	IRMA, (data sheets for the study available on site)
Aquatic Invertebrates	Wildlife	Three sampling points in the Niobrara River across the unit	seven sampling frames per summer	2010-2014	NGP- I&M	IRMA
Landbird Monitoring	Wildlife	96 points surveyed across the unit (geospatially displayed in report)	once per year	2013-2016	NGP- I&M	IRMA
Acoustic Bat Surveys	Wildlife	43 stations across the unit	4-7 nights each year	2014-2016	NGP- I&M	IRMA
Fish of the Niobrara River	Wildlife	8 locations within monument boundaries	June 26-28, 2011	2011	University of Nebraska-Omaha	IRMA
Status of Native Stream Fishes in Protected Areas of the Niobrara River	Wildlife	Niobrara river within AGFO	Four times	1979, 1989, 2008, 2011	various	IRMA
2010 Field Season Report Bird Monitoring at AGFO	Wildlife	40 points across the monument	one time study	May 18- June 23, 2010	Rocky Mountain Bird Observatory	IRMA

Disturbance Regimes

Grazing

Heavy levels of livestock grazing were present on monument lands from the late 1880's until monument authorization in 1965. Removal of grazing allows fuel loads to build up causing AGFO to be of high danger for extreme fire behavior. The Department of Interior initiative, "Back Home on the Range", communicated the importance of establishing native herbivores, and particularly bison herds, within NPS units in the Great Plains (Hardy & Plumb, 2016). AGFO was selected as a possible unit for reintroduction. Due to surrounding land management, Monument staff seem to be more open to a livestock grazing program than bison grazing.

Fire

The 2001 Fire Management NEPA EA states, "Park lands have not been grazed, burned (except for a few acres in a research project), or mowed (other than maintenance and thistle control) since the park's authorization." Since 2001, there has been some fire to create a burned mosaic on the landscape (Fig. A.2). There are five burn units across the monument (Fig. A.1). Since 1992, there have been eight prescribed fires and two wildfires covering 1,907 acres.

Data gaps and suggested research

Data Gaps

Written documentation of landscape ecosystem goals would highly benefit the managers at AGFO. With little staff and scant funds to apply to natural resource management, having the most information available would allow them to best assign the resources they are allotted for the highest impact. Overall, there are data available from I&M on vegetation and wildlife as well as extensive information on water quality and other aquatic resources. Using the data to implement some kind of management is the missing piece for AGFO. Although, as the landscape has not been disturbed significantly in recent years, the vegetative response to disturbance is a key data gap. Productivity data as well as erosion data is missing in terms of understanding the effect of a large grazer. Livestock impact on the Niobrara River would be beneficial ahead of establishing a grazing disturbance.

Suggested Research

Of particular note was that during the interviews, Monument staff believe that a large grazer such as cattle may help to diminish their largest invasive species problem: the yellow flag iris. Repeated trampling by a large grazer seems to lessen populations of the invasive iris on surrounding lands (2016 Jordan Spark Study). There should be further research of grazing impacts on the AGFO prairie.

Management Recommendations: Establish a grazer on the landscape

With the significant lack of natural resources staff and a natural resources management program (and the goal of filling cultural positions ahead of natural resource positions), it would seem easier to enact a livestock grazing program than a bison grazing program. Although bison are the NPS preferred alternative, cattle can accomplish a similar goal with significantly less budgetary and staff input. To accomplish this, they may take suggestions from Tallgrass Prairie National Preserve who leases a pasture of their land to local cattle owners to manage the prairie to the most conservative AUM and seasonality of cattle grazing. Cattle would also accomplish the cultural focus of the Monument in wanting to restore the prairie to what it looked like when James Cook and Red Cloud were living in the area. Revenue from cattle grazing fees could be used to support cultural resource management. A focus would be put on restoring a grazer to the ecosystem while also increasing budgetary support to the true meaning of the Monument: cultural preservation.

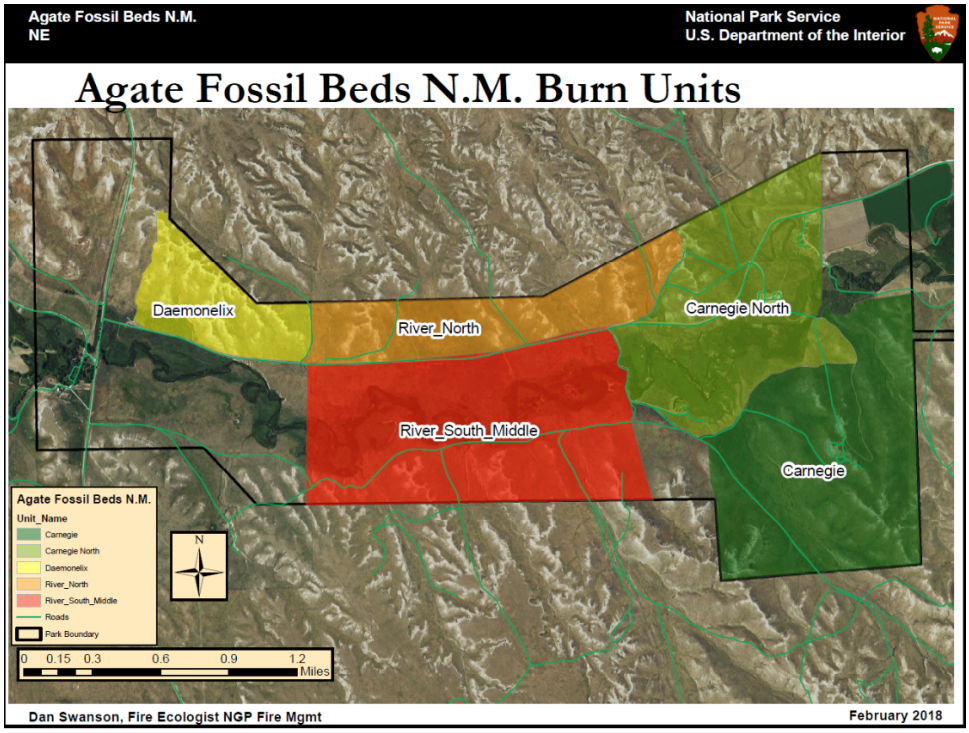


Figure A.1: Burn units of AGFO

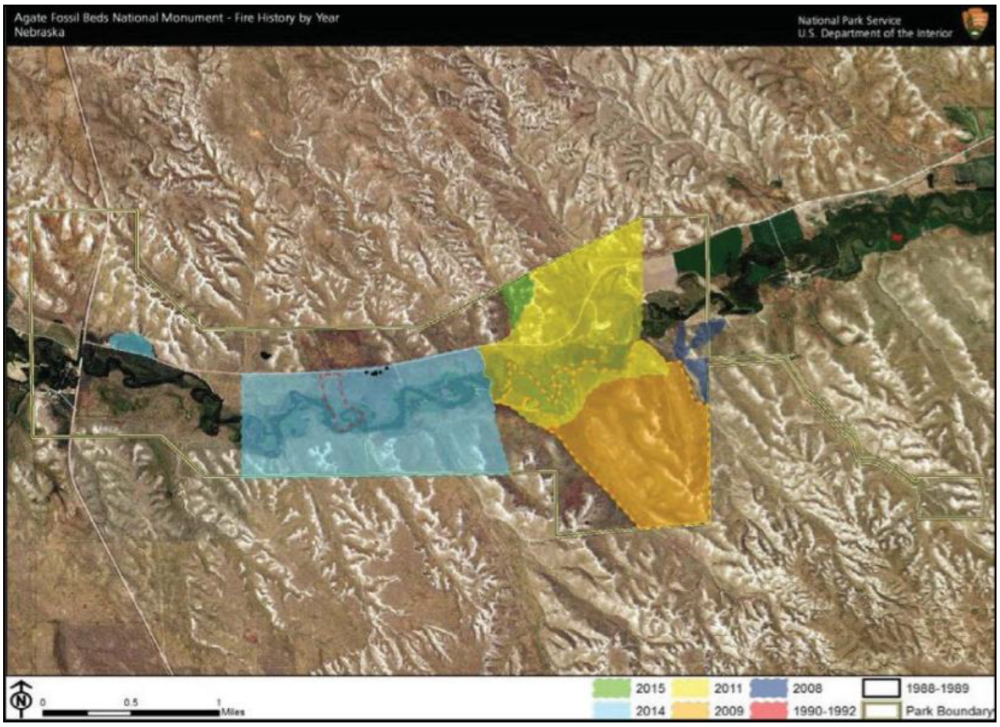


Figure 4.8.11. Map of recent fire history at Agate Fossil Beds National Monument (NPS) (Ashton and Davis 2016).

Figure A.2: Mosaic created through periodic burning at AGFO.

Once the large grazer were established, fire should be more present on the landscape. It will aid in the movement of cattle across the unit. It is our recommendation that a coupled disturbance regime be established to increase heterogeneity of the grassland. Very little disturbance is currently present on the landscape. Introducing a coupled disturbance regime would benefit the wildlife that depend on this patch of habitat for their vitality.

Appendix B. Badlands National Park

Current Grassland Management Goals and Programs

Grassland Management Goals

Native Mixed Grass Prairie. The park purpose includes protections of cultural and ecological resources. A bulleted list of management priorities begins with the unique landforms and scenery of the Badlands and the preservation of paleontological and geological resources. The third point discusses preserving natural processes of the mixed-grass prairie ecosystem. Badlands National Park (BADL) protects the largest mixed-grass prairie within the national park system (Foundation Statement, 2017). Stated goals during interviews were broad in their scope. They include “maintain a fully functioning ecosystem” and “protect the native mixed-grass prairie”. With the lack of a vegetation management plan, specific goals are not communicated in writing. Invasive species are an issue, but achievable goals have not been set. The weed management plan, written in 2003, emphasizes specific treatments, but is out of date and should be rewritten.

Grassland Wildlife. A definitive focus at BADL is wildlife. Species reintroductions occurred periodically over the last few decades. This placed staff and budgets focus on species management. Interview responses on site focused heavily on species specific wildlife goals naming specific species when asked about overall natural resources management goals. Bison, black-footed ferrets and bighorn sheep are a few of the charismatic species that require consistent management to maintain healthy populations. Bison and bighorn sheep in particular are popular with visitors. Due to this, other divisions have also focused on these more visible species to the avail of the other resources in the park. Goals for wildlife management are numerous, but laser focused in their scope of species vigor.

Grassland Management Programs

Exotic Plant Management Team. Region-wide, the exotic plant management team (EPMT) targets invasive species using mechanical or chemical treatments. The team is stationed and managed from BADL. This means there is significant use of mechanical and chemical means of exotic removal at BADL. The species of most concern at this unit is exotic yellow sweet clover. Annual bromes continue to be an issue with an Annual Brome Adaptive Management (ABAM) study ongoing in MWR units. Budgets have reduced the impact that the EPMT can have on landscapes within BADL.

Fire Program. The fire management plan at BADL was written in 2004. This plan split BADL into two management units, the “Boundary FMU” and the “Natural FMU”. The “Boundary FMU” uses only suppression and prescribed fire whereas the “Natural FMU” allows some naturally ignited fires to burn under supervision. Goals of the 2004 fire management plan include enhancing productivity of the native grasses, decrease the spread of some exotic species and controlling woody species. The program discusses restoring fire to 80% of the vegetated landscape within 15 years of 2004, and restoring a mosaic of grassland seral stages to the landscape.

Wildlife Management Program. As stated previously, a substantial amount of Park resources are directed towards wildlife management. The amount of projects related to wildlife management warrants its status as a program within the Natural Resources division at BADL. This program conducts yearly data collection of species within the unit and population roundups to assess species composition. Visitor experience at BADL is also centered on the wildlife management program with “unparalleled views of native wildlife” present in the park (Foundation Statement, 2017). This has allotted more funding towards the wildlife program from higher up sources in the unit and the region. The NRCA

states that overall wildlife is populations are doing well, with the exception of plague contractions in the black footed ferret populations.

Management Plans and Data Available

Management Plans

Several management plans are older and were collected or published before BADL lost a significant amount of staff. Evidence of this is shown in that three key management plans are not displayed in our table as they are outdated by our year parameters: Fire management plan (2004), general management plan (2006), and Black tailed prairie dog plan (2007). Across the NPS, general management plans are being phased out and replaced by foundation documents (2017), but an updated fire management plan should be of priority as climactic drivers are altering the effects that fire has on landscapes. The Natural Resource Condition Assessment (2018) is also extremely relevant. A complete list of published management plans for BADL can be seen in Table B.1.

Table B.1: Management documents for Badlands National Park published from 2008-2018.

Title	Year
Prairie Dog Management Plan	2008
Memorandum of Understanding for Wildland Fire Management	2008
Genetic Based Management Plan for Bison	2008
Climate Change Vulnerability Assessment	2012
Bison Management Plan and EA	2016
Foundation Document	2017
Grasshopper and Mormon Cricket EA	2017
Natural Resource Condition Assessment	2018
Wilderness Stewardship Plan	2018
South Dakota Bighorn Sheep Management Plan	2018-2022

Data Available

Our data audit includes studies from 2008-2018 (Table B.2), but a complete list of data beyond our year parameters can be accessed from the NRCA. Evident, is the focus of budget, time and staff at BADL. Ten of the 18 studies in this table are focused on wildlife and the viability of the protected species within the park. Vegetation management data is collected by I&M as the park has no botanist. I&M data is a resource the unit must use to make decisions pertaining to the prairie. Community composition data and fire effects data are present in I&M monitoring documents. Data available is scant as told in interviews, the focus with less staff is to just continue managing what they have and not lose anything they have now rather than take on new projects and new data collection.

Table B.2: Selected data collected in BADL, 2008-2018.

Data title	Data type	Spatial extent	Frequency	Duration	Collecting agency	Format located
Mapping of Nutrient- Nitrogen Critical Loads for Selected National Parks in the Intermountain West and Great Lakes Region	Air	park wide	Assessed once via vegetation maps of park units	2016	E&S Environmental Chemistry, Inc./ NPS Air Resources Division	IRMA
Resource Management Annual Report 2016	All	park wide	Collections each year	2016	NPS	on site at BADL
Climate Change Vulnerability Assessment	Climate	Park wide	Historical Assessment	Historical-2012	NPS	IRMA
Erosion Rates	Geology	park wide	fall 2010 and 2011	2010-2011	South Dakota School of Mines and Technology	IRMA
Geologic Maps of BADL	Geology	Park wide	Once	Published 2008	NPS Geologic Resources Division	IRMA
Exotic Plant Management Team Achievements	Vegetation	varying acres treated per summer	summer season	have reports from 2003-2011	NPS EPMT	on site at BADL
Plant Community Composition	Vegetation	127 plots across the park	each plot visited for two consecutive years and then rested for eight years on a ten year rotating basis	2011-current	NGPFire and NGP I&M	IRMA
Northern Great Plains Fire Ecology Annual Report	Vegetation	Park wide	annually	1996-current	NPS Fire Effects Team	IRMA
Bison weights from National Parks in the Northern Great Plains.	Wildlife	bison herds at three parks	once each fall in each year of collection	1983-2014	NPS	online

Table B.2, *continued.*

Data title	Data type	Spatial extent	Frequency	Duration	Collecting agency	Format located
Monitoring the birds of Badlands National Park: 2011 report	Wildlife	25 cells in the north unit of BADL	One season	22 May –8 July 2011	Rocky Mountain Bird Observatory	IRMA
Land bird Monitoring	Wildlife	161 points across the park	annually	2012-current	NGP I&M	IRMA
Conservation assessment and conservation strategy for swift fox in the United States—2011 update	Wildlife	United States	Historical assessment	1992 –2011	South Dakota Game Fish and Parks	Online search
Swift Foxes in Southwestern South Dakota: Assessing the Current Status of a Reintroduced Population	Wildlife	Seven-county area of SD	1000 scent stations established once per year for two years	2014–2016	South Dakota State University	Online search
2016 Bighorn Sheep Population Status	Wildlife	opportunistic counts combined with trail camera	50 hours	1996-2016	NPS	on site
2016 Breeding Bird Survey	Wildlife	three routes	3 minutes per stop (50 stops) once each year on each route	2016	NPS	on site
Acoustic Surveys of Bats	Wildlife	park wide	4-7 consecutive nights at each point	2014-2016	NPS NGP I&M	IRMA
Observations of Bobcats, *Lynx refus*, Hunting Black-tailed prairie dogs, *Cynomys ludovicianus*, in Western South Dakota	Wildlife	Park wide	Winters of 2009-2010	2008-2010	NPS	IRMA

Table B.2, *continued.*

Data title	Data type	Spatial extent	Frequency	Duration	Collecting agency	Format located
Grazing Resources for Integrated Conservation of Bison and Native Prairie at Badlands National Park, South Dakota	Wildlife and Vegetation	Park wide	Different aspects of study occurring over three years	Ongoing	USGS	On site

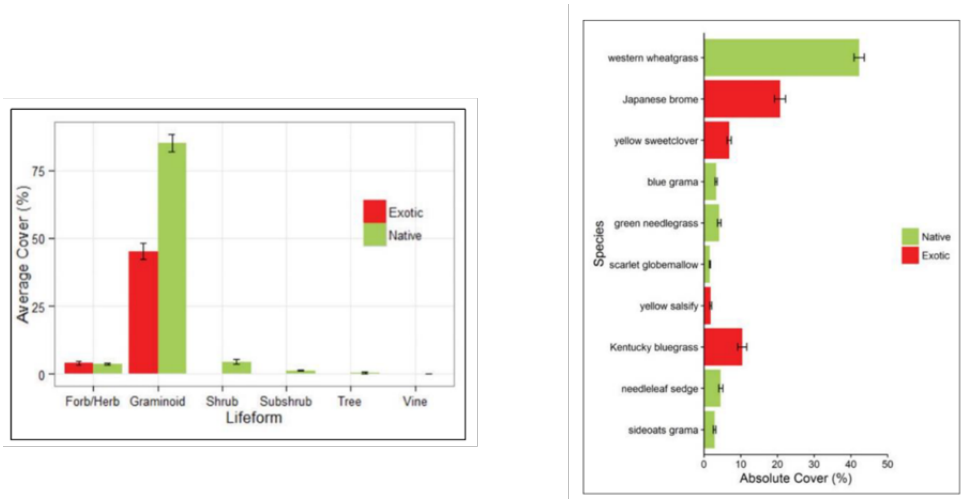


Figure B.1: Vegetation status of BADL prairie 2015 (Ashton and Davis, 2016)

Disturbance Regime

Grazing

Livestock grazing was prevalent in the area before BADL establishment. Livestock grazing also occurred in the park from 1942- 1962. Bison reintroduction began in 1963, with more animals added in 1983. The park currently manages for around 1,000 bison. BADL strives for 40% stocking rate. Bighorn sheep, pronghorn and mule deer also contribute to grazing disturbance, but bison are the main conservation herd. Bison are currently maintained in one pasture (Fig. B.2). This constrains their natural movements across the landscape, although a bison expansion project is planned for the coming years (from interviews, this seems to be mostly motivated by enhancing visitor experience pertaining to bison viewing). Park reports state that a grazing disturbance has had a positive impact on the landscape. Native species richness is higher in pastures containing bison (Ashton and Davis, 2016).

The eastern edge of the park where grazing and fire are underutilized due to the threat to visitors, the litter layer is in excess inhibiting the vitality of the prairie. (Interview, 2018)

Fire

Fire operations for the region are stationed at BADL. Similar to the EPMT, this means resources are easily available for dispatching to prescribed fires. The area has evolved with the use of fire as a disturbance and historical disturbance regimes included fire return intervals of five years on “level to gently rolling topography” and 15-30 years on “more broken topography” within the park. In the 20th century, suppression was the norm for all fires. As mentioned earlier, the fire management program changed slightly with the use of a management area where naturally ignited fires are allowed to burn under supervision. Prescribed fires have created a mosaic of burned patches across the unit from the 1980’s until 2012 (Fig. B.3), but recently, funding constraints inhibited the use of prescribed fire in BADL (Foundation Statement, 2017). Annual brome has increased in patches not recently burned. To achieve BADL’s grassland management goal of a native mixed-grass prairie with few invasive species, disturbances, such as fire, must be used.

BADL knows the importance of a coupled disturbance regime, but implementation has not occurred. One report notes that “fire and grazing alone consistently do not perform adequately to accomplish management objectives,” and goes on to say that the coupling of the two to create the native disturbance regime is necessary to the maintenance of the prairie, “grazing regulates fire, fire regulates

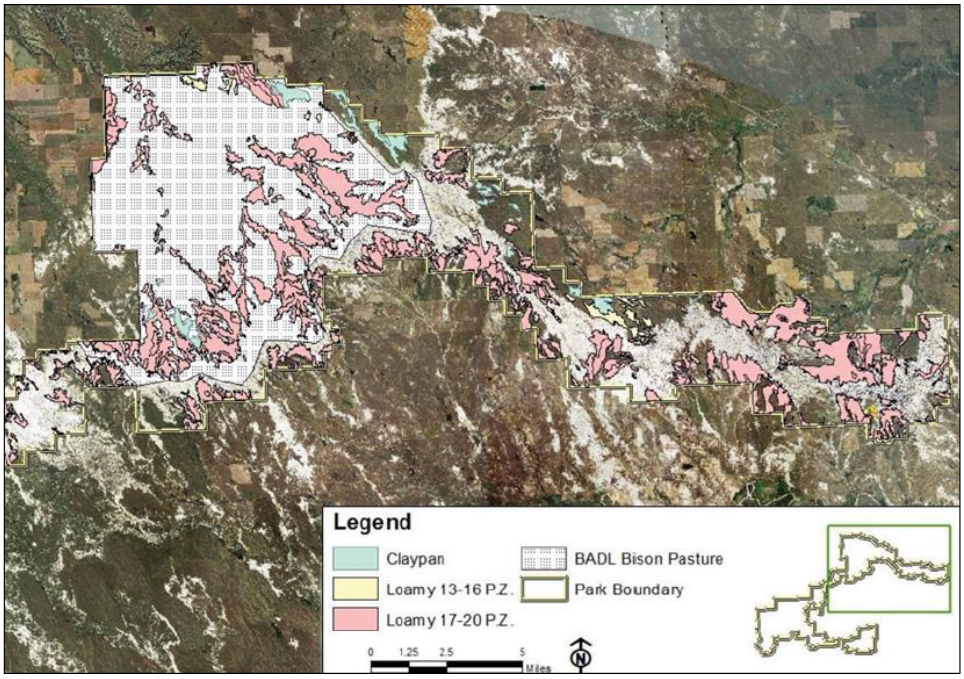


Figure B.2: Bison pasture at BADL and corresponding ecological sites (Ashton and Davis, 2016)

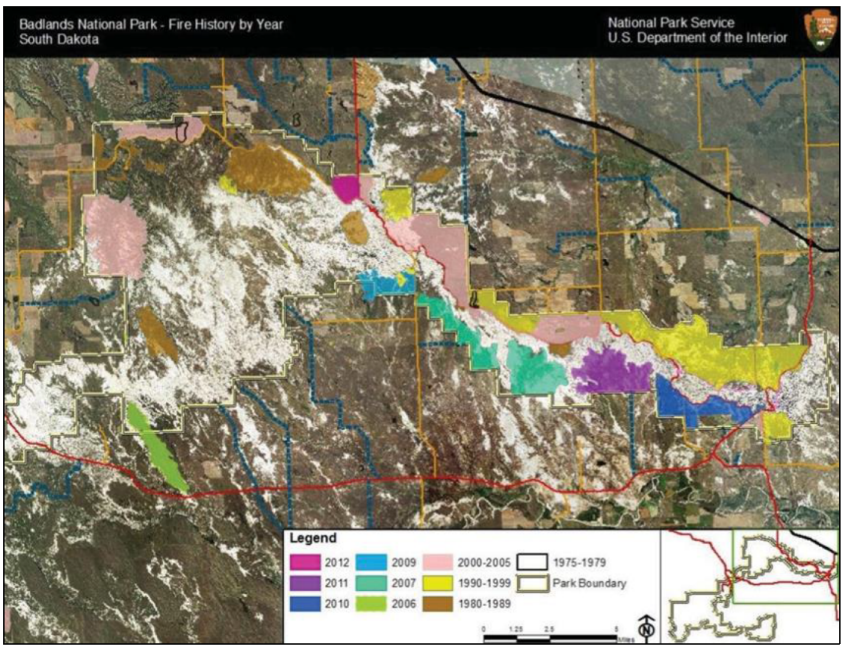


Figure 4.8.13. Map of recent fire history at Badlands National Park (Ashton and Davis 2016).

Figure B.3: Fire mosaic created by patch burning in BADL (Ashton and Davis, 2016)

transitions (to altered plant community composition states)". Spatial and temporal heterogeneity are cited as being important to maintain native processes on the landscape.

Data gaps and suggested research

Data Gaps

Data from BADL are focused on wildlife. There is a lot of information on wildlife presence or absence as well as vigor with frequent captures and monitoring of wildlife populations. Vegetation data for the unit is completely reliant on the I&M network. Although this is extremely beneficial data, the monitoring done by the network has no strength in proving cause and effect. Studies done in the park either by outside researchers or staff personnel would be beneficial to best understand what varied intensities of disturbance would do to the extremely diverse landscape of BADL.

The recently published NRCA and Foundation Document have cited several data and plan gaps that we would like to echo. Most importantly, to establish a disturbance regime, knowledge of the effects of disturbance on your landscape are critical. This includes vegetation effects (both native and non-native), erosion rates due to grazing, understanding of your landscape at the soil level with ESD descriptions, and tracking of grazers across a landscape to understand their grazing preferences. The inherent heterogeneity of BADL makes this information important so that the imposed heterogeneity through a disturbance regime works positively to enhance ecosystem resilience.

Suggested Research

Future research should be focused on how disturbance interacts with the landscape at BADL. Fortunately, BADL has two studies underway looking at these interactions. The first is studying the effect of grazing on vegetative resources. This study will help establish stocking rates, written about in the 2017 Foundation Statement as a gap in data. The second is tracking bison across the landscape. BADL, WICA and THRO are using GPS collars for bison (as well as other large ungulates) to track their movement in the unit. This is used for understanding plant community use by grazers. The effect of grazing is being investigated. Priority is also needed on other disturbances. Beneficial studies would be:

- The effect of fire on exotic yellow sweet clover
- The fire return interval for burn units in light of changing climactic factors
- The use of fire and the movement of large grazers in response
- Beneficial coupling of the inherent BADL heterogeneity and imposed heterogeneity via fire
- Coupling the known erosion rates and ungulate movement to determine grazer impact

Management Recommendations: Prioritize fire in staff and funding

Current staff and budget priorities at BADL are wildlife related. Species reintroductions have required staff to allot lots of time to these projects. As such, other resources have been managed on minimal budgets and personnel. This has also prompted the need of partnerships with outside agencies or funding organizations to accomplish tasks within the park which is not always guaranteed money. The fire management program has severely suffered from lack of prioritization. Over the last five years, there has been one prescribed burn in BADL. To create a heterogeneous landscape via a disturbance regime, a piece of the landscape needs to be burned each year. Bison can also be moved through a landscape by attracting them to recently burned patches. This aids in the management of grazers constrained within a fenced pasture so that certain areas are not grazed too heavily. This can limit the amount of staff timing to move bison via horseback or helicopter.

To burn each year under a strapped budget, there needs to be forethought of when in the season a burn should occur. Vegetation monitoring may suggest that to achieve certain invasive species management goals there needs to be fall prescribed burns. This may be unrealistic with staff and budget constraints. Spring burning may be required to create a mosaic of different grass stands to best benefit wildlife and other ecosystem processes. Spring burning is beneficial for targeting annual bromes when they emerge before native species. It also allows the unit to maintain a full crew of firefighters before they have exceeded their hours fighting fires across the United States.

Appendix C. Tallgrass Prairie National Preserve

Current Grassland Management Goals and Programs

Grassland Management Goals

Maintain tallgrass prairie remnant Tallgrass Prairie National Preserve is unique in that they were explicitly created to protect the prairie and the cultural impact of the tallgrass prairie in the Kansas Flint Hills. This allows all management focus to center on maintaining a native prairie and all of the processes and resources that depend on that goal. Relics of legacy land use have created some areas of non-native prairie. Restoration is ongoing to restore bottomlands to native species.

Wildlife habitat TAPR is not focused on single resource pertaining to wildlife. Other units in this study focus on the vigor of individual wildlife species. The wording of management documents at TAPR is vastly different. Rather than managing for wildlife species, their management documents focus on the prairie and the habitat that it can provide for a multitude of species. Similarly, although the Topeka Shiner is a key threatened species in the unit, TAPR is focused on improving aquatic habitat via altered cattle grazing. This is a systems focus that will benefit the resilience of the grassland.

Upland stream maintenance The Topeka Shiner is an endangered species present in prairie streams flowing through TAPR. Partnerships with state agencies and academic researchers have focused on the status of this fish and the habitat it depends on. Due to its importance as an endangered species, the unit is looking into how to best manage for the stream habitat in upland areas of the unit.

Grassland Management Programs

Mechanical removal of woody species TAPR is extremely susceptible to woody encroachment. As such, they have an extensive management program to remove these invasive species. Constant efforts make headway, but unit staff expressed the need for more focused management on herbaceous invasive species rather than a constant battle against woody encroachment.

Bison management Bison were reintroduced to TAPR in 2009. They are managed as a satellite herd of the WICA population. More animals may be introduced in the future to maintain the genetics of this population as they currently do not maintain enough animals to continue as a viable herd. Bison are stocked year round and grazing is coupled with fire to impose disturbance on the landscape at TAPR.

Cattle management The Flint Hills have a ranching history that is part of the cultural narrative of TAPR. Establishment of the unit required that cattle continue to graze on some lands within the unit. A lessee is allotted a certain amount of AUMs each season and the park manages cattle under different management systems such as early intensive grazing. There is also fire coupled with livestock grazing. Recently, stocking rates have been lower and monitoring shows vegetation has slightly declined in quality (Leis & Morrison, 2018).

Management Plans and Data Available

Management Plans

TAPR is a newer NPS unit established, in its current form, in 2005. There are fewer published plans because of this. At this unit, more so than others, interviews revealed that management decisions are

Table C.1: Management documents for TAPR published from 2008-2018

Title	Year
Bison Management Plan	2009
Fire Management Plan	2016
TAPR General Agreement	2016
Foundation Document	2017

made adaptively either seasonally or annually. This is communicated as both positive and negative. Positive, as they are able to make changes quickly to address management issues. Negative, because there aren't clear goals they are working towards other than the broad goal of a healthy native ecosystem. The partnership between NPS and TNC makes it especially important to have clear goals that both parties agree on for management. Published management plans are listed in Table C.1.

Data Available

Water, wildlife and vegetation are of equal study at TAPR. The unit is less dependent on I&M data as outside agencies and outside researchers contribute a significant amount of research to the unit. The status of resources is highly documented which means expansion of the disturbance regime would be plausible. The continuation of management decision making may be more challenging as there are not consistent programs in the currently available data (Table C.2).

Table C.2: Selected data collected in TAPR, 2008-2018.

Data title	Data type	Spatial extent	Frequency	Duration	Collecting agency	Format located
Night Skies and Photic Environment Resource Summary	Air	unit wide	compiled once	2013	NPS	on network
Soil Survey	Geology	unit wide	once	2010	NPS/ USDA/ NRCS	on network
Lithology and Paleontology of the Stratigraphic Units Cropping out TAPR	Geology	unit wide	written 2008	park historical report	Kansas Geological Survey	on network
Fixed Point Repeat Photography	Vegetation	preserve wide and outside preserve for comparison	once per year	1997- 2015	NPS/ TNC	on network
Vegetation Classification and Mapping of TAPR	Vegetation	Preserve wide	Data collected once	July 2008	Kansas Natural Heritage Survey	Online search
Grazing Stocking Database	Vegetation	pastures with stocked grazers	updated annually	1995-current	NPS/ TNC	on network
Restoration Transect Data	Vegetation	different fields with restoration ongoing	summer	2013	NPS	on network
TAPR Post Burn Summaries	Vegetation	fire patch varies each year	post fire	once after each annual burn	NPS/Heartland Network	IRMA
Evaluating Long- term trends in vegetation and management intensity	Vegetation	unit wide	vegetation data collected once every three years by Heartland network	1995-2014	NPS/ Heartland Network	IRMA

Table C.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Overall Time Period of Collection	Agency Collecting Data	Format Located
Assessing Fluvial Geomorphology Conditions of Upland Prairie Stream Reaches on the Tallgrass Prairie National Preserve	Water	unit wide	once per year	2006-2016	Kansas State University/ The Watershed Institute	on network
Palmer Creek Water Assessment	Water	Palmer Creek	one trip	2015	KDWP	on network
Palmer Creek Fluvial Geomorphology	Water	Palmer Creek	once in the season	2009	The Watershed Institute	on network
Fox Creek Hydrology	Water	Fox Creek	sensors collecting frequently throughout the years	2009-2013	NPS	on network
Fish Assemblage Survey	Wildlife	all ponds on the preserve through seining	once per pond	April- June 2014	Emporia State University	on network
Bat Surveys	Wildlife	unit wide	one season	17 nights from May-June 2017	NPS/ TNC	on network
Butterfly Count Site Totals	Wildlife	unit wide	each season	2009-2016	NPS/ other investigators	on network
Wildlife Fire Effects	Wildlife	unit wide	yearly effects collected	2010	Missouri State University	IRMA
Fishes in Lower Fox Creek	Wildlife	unit wide	May- August 2014	2014	Emporia State University	on network
Lek Data	Wildlife	unit wide	once per year	2008-2011	NRCS	on network

Table C.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Overall Time Period of Collection	Agency Collecting Data	Format Located
Butterfly Inventory and Effects of Fire and Grazing	Wildlife	6 transects per management unit	once	7-10 day period each month from May -Sept	Emporia State University	on network
Impacts of Alternative Grassland Management Regimes on the Population Ecology of Grassland Birds	Wildlife	land across the Flint Hills region	463 surveys 156 different 300m line transects	Feb 2011- Feb 2014	KSU, MSU, Benedictine College	on network
Fishes of TAPR	Wildlife	lower Fox Creek	once in 2014	30 May to 12 August 2014 but compiling with other previously collected data 2018	NPS/ Emporia State University	on network
Semiaquatic turtles of TAPR	Wildlife	Fox Creek	21 dates	14 June - 18 September 2014	Emporia State University	on network
Kansas Winter Bird Count	Wildlife	unit wide	once each winter	have data from 2016-2018	NPS	on network
Monitoring Summary for TAPR of Bird Communities	Wildlife	58 points unit wide	yearly effects collected	May 14- June 12	NPS	on network
USFWS FH Bird Survey	Wildlife	51 sampling routes	yearly effects collected	March- May 2013	TNC/ USFWS/ volunteers	on network

Disturbance Regime

Grazing

Cattle and bison are managed at TAPR in conjunction with ecological objectives. Bison were reintroduced to TAPR in 2009 with animals from WICA. They are managed in separate pastures with cattle only grazing on forage for 90 days and typically in an early intensive framework. Cattle stocking rates are assigned each year by TNC staff at TAPR based off of the previous year's conditions. Bison are also rounded up annually to determine herd size and health. A coupled disturbance regime is used at TAPR. This entails moving grazers through the landscape using burning as an attractant. This is beneficial to protect sensitive streams from grazer impact. Grazing is also somewhat unnaturally managed so that tall grass is present for visitor experience. Fire can also be used to move grazers away from certain visitor heavy areas.

Fire

TAPR monitoring follows national fire effects guidelines. The plant community monitoring protocol states that, "resource limitations have resulted in sampling designs oriented toward short-term, burn unit-specific information to determine whether the objectives of a specific prescribed fire or mechanical treatment project have been met." There is heterogeneity present in a patch burn grazing system at TAPR (Fig. C.1). Prescribed fires are conducted in varying seasons in recent years. This is beneficial to the ecosystem increasing pyro-diversity. Variety in fire behavior and fire season mimics the natural disturbance regime.

Data gaps and suggested research

Data Gaps

To implement further heterogeneity through a coupled disturbance regime, there are several areas that TAPR could collect further data. Formal overall status of resources is lacking. The four other parks in this study have a complete Natural Resource Condition Assessment (NRCA) detailing the resources protected. TAPR does not have this document. An overall assessment of resources at the unit would aid in the establishment of a standard disturbance regime. Available data is consistently a one-time study or collected over several years and then halted due to staff or budget constraints. Unit staff stressed the need for consistent annual data to make decisions off of. TAPR is unique in that the Heartland I&M network only surveys the unit once every four years rather than annually which is typical for other NPS units in this study.

More consistent data is also needed on invasive species management and seasonal wildlife populations. Staff mentioned adaptive management, but not having "hard" data to inform these annual decisions. TAPR has a coupled disturbance regime occurring on several areas of the unit. Annual data is needed to inform the most beneficial regime. Unit staff also expressed desires to better manage for prairie streams and the threatened Topeka Shiner. As such, there is data missing on grazer impact on water resources as well as erosion rates in high use areas.

Suggested Research

The disturbance regime at TAPR has a high level of established heterogeneity. Patch-burn grazing created diversity on the landscape that benefits wildlife species. Annual management are required in an ongoing disturbance regime. Disturbances cannot be applied once in a while as a tool but must be a continuous process. Invasive species management is a major issue at TAPR. This includes both herbaceous and woody species. Goals need to be established for management of these species.

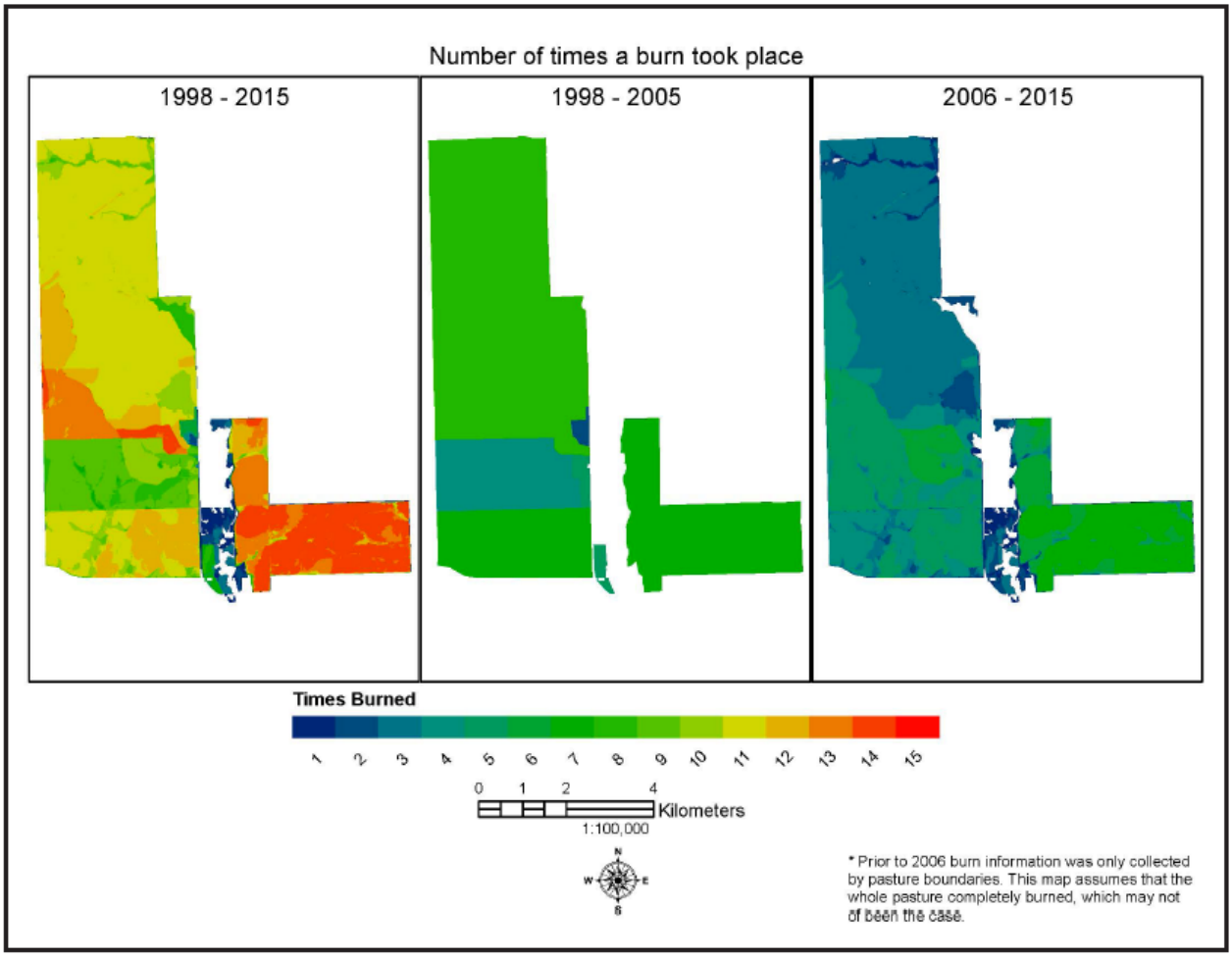


Figure C.1: Mosaic created through patch burn grazing at TAPR (Sievert & Prendergast, 2011)

Fire and grazing can impact these species, but goals need to be established to prescribe the ideal disturbance to apply.

- The effects of grazing on erosion and water resources/aquatic species
- Range utilization collected each year

Management Recommendations

Expand coupled disturbance regime

Expanding the coupled disturbance regime at TAPR will increase the resilience of the tallgrass prairie. Expanding the disturbance process can also affect more of the landscape that is being affected by invasive species invasions. *Sericea lespedeza* is a critical concern at TAPR. Late spring burning or fall burning are known to affect this species, but further research in the context of the landscape at TAPR would be beneficial to understand the best course of action.

Target woody encroachment

Mechanical treatment of woody invasives also require many man hours. Strapped budgets and staff at TAPR could be used in many other ways if woody species were targeted via a natural disturbance regime. Fall burns and more intense burns can reduce woody species in tallgrass prairie (Weir & Scasta, 2017). TAPR has begun to burn in other seasons, but researching the impacts and communicating these to the public could make the use of fall prescribed fires more acceptable to surrounding landowners.

Appendix D. Theodore Roosevelt National Park

Current Grassland Management Goals and Programs

Grassland Management Goals

Lightly utilized prairie Grasslands at THRO are lightly stocked. This allows the protected lands within the park to contrast the heavily grazed lands surrounding the three units of the park. The bison herds at THRO are culled to maintain this light utilization and horse bands are being assessed for contraceptive control to inhibit the growing population. The landscape at THRO is inherently heterogeneous. A patchy disturbance regime needs to interact positively with this diverse landscape to maintain forage banks for herbivores in the unit. Intense disturbance is needed rather than an even stand of lightly utilized prairie.

Conservation and cultural wildlife management Population genetics of wildlife are studied at THRO. Genetic testing of bison informs which animals to cull in annual roundups to maintain an even spread across age and sex. This aligns with the "conservation herd" parameters the MWR sets for bison. Genetics are also used in feral horse management. The small genetic pool of the band has led to non-viable offspring. Feral horses and longhorn cattle are managed as cultural exhibits, although these non-natives species still require significant time on the part of natural resources staff.

Grassland Management Programs

Wildlife Management Feral horses, bison, longhorn cattle, and several other herbivores graze in the park. Feral horses and longhorn cattle are managed as an interpretive exhibit while bison are managed as a conservation herd. Bison are the focus as they are a native grazer, reintroduced in 1956. The park maintains 200-400 animals in the south unit of the park and 100-300 animals in the north unit. Feral horses are maintained for the cultural aspect and visitor experience. Both bison and feral horse genetics are studied extensively to optimize population vitality. Finally, longhorn cattle are maintained as an interpretive exhibit in the Elkhorn Ranch Unit to recreate Theodore Roosevelt's ranch. Elk were also reintroduced to the south unit in 1985 with a major cull occurring 2010-2013.

Invasive Species In 2018, the park began treating invasive species after a period (2012-2017) without treatment of any kind. This gap allowed leafy spurge, Kentucky bluegrass, and Canada thistle to increase (Folluo, 2017). Riparian areas are especially invaded with smooth brome and Kentucky bluegrass. Priority is placed on the management of these species so that the prairie is not taken over by non-native species.

Management Plans and Data Available

Management Plans

Plans at THRO cover a diverse range of resources. The Fire Management Plan, written in 2008, although present in our time parameters, could be updated. Management goals in the unit have changed. Invasive species are increasing, and climactic conditions are changing at an accelerated rate. A complete list of published management plans for THRO is shown in Table D.1. The vegetation management strategy from 2012 gives a complete background on vegetation management done in the park and previous research completed pertaining to vegetation.

Data Available

In 2012, THRO lost their park botanist and efforts related to vegetation ceased for some time. I&M still collected data, but park staff communicated that I&M data are not the most useful due to the

Table D.1: Management documents for THRO published from 2008-2018

Title	Year
Fire Management Plan	2008
Elk Management Plan	2010
Long Range Interpretive Plan	2011
Vegetation Management Strategy	2012
Natural Resource Condition Assessment	2014
Foundation Document	2014

variability present on the THRO landscape. Selected data can be seen in Table D.2. Vegetation data collected prior to 2008 can be found in the vegetation management strategy. Table D.2 shows the vegetation data gap from 2012-2017. Wildlife data is up to date and has recently been the focus of collection and management efforts. This lack of time on vegetation is the impetus for vegetation data collection starting again in 2018.

Table D.2: Selected data collected in THRO, 2008-2018.

Data title	Data type	Spatial extent	Frequency	Duration	Collecting agency	Format located
Oil and gas impacts on air quality in federal lands in the Bakken region: an overview of the Bakken Air Quality Study and first results	Air	Bakken surrounding region	48 hr integrated samples, 6 days per week- 15 February- 6 April	began in 2013	NPS - Air Resources Division	unit network
Pre- Burn Pedestrian Survey of the Halliday Wells Burn Unit at THRO	Fire	one burn unit	once to assess archeological resources in a planned burn area	April 20, 2015- May 21, 2015	Midwest Archeological Center	unit network
Acoustic Monitoring Report	Sound	parkwide	30 day monitoring periods- 831 sound level meters	2012-2015	NPS	unit network
THRO Vegetation Monitoring – 2017 Summary Report	Vegetation	all three units of the park. Leafy Spurge (20 plots S, 3 N, 5 ER), Canada Thistle (13 N, 1 ER)	plots each summer	2008-2012 then lapsed and began again in 2017	NPS (Jenna Folluo, RM Volunteer)	unit network
Dendroclimatic Potential of Plains Cottonwood from the Northern Great Plains, USA	Vegetation	north unit of THRO	cored random tree once	July-October, 2010	USGS, University of Arizona, University of Arkansas	unit network
Plant Community Composition and Structure Monitoring for THRO	Vegetation	parkwide	once per summer	2011-current	NGP I&M	IRMA
Exotic Plant Management Team 2008 Annual Report	Vegetation	parkwide	annual report written each year for work accomplished during the summer season	EPMT established in 2000	NGP EPMT	unit network

Table D.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Duration of Collection	Agency Collecting Data	Format Located
Summary of observations on dieback of ash trees THRO (south unit)	Vegetation	three sites in the south unit of THRO	once	Aug-10	NDSU	unit network
Herbicide Application Report	Vegetation	parkwide			NPS	paper copy at unit
Canada Thistle and Leafy Spurge plot data	Vegetation	parkwide	once per season	2008-2012	NPS	unit network
North Dakota Plant Species of Concern	Vegetation	state wide		published 2010	ND Natural Heritage Inventory	unit network
Leafy Spurge Density Charts	Vegetation	parkwide	once per season	1983-2011	NPS	unit network
Leafy Spurge Status Report	Vegetation	parkwide	different areas treated each year	data as far back as 1970, report published in 2009	NPS	unit network
Plant Community Descriptions of THRO	Vegetation	parkwide		describing characteristic landscapes in THRO	NPS	unit network
Canada Thistle Status Report	Vegetation	parkwide	annual report written each year for work accomplished during the summer season	1997-2009	NPS	unit network
Brine Contamination to Aquatic Resources from Oil and Gas Development in the Willison Basin, US	Water	three sites across the basin	one time in 2008	2008	USGS	unit network
Aquatic Resources along the Little Missouri River near THRO	Water	four sites along the Little Missouri River	once	Aug 30 2011-Sept 1 2011	University of Wyoming	unit network

Table D.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Duration of Collection	Agency Collecting Data	Format Located
Annual Wildlife Report	Wildlife	parkwide	each year surveys of different wildlife populations	2008-2011	NPS	unit network
Elk Surveys	Wildlife	parkwide	one survey each year	1985-2000, 2010-2012	NPS	unit network
Gypsy Moth Trap Record	Wildlife			2017		
Pronghorn Migration and Resource Selection	Wildlife	southwest ND	tracking fall migrations	2004-2008	University of Missouri-Columbia	unit network
Detections of *Yersina pestis* East of the Known Distribution of Active Plague in the United States	Wildlife	five NPS units: THRO, WICA, DETO, SCBL, BADL	once per year in different months	2009-2011	University of South Dakota	unit network
The prairie dog: a century of confusion and conflict in park management	Wildlife	NPS units with prairie dogs	assessing data for one time report	written in 2009 assessing data from history-2009	NPS	unit network
Use of water developments by female elk at THRO	Wildlife	parkwide	26,081 samples at 7-h intervals	June- September, 2003-2006	USGS, NPS	unit network
Bison Handling Database	Wildlife	parkwide	yearly added to database	1985-current	NPS	unit network
Elk Handling Database	Wildlife	parkwide	yearly added to database	1985-current	NPS	unit network
2016 NU Bison Roundup Data	Wildlife	north unit of THRO	each roundup	this report is from 2016	NPS	unit network
Elk Count Data	Wildlife	parkwide	each year surveys of different wildlife populations	fall 2015	NPS	unit network

Table D.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Duration of Collection	Agency Collecting Data	Format Located
2010 Bighorn Sheep Capture	Wildlife	north unit of THRO	once	15-Feb-10	NPS	unit network
Description of Bobcat Harvest	Wildlife	state wide	yearly added to database	2004-2008	ND Game and Fish Department	unit network

Disturbance Regime

Grazing

Bison are free to roam in the north unit and south unit of the park. Elk and feral horses roam the south unit. The goal of herbivory in the park is a lightly utilized landscape in comparison to the surrounding heavily grazed lands. Bison are stocked at a conservative rate and forage quality seems to be good (Licht, 2016). Some areas of the park are heavily grazed. A study is ongoing to determine locations of bison in the park using GPS collars. This will help in developing forage use management. Grazers can be drawn away from an area through a coupled disturbance regime. They can also be drawn to an area that has been recently burned to feed on nutritive new growth.

Fire

Fire is another natural disturbance on the landscape at THRO. The unit is inherently heterogeneous. This complicates goal setting for ecosystem processes. Imposed heterogeneity must align with the inherent heterogeneity to create beneficial patches on the landscape. Fire has been absent on the landscape at THRO recently. Nine fires have occurred in the last ten years with four of those occurring in 2009. An 8,000-acre fire occurred in May of 2018 but was the first since 2011. The fire return interval for a patch is longer than other units in this study, but fire should occur in some form each year to ensure nutritive new growth for herbivores the following year. It would also aid in the fight against woody encroachment and other invasive species prevalent in the unit.

Data gaps and suggested research

Data Gaps

The main data gap in the last decade is vegetation related. Staff time and money has been focused on wildlife research. Vegetation surveys and invasive species treatment was highly documented, but then ceased in 2012. The park is beginning to reassess vegetative resources, but the status of the prairie after this management gap is needed. This includes assessment of I&M documented community composition data as well as determining the status of various ecological sites within the park that the I&M data may not capture. Once resource status is quantified, specific data collection can begin to assess beneficial disturbance to the landscape. The North Dakota Badlands are highly erosional landform. Understanding the erosion rates in highly grazed areas will enlighten the areas that cannot handle as much grazing disturbance.

Suggested Research

To develop a disturbance regime in the prescribed manner, there are several areas the park could investigate. The first is understanding the status of vegetative resources in the unit. Second, collecting productivity data for varying ecosystem types in the park. Ecological site descriptions (ESD) are available for the unit. Interview responses state the ecosystem is so highly variable that ESDs are not the best tool to use in management prescriptions. Site- specific data is necessary especially on an extremely diverse landscape to create disturbance patches. Lack of fire in recent years has also allowed woody encroachment to expand in the park. Intense fire behavior is necessary to combat woody encroachment once individuals have established. Altering season of fire can create more intense fires. Understanding how the landscape at THRO responds to altered fire season would benefit resource managers in establishing a disturbance regime to achieve invasive management objectives.

- Establish cages to determine productivity of the range in various areas of the park

- Impact of grazers on erosion rates of riparian areas
- Highly grazed areas and effects on that landscape pertaining to high grazing pressure
- Invasive species response to season of burn

Management Recommendations

Maintain prairie through coupled disturbance regime

The most significant issue at THRO is invasive species management coupled with the necessary focus of time and money on wildlife species. Better managing the processes that the prairie depends on will benefit both wildlife and native species competitive ability. An important natural process in the THRO landscape is a disturbance regime. Coupling disturbances to create a regime will impose heterogeneity on the already diverse landscape at THRO. These imposed disturbances can be used to target specific areas for invasive species management. There can also be a benefit of burning in different seasons of the year or at different intensities to reduce exotic cover. Recently, a prescribed burn was conducted with the goal of lessening woody encroachment. To do this, fire intensity needs to be high. The fire was 8,000 acres and was much more focused on extent than on intensity of the patch disturbance. A smaller patch of disturbance can then concentrate a secondary disturbance such as grazing. With uniform light grazing, the park is not creating enough heterogeneity for certain wildlife species. Concentrating grazers in a small area post fire creates intensive disturbance for a season. This benefits the landscape by creating patches of disturbance while still maintaining other areas of the unit in mid to late seral stages in case of detrimental weather conditions.

Appendix E. Wind Cave National Park

Current Grassland Management Goals and Programs

Grassland Management Goals

Diverse ecosystems Wind Cave National Park (WICA) is set within the eastern slope of the Black Hills region of South Dakota. Because of this, it has an array of ecosystems ranging from montane woodlands to open grasslands. It is also unique in that it has a teeming ecosystem underground within the cave that the unit is known for. This variety in ecosystems and processes requires a diverse set of management goals. The Foundation Statement voices the desire to maintain wildlife populations with the acknowledgement of maintaining natural plant communities.

Water Another management goal is groundwater. Pressures from outside the park are impacting both quality and quantity of groundwater reaching the park. Interviews revealed that the park staff expect development and thus pressures to only grow in the future. Overall, they desire management to focus on how best to maintain the natural state of the ecosystem.

Grassland Management Programs

Wildlife Management Program Wildlife management includes the most pure herd of bison in the NPS system. Many satellite herds of the WICA herd exist across the MWR. This has spawned the creation of the Bison Leadership Team which is assessing the status of bison and the grazing resources it depends on. Reintroductions at WICA include black footed ferret, bison, elk and pronghorn. Management plans for these species include an aspect of ecosystem effects.

Invasive Species Management Over the last two years, rather than the EPMT visiting Wind Cave, they have managed invasive species with their own budgets and staff. The unit was not approved for use of chemicals until 2011. Without fire and herbicide, invasive species has expanded across the park. Most impactful invasive species are Canada thistle, leafy spurge, and horehound. The park has ramped up its herbicidal efforts in the last few years for these species.

Management Plans and Data Available

Management Plans

Along with the Zoning Management Plan, there have been several other strategies written from 2008-2018. Although, a vegetation management plan, fire management plan and many wildlife management plans fall outside of the last ten years. Although these directives are in all likelihood still followed, operating on information that is over 10 years out of date is keeping the unit from most skillfully managing the landscape. A full list of management documents published from 2008- 2018 is displayed in Table E.1.

According to the foundation document for the park, with a draft document written in 2011, the desired conditions for vegetation are to maintain healthy plant communities and to further research endemic flora. At the time this document was written, 20-25% of the landscape was ponderosa pine ecosystem type and 75-80% was prairie. This showcases the uniqueness of this area as a “mixing zone” of ecosystem components.

Interview responses expressed that these plans are written by species and then integrated to manage ecosystem wide. Ecosystem management goals have not been laid out within the last ten years. A comprehensive management plan with current management plans would benefit WICA. This would make the integration of single resource management plans seamless.

Table E.1: Management documents for WICA published from 2008-2018

Title	Year
Integrated Pest Management Plan	2010*
Foundation Statement	2011*
Invasive Species Action Plans	2010-2018
Elk Management Plan	2009
Natural Resource Condition Assessment	2011
Long Range Interpretive Plan	2012
Zoning Management Plan	2015

Data Available

WICA has a significant amount of ecosystem data. It is fairly spread among resources as well. Staff at WICA, compared to other parks is fairly specialized giving focus to data collection for different resources at the park. WICA is the only unit with a designated, permanent vegetation specialist on staff.

Table E.2: Selected data collected in WICA, 2008-2018.

Data title	Data type	Spatial extent	Frequency	Duration	Collecting agency	Format located
Develop Forage Production and Allocation Model for WICA	Vegetation	cages across the park and using the park GIS to get the rest of the data other than production	once	2008	University of Missouri-Columbia/ NPS	site network
AUM Range Stocking Rate	Wildlife/ Vegetation	site wide	range assessments each year	2001-2009	NPS/ NRCS	site network
Park rare plant survey/monitoring	vegetation	site wide		2004-2008	NPS	site network
Scotch Thistle locations	Vegetation	sitewide		2000-2008	NPS	site network
Forage Management WICA	Vegetation	sitewide	range assessments each year	2001-2008	NPS	site network
Pronghorn Survey	Wildlife	sitewide	this count was in 2010	2010	NPS	site network
Fuel Sampling History	Vegetation	sitewide	this was an assessment of previous data ahead of the begin of the Fire Effects monitoring through I&M	2011	NGP I&M	site network
Reduce highly invasive white horehound impacting prairie dog/ black-footed ferret habitat	Vegetation/ Wildlife	prairie dog towns across the unit	applications of herbicide in 2009-2011	2009-2012	NPS	site network PMIS
Water Resources of WICA	Water	parkwide	an overview of water resources in the unit	2016	NPS	site network
Example of Herbicide application data sheets	Vegetation	specific sites within the park	each application	2016	NPS	on site

Table E.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Duration of Collection	Agency Collecting Data	Format Located
Bison, Pronghorn and Butterfly Survey	Wildlife	parkwide	once	2015-2017	NPS	on site
Habitat restoration guidelines for highly disturbed natural areas (prairie dog towns) following invasive weed eradication	Vegetation	prairie dog towns across the unit		2009	NPS	on site
Determine strategies for efficient early detection of invasive plants after prescribed fire	Vegetation	215 plots site wide	once each year (pre-burn and post-burn)	2010-2012	USGS, NGPFire	on site
Monitoring of Sharp-tailed Grouse Leks in WICA	Wildlife	parkwide	once in spring	1999-2011	NPS	on site
Monitoring Bird Populations in WICA using point counts and autonomous recording units	Wildlife	parkwide	once	May-July 2008	Rocky Mountain Bird Observatory	on site
WICA Nightjar Survey	Wildlife	parkwide	2 survey routes per year	2009-2017	NPS	on site
WICA precipitation	Weather	parkwide	average each month	1983-2017	NPS	site network
Bison Population Numbers	Wildlife	parkwide	yearly numbers	1996-current	NPS	site network
Vegetation Projections for WICA with Three Future Climate Scenarios	Vegetation	parkwide	modeled using already collected data	2013	Oregon State University/ USGS	site network
Vegetative Reproduction and Bud Bank Dynamicsof the Perennial Grass Andropogon gerardii in Mixedgrass and Tallgrass Prairie	Vegetation	parkwide	once	2010 compared to previously collected data in 2008	Kansas State University	site network

Table E.2, *continued.*

Title of Data	Type of Data	Spatial Extent	Frequency of Collection	Duration of Collection	Agency Collecting Data	Format Located
What role does prescribed fire play in managing annual bromes in northern Great Plains grasslands?	Vegetation	inside edges of Headquarters east burn unit/ inside edges of Bison Flats burn unit			USGS/NPS	on site
An Adaptive Management Framework to Control Cheatgrass in Norhtern Great Plains Parks	Vegetation	parks throughout the MWR			NPS	PMIS
Vegetation Baseline for Casey Addition in WICA	Vegetation	new addition to WICA			NPS	PMIS

Disturbance Regime

Grazing

Livestock grazing was common in the area before establishment of WICA in 1903. In 1913, management began of a bison herd. The bison management plan, written in 2006, discusses the cultural and genetic importance of the herd while also acknowledging effective use of the range. The focus of bison management lies on maintaining a viable genetic population. The park maintains a herd of near 400 animals using over 28,000 acres of mixed grass prairie and Ponderosa pine forest. Bison at WICA are free to move about the entire park. The herd at WICA had consistently lower body weights compared to other parks. This could be attributed to poor forage quality within the unit or herd changes due to lack of predators or climate change (Licht, 2016). Elk, mule deer and pronghorn also contribute to the grazing disturbance at the park.

Fire

Wind Cave National Park was the first MWR unit to reinstate prescribed fire in 1973 following decades of complete suppression (Wienk et al., 2011). The largest threats to WICA are fuel loads throughout the park (Interviews, 2018). Fire has not occurred as frequently as it could and is highly susceptible to a stand replacing fire. In the last ten years there have been ten prescribed fires with some years seeing no fire. Minimal use of fire has created a mosaic on the landscape (Fig. E.1a). The zone management plan treats different areas of the unit in different ways, either letting them burn or extinguish immediately.

Data gaps and suggested research

Data Gaps

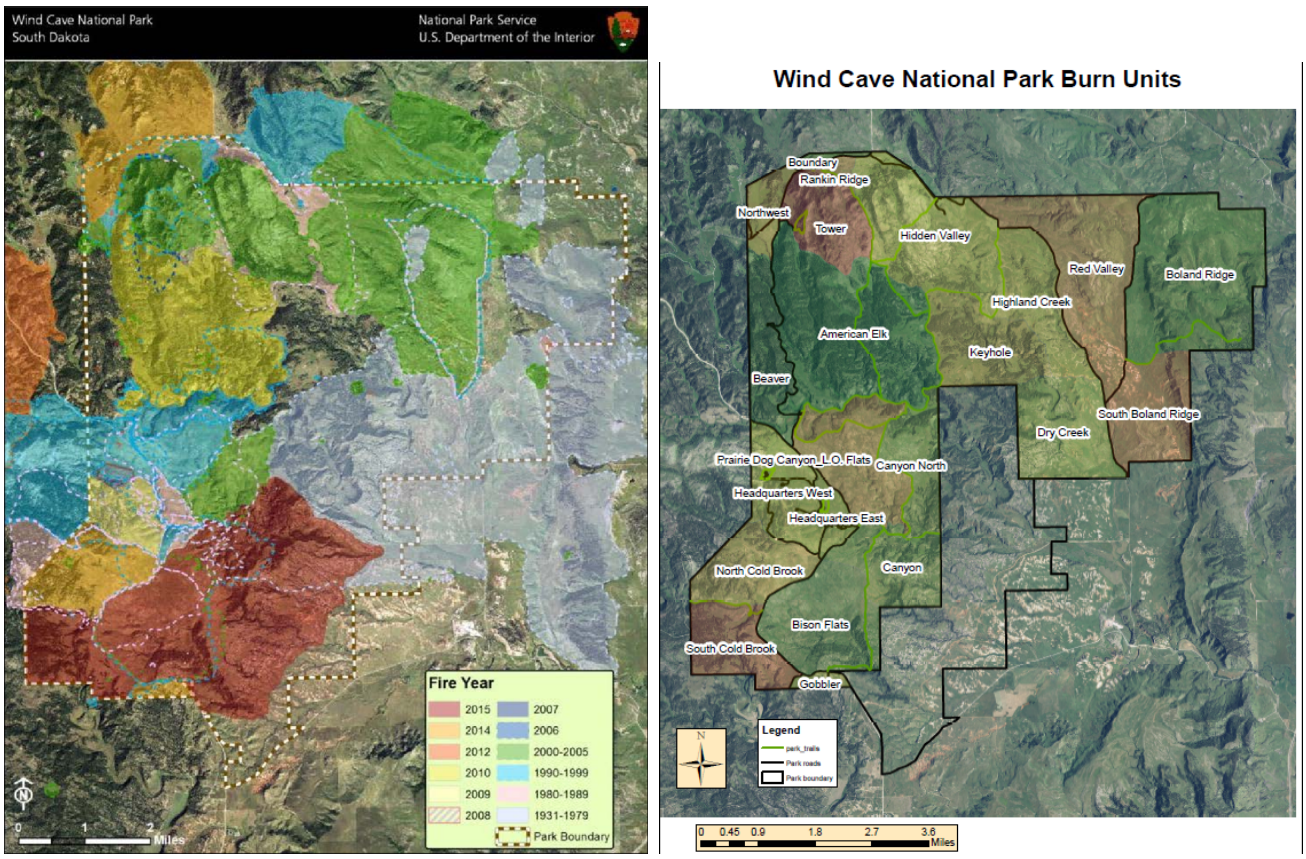
WICA data is substantial in comparison to other units in this study. It covers many resources and will aid in the development of a coupled disturbance regime. Understanding the status of resources in the park is the first step in planning. The effect of disturbance on resources is the next. Diversity of fuels is an issue at the park. Beneficial data would be understanding how different ecosystems within the park respond to varied fire season and varied intensity. The inherent heterogeneity of the WICA landscape is critical to its character. Imposed disturbance will be critical in maintaining inherent heterogeneity. For example, in the last year, a stand replacing fire occurred in the ponderosa pine ecotone. Diverse fire behavior can have desired effects on the landscape to remove dangerous fuel loading.

Bison movement in response to fire is also missing. On a fenceless landscape, bison are free to graze in whatever area they choose. Bison GPS collars are currently used in BADL, THRO, and WICA. Combining this with fire data could determine if fire is a beneficial attractant to bison to move them or disperse them to desired areas of the landscape naturally. Finally, a vegetation management plan with specific vegetation goals would aid in the development of a disturbance regime.

Suggested Research

There is historical data of exclosure locations in WICA. This makes the possibility of collecting exclosure clippings to determine vegetation productivity replicable. Aligning exclosure locations with burn unit locations is beneficial. A park that protects such vastly different ecosystems requires a heightened sense of site-specific data. Productivity data will aid in developing a coupled disturbance regime. This is needed to determine the amount of disturbance the landscape would benefit from. The diversity of ecosystems in WICA would benefit from the following studies:

- Season of fire effect on vegetation resources



(a) Mosaic created by prescribed fires. **(b)** Burn units.

Figure E.1: Prescribed fire maps for WICA (Aston & Davis, 2016).

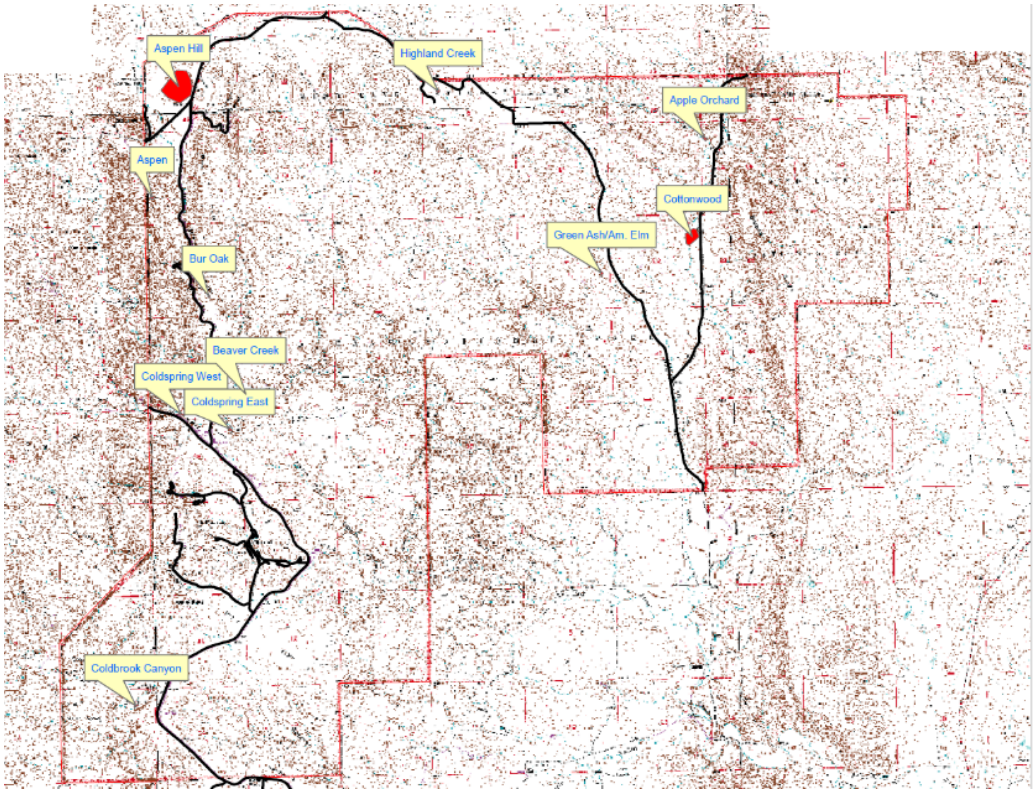


Figure E.2: Past exclosure locations within WICA

- Effect of frequent fire on forage quality
- Response of horehound to patchy fires
- Bison movement in response to fire
- Erosion rates in relation to bison occupation

Management Recommendations

Reduce high fuel loads, create disturbance mosaic

WICA manages the landscape to benefit the ecosystem. Management plans are written to specific species, but interviews revealed that the integration of the plans is forefront. Interviews also revealed that the biggest threat to the unit is wildfire. This may be attributed to recent events in the park, but is a definite concern nonetheless. The landscape at WICA requires a varied disturbance regime. One way to achieve this is through pyro diversity. Fire in the mixed-grass prairie should be managed differently than fire in the Ponderosa pine forests. WICA contains a fire prone ecosystem with large fuel loading particularly in the forested regions of the unit. Prescribed fires may not remove all wildfire threat from the landscape but will significantly reduce the likelihood of a stand replacing fire.