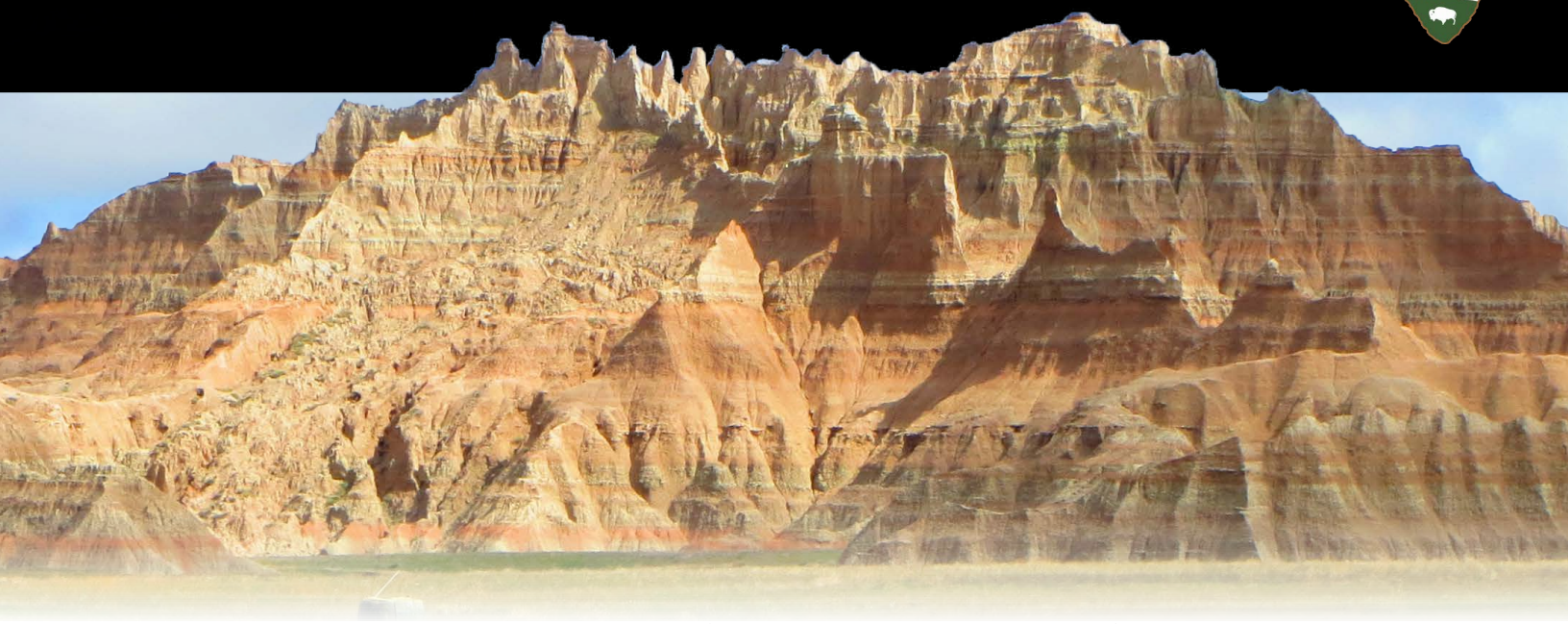
Implications of Climate Scenarios for Badlands National Park Resource Management

National Park Service
U.S. Department of the Interior



Badlands National Park (BADL) hosts a myriad of natural and cultural resources, including bison and black-footed ferrets, the mixed grass prairie in which they live, fossils from animals that lived 23-75 million years ago, and historic buildings, trails, and roads. All are sensitive to climate, but anticipating precisely how climate change will affect each is difficult. Despite this challenge, park resource managers must make forward-looking decisions and act to meet resource management goals.

Fortunately, tools exist to identify strategies and actions likely to succeed under a range of potential future climate conditions. We used two such tools—qualitative scenario planning and quantitative ecological simulation modeling—to anticipate management challenges and identify options for BADL and adjacent federal and tribal lands in the coming decades (through 2050). In corporate and military contexts, scenario planning has long supported effective decision making in the face of uncertainties about the future, and the National Park Service now applies this technique to address climate change in resource management planning and decisions (Star et al. 2016). Scenario planning is a process that considers multiple plausible futures, including how driving forces such as climate change may affect park resources and facilities. Ecological simulation models can help track such complexities of the real world and serve as virtual laboratories for asking "what if. . .?" questions about how systems might respond under different scenarios.

Here, we summarize results of collaborative work—involving resource managers, subject-matter experts, ourselves, and a larger climate change adaptation team—to identify potential climate impacts and management responses in BADL. Results also include key insights from examining management approaches on adjacent lands. See Fisichelli et al. (2016) and Miller et al. (2017) for a more detailed description.

This project was conducted under a formal partnership between the United States Geological Survey and the National Park Service.

USGS science for a changing world

Badlands National Park provides the largest area for bison to range freely in the Great Plains. NPS Image by Brad Barker.

WHAT CLIMATE CONDITIONS MIGHT WE FACE?

Climate scientists use complex models to understand how Earth's climate works and, in turn, project climate trends into the future. Because our understanding of Earth's climate is incomplete, each model is unique in the way it represents the physical and biological forces that influence climate patterns. Consequently, each climate model produces a different—and plausible—view of future climates. For instance, models consistently project warming temperatures in the Northern Great Plains, but they differ as to whether precipitation will increase or decrease. Moreover, the magnitude of climatic changes also depends on societal decisions that affect the emissions of gases that influence climate—principally carbon dioxide and methane. Climate scientists have thus developed projections for multiple greenhouse gas emissions pathways. It is tempting to reduce the range of potential future conditions resulting from both different models and different emissions pathways to a single future—for example, an average of all the projections—but doing so puts managers at risk of planning for an outcome that doesn't materialize and failing to anticipate one that does. Potential consequences include mis-investment and lost opportunities. Scenario planning is highly appropriate in this situation.

Scenario planning and ecological simulation modeling for BADL began with selection of four climate projections from a set of 36. Each projection describes coherent, scientifically plausible climatic conditions for the coming decades (through 2050). We selected four projections relevant to major park resources and sufficiently divergent to bracket the range of potential future conditions, and thereby facilitate planning for the spectrum of possibilities and challenge conventional assumptions. Then, for each climate projection, we compiled information on how the aspects of climate most important to major park resources would differ from recent history. We summarized this information with graphs, tables, and narratives, then gave each climate future a memorable name (Table 1). We used these climate futures in qualitative scenario planning and quantitative ecological simulation modeling.

Table 1. Changes in key aspects of BADL climate through 2050 for four climate futures. Arrow size and direction denote trends compared to conditions of the recent past (1950-1999). Down arrows denote decreasing values or earlier dates, up arrows increasing values, and sideways arrows no change. Larger arrows indicate greater change.

Climate Feature	Rather Hot	Awfully Dry	Wet in Bursts	The Jungle
Temperature	↑	↑	↑	↑
Spring Precipitation	↔	↓	↑	↑
Start of Spring	↔	↓	↔	↓
Heavy Precipitation Events	↑	↔	↑	↑

HOW WILL THESE CHANGES AFFECT RESOURCES AND THE ABILITY TO ACHIEVE MANAGEMENT GOALS?

After defining scenarios, we used the two tools to identify resource impacts and management implications of each climate future. In qualitative scenario planning, we facilitated discussions among BADL resource managers and subject-matter experts to identify expected responses of resources and appropriate management strategies in each climate future. In simulation modeling, we developed and ran a computer-based representation of ecosystem dynamics for all combinations of the four climate futures and four different management strategies. We based these management strategies on qualitative scenario planning outcomes and focused on the effects of grazing, fire, and invasive species treatment on native vegetation. The strategies represented:

(1) current practices

(2) manager-preferred practices

(3) practices anticipated under wetter conditions

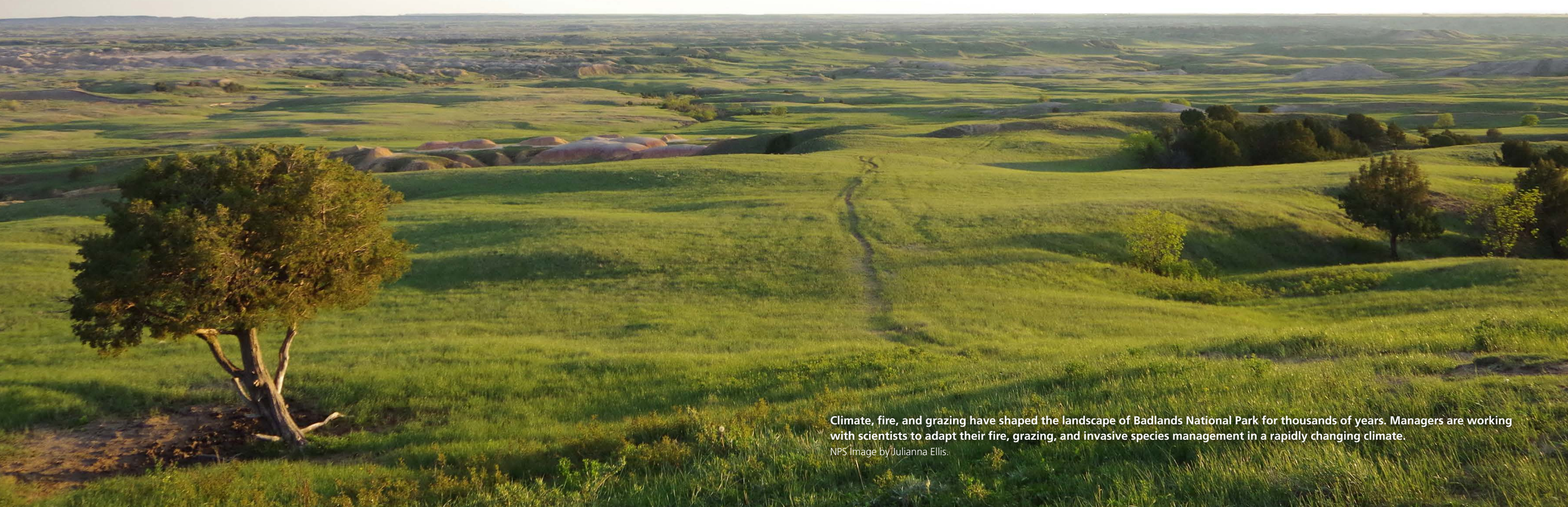
(4) practices anticipated under drier conditions

Although scenario planning and modeling both explored the impacts of the four climate futures, scenario planning considered a broader range of resources than the simulation model. Table 2 summarizes the impacts and potential responses for each of the four climate futures given current management goals. In some cases, a business-as-usual approach was expected to be sufficient for meeting management goals. In others, changes to management actions may be required. In extreme cases, management goals themselves may need to be reconsidered and updated.

WHAT DOES THIS MEAN FOR HOW RESOURCES ARE MANAGED?

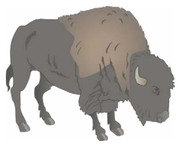
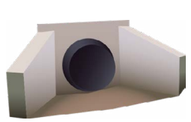
Scenarios can also be used to test whether existing plans and ideas about adaptation options remain effective across a wide range of plausible, potential futures. In conditions under which existing plans and options fall short, scenarios can be used to help revise current approaches or develop new ones. Appropriate management responses will often depend on the scenario, but some responses will be robust across all scenarios; each robust response can be thought of as a 'no-gainer', 'no-brainer', or 'no regrets' action (NPS 2013). 'No-gainers' are current actions that are unlikely to be beneficial for achieving desired outcomes under any future scenario. 'No-brainers' are currently implemented actions that are likely to be beneficial going forward. 'No regrets' are new actions that are likely to be successful in achieving desired outcomes under all future scenarios. We used these categories to organize potential management actions for each resource or concern in Table 2.

Deciding which actions to take and when, particularly for the scenario-dependent actions, requires careful consideration of constraints, risks, risk tolerance, available funding and staff, and priorities. For instance, wilderness designation in some parts of BADL is a further filter through which goals and actions must be assessed; goals requiring intensive management intervention may not be achievable or suitable in wilderness areas. Although the information presented here is but one contribution to the complex and nuanced process of making resource management decisions, it is the product of a collaborative process that leveraged the scientific expertise of the research team, as well as the park staff's in-depth local knowledge of the resources and management activities. By bringing together these bodies of knowledge with advanced tools for planning and modeling, we identified current practices likely to be ineffective under all plausible future climates, as well as new activities that might help address future climate conditions. These insights can help managers prioritize investments that better position the park to meet the challenges posed by climate change.



Climate, fire, and grazing have shaped the landscape of Badlands National Park for thousands of years. Managers are working with scientists to adapt their fire, grazing, and invasive species management in a rapidly changing climate.
NPS Image by Julianna Ellis.

Table 2. Resource implications, achievability of current goals, and potential management responses for four climate futures by mid-century, for five resources and management concerns. Conclusions for native vegetation are based largely on simulation modeling; for all other resources and concerns, they are based on qualitative scenario planning assessments, with some modifications or notes based on simulation modeling.

Resource or Concern	Current Goals	Rather Hot Impacts	Awfully Dry Impacts	Wet in Bursts Impacts	The Jungle Impacts	Achievability of Current Goals & Scenario-Dependent Responses	Additional Management Implications & Robust Responses
Native Vegetation 	• 30-60% of BADL vegetation in "historical climax plant community" (grassland with large component of grazing-sensitive species), 10-20% in each of late-intermediate and early-intermediate stages of succession, and 10% in early successional stage (composed largely of species highly tolerant of multiple disturbances)* • Exotic species comprise a small component	• Lowest vegetation production of all scenarios	• Lower vegetation production • Strongest expansion of shortgrass species of all scenarios	• Higher vegetation production • Tends toward greatest increase in Canada thistle of all scenarios	• Higher vegetation production • Tends toward greatest woody encroachment into grasslands of all scenarios under current management**	Regardless of future climate, current goals are not achievable with current actions. Increasing fire frequency from every ~100 years (the current frequency) to every 10 years, expanding bison grazing to the whole park, and an aggressive invasive species treatment program would bring the park closer to, but still not achieve, current goals by the year 2050. Higher grazing rates achieved through higher bison herd sizes, or directing bison grazing to certain locations through water developments, mineral licks, or prescribed fire, may be tools for achieving vegetation goals under all climate scenarios. However, grazing pressure as high as in adjacent national grasslands may be too high, especially in the drier scenarios.	• **No-gainer**: Continue the current combination of infrequent fire, conservative bison herd size, and insufficient weed inventory and treatment. • **No-regrets**: Develop a Vegetation Management Plan incorporating (1) park-determined vegetation goals; (2) increased prescribed fire frequency and extent; (3) increased invasive monitoring and treatment; (4) adoption of appropriate and vetted biocontrol methods as they become available; and (5) integration with bison and prairie dog management. • **No-brainer**: Continue vegetation monitoring by outside programs.
Bison 	• Maintain herd health, promote genetic diversity, protect vegetation, and work with Tribes and the Intertribal Buffalo Council to establish and maintain tribal herds for sustenance and cultural use	• Reduced forage and water	• Similar to Rather Hot, but also increase in wildlife disease with concentration around water sources	• Larger bison populations may be supportable • Increase in ticks and mosquitos and associated pathogens and diseases	• Similar to Wet in Bursts	Likely achievable for all climate futures, but may require new or modified actions that are dependent on the climate future: **Rather Hot** and **Awfully Dry**: • Stronger fencing and additional water sources to keep bison from escaping the park in search of water • Supplemental feeding (but simulation modeling suggests this would not be necessary) **Wet in Bursts** and **The Jungle**: • Round-up approaches relying on something other than water scarcity in autumn to attract bison • Enhanced monitoring for pathogens and diseases carried by ticks and mosquitoes	• **No-brainer**: Continue participating in the development of a regional bison management strategy that (1) includes best practices or guidelines for bison genetics, breeding, and culling strategies based on recent science and modern tools, and (2) ensures strong relationships with Tribes and the Intertribal Buffalo Council. • **No-regrets**: monitor for new diseases in bison and cattle on adjacent lands.
Black-Footed Ferret 	• Expand the area occupied by prairie dog (the ferret's primary prey)	• Dry conditions favor expansion of prairie dog towns because shorter vegetation reduces predation risk	• Similar implications as Rather Hot	• Increase in unsuitable habitat (taller vegetation and potentially greater woody encroachment)	• Similar implications as the Wet in Bursts scenario, but impacts may be more severe due to persistently wetter conditions	**Rather Hot** and **Awfully Dry**: current goal is likely achievable with current actions **Wet in Bursts**: may require more intensive grazing **The Jungle**: may require revision of overall goal from expanding to simply maintaining prairie dog area	• **No-brainer**: Continue to (1) monitor prairie dog and ferret population sizes and disease rates; and (2) research methods to immunize both against plague.
Archeological & Paleontological 	• Preservation and protection	• Exposure of resources to weather and looting due to greater erosion from extreme precipitation events and reduced vegetation cover	• Exposure of resources to weather and looting due to reduced vegetation cover	• Loss of some sites due to vegetation growth • Exposure of resources in other sites to weather and looting due to greater erosion from extreme precipitation events and flooding	• Similar implications as Wet in Bursts	**Awfully Dry**: achievable with current actions **Rather Hot** may require revised actions, including: • Increased salvage collection and the funds and personnel to do so • Additional cooperative agreements for storing additional specimens • Increased visitor education and outreach regarding fossil poaching • Enhanced modeling to identify potential sites **Wet in Bursts** and **The Jungle** may require revised goals, including: • Prioritize archeological sites for stabilization and data recovery • Target fossil rich areas for protection and preservation • Access to priority sites may need to be restricted	• **No-regrets**: Increase capacity for collecting and storing specimens.
Infrastructure & Geohazards 	• Maintain infrastructure safety and usability and minimize geohazards	• More erosion, flooding, mass wasting • Damage to road infrastructure	• Increased soil instability due to decreased vegetation	• Similar implications as Rather Hot, plus increased flood- and erosion-related geohazards	• Similar implications as Wet in Bursts	**Rather Hot**: in the long term, revised goals for usability of existing infrastructure are likely required. In the short term, the current goal may be achievable with revised actions: • Installation of additional culverts • Switching investment from contracts to park-owned equipment **Awfully Dry**: achievable with current actions **Wet in Bursts** and **The Jungle**: similar to Rather Hot, but may require new actions, including: • Updating current drainage systems • Re-aligning and re-engineering current roads, many of which have cultural resource status	• **No-regrets**: compare the cost-effectiveness of contracting infrastructure repair to purchasing equipment so that the park can implement repairs on its own.

*Badlands National Park does not have an established goal for vegetation composition. The goal listed here is an approximation of the current goal for the adjoining Buffalo Gap National Grassland, and it was used as the BADL vegetation goal in the qualitative scenario planning discussions.

**Workshop participants expected greater woody encroachment under this scenario, whereas the simulation model projected relatively stable or slightly decreased woody encroachment for all climate futures under current management practices.

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MORE INFORMATION

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Badlands National Park paleontologist Wayne Thompson excavates an oreodont skull discovered and reported by park visitors.
NPS Image by Brad Barker.