Annual Brome Adaptive Management Project:
Development of an adaptive resource management framework for National Parks within the Northern Great Plains

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Problem:

National Park Service units in the Northern Great Plains (NGP) preserve and protect both historical and ecological landscapes. Invasion by annual brome grasses (*Bromus tectorum* and *Bromus japonicus*) into these landscapes reduces their historical and ecological integrity, in part by reducing native plant diversity, which is the hallmark of high quality prairie and woodlands. Currently, there are few management actions targeting the control of annual bromes, and consequently they persist and have increased in some parks over the past 15 years (Figure 1). Uncertainty about the effectiveness of specific management treatments in controlling annual bromes and limited capacity to apply management treatments make the problem of managing bromes complex.

Figure 1. Annual bromes within one of the long-term monitoring plots.

Approach:

The Annual Brome Adaptive Management project (ABAM) is tackling this problem through a cooperative effort of the Northern Great Plains and the Rocky Mountain Inventory and Monitoring Networks (NGPN and ROMN), the NGP and Northern Rocky Mountain Exotic Plant Management Teams, the NGP Fire Management Office, the USGS Northern Prairie Wildlife Research Center, and seven parks (Figure 2). ABAM is developing a structured adaptive management framework that will guide parks and their supporting networks in making more effective and strategic vegetation management decisions.

The project began in spring 2017 with a workshop including fourteen participants from the parks and networks. Workshop participants began by developing the fundamental objectives of the adaptive management framework—reducing annual brome invasion, improving native vegetation condition, and minimizing costs. They also identified currently feasible management actions and began outlining other key components of the model that will be the heart of the framework.

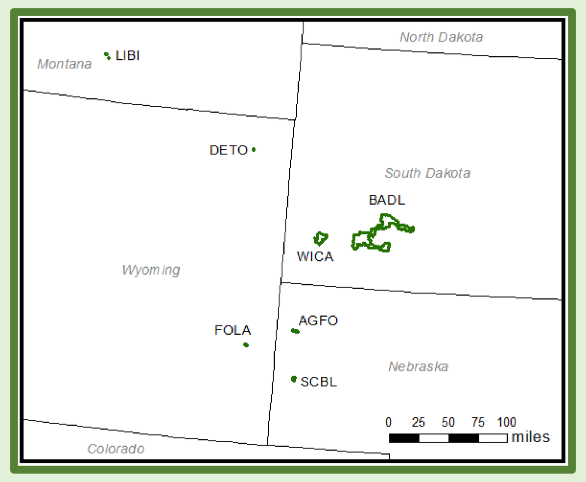

Figure 2. Locations of the seven ABAM consortium parks located in western Nebraska, western South Dakota, eastern Wyoming, and eastern Montana. The parks are: AGFO = Agate Fossil Beds National Monument, BADL = Badlands National Park, DETO = Devils Tower National Monument, FOLA = Fort Laramie National Historic Site, LIBI = Little Bighorn Battlefield National Monument, SCBL = Scotts Bluff National Monument, WICA = Wind Cave National Park.

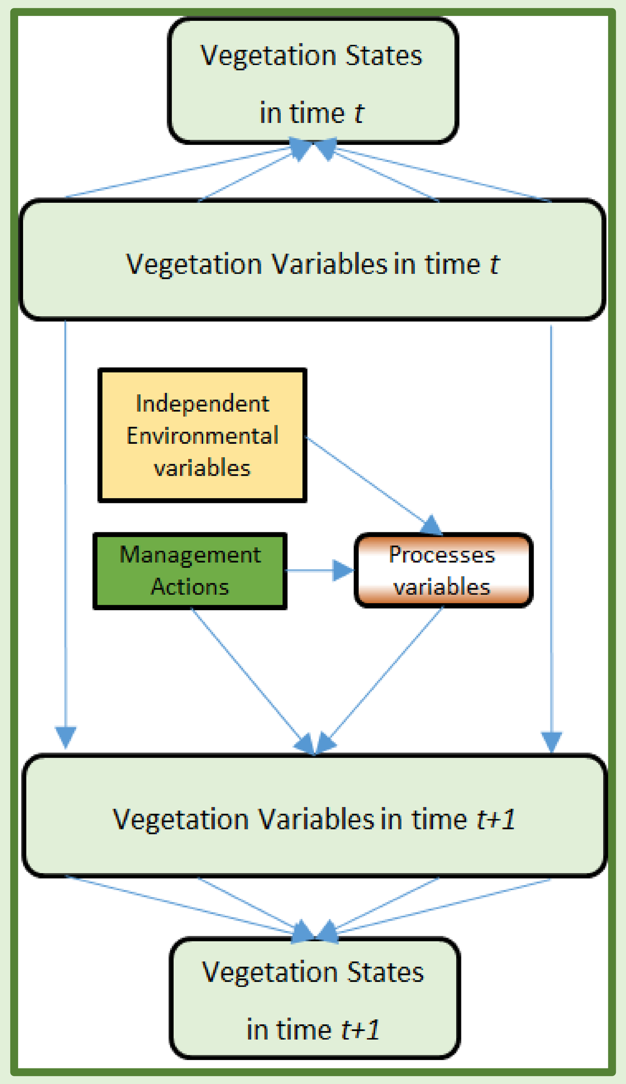

Figure 3. Template of Bayesian belief network.

Model type and structure:

We will be using a type of predictive model called a Bayesian belief network (BBN). These are probabilistic models that represent sets of conditional dependencies between variables as a directed acyclic (i.e., no feedback loops) graph. The network structure of the model contains nodes (*boxes* in the graphical representation of the model), which represent the variables, and edges (*arrows* in the graphical representation), which represent the conditional dependencies. The Bayesian aspect of the model allows for specifying prior information (either expert opinion or empirical data), which can be updated using new data to compute posterior probability estimates (learning using Bayes' Theorem).

The BBN will be in the form of a state-and-transition model in which an initial state is defined and a set of probabilities are associated with predicted subsequent states based on ecological drivers. In our case, we worked with NPS managers to develop a set of vegetation states (grassland and woodland types) commonly found within the parks. The states are defined by probabilities associated with specific combinations of ranges within vegetation measurements collected in the field by the monitoring program. Environmental variables, process variables, and management actions may induce shifts in values of these vegetation variables over time, which subsequently change the probabilities associated with individual vegetation states (Figure 3).

Since the workshop, the USGS partners have completed a draft conceptual model that coalesces information about various aspects of vegetation, independent environmental drivers like precipitation and soil disturbance, and management actions including prescribed fire and herbicide application, and how they all interact to affect annual brome growth, while considering the impacts on native species as well. The draft model was developed by conducting a thorough literature review, followed by a formal expert elicitation discussion led by draft conceptual models. The purpose of the expert elicitation discussion was to ensure that we are capturing potentially relevant variables for analyses, and to discuss the degree of certainty associated with the relationships between drivers of annual brome populations and how these drivers impact park vegetation (Figure 4).

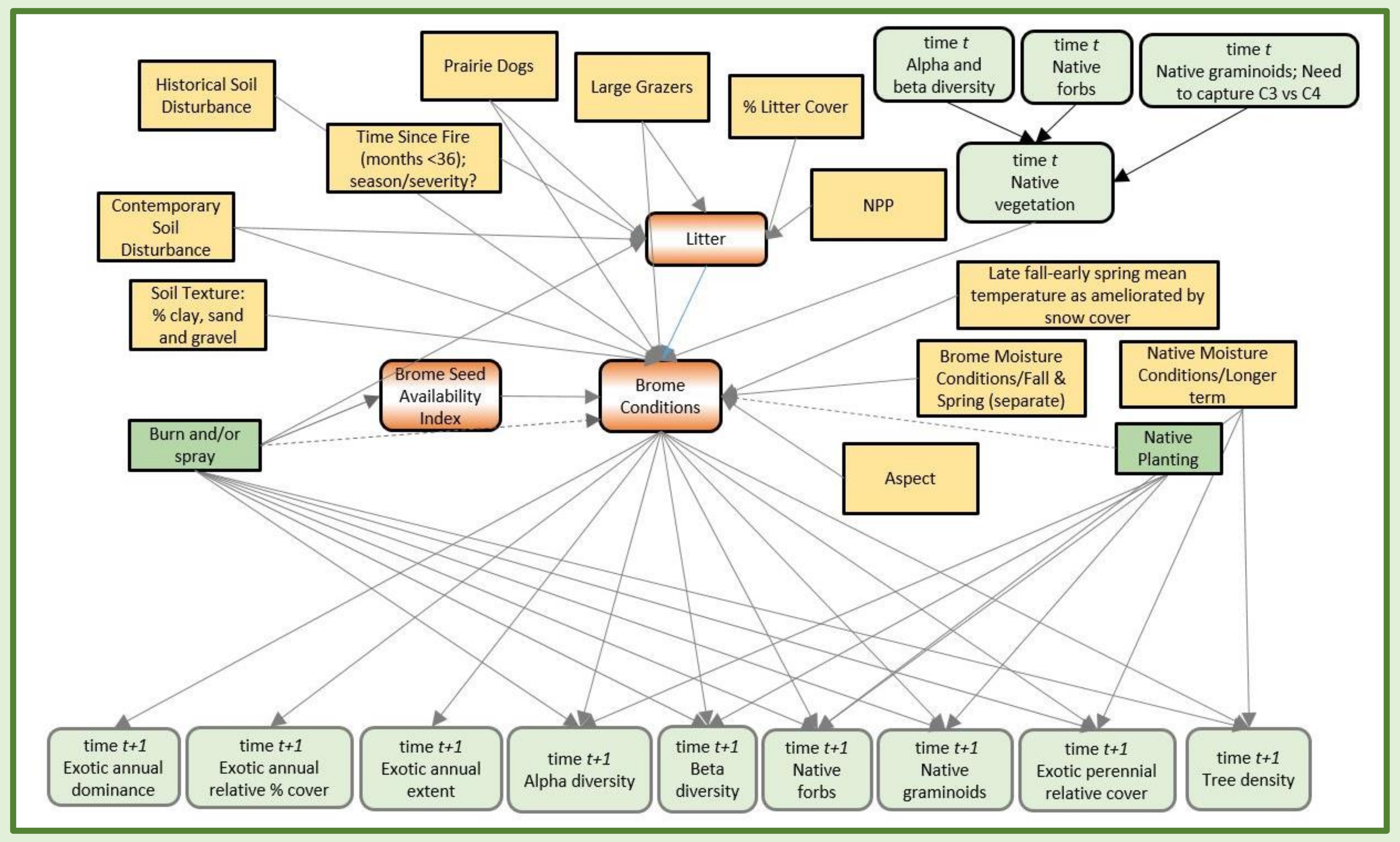

Figure 4. Draft conceptual model describing the relationship between environmental variables (yellow nodes), process variables (orange nodes), management decision variables (green nodes) and vegetation variables (light green nodes). *Independent environmental* nodes represent system inputs that are not manageable, yet are likely to alter the predictive outcome of interest. *Process* variables, within our model, are not reliably measurable, yet represent conditions we believe are important in predicting outcomes of interest. *Decision* nodes include management actions that are currently feasible possibilities based on our most recent information. *Vegetation variable nodes* are the monitored metrics that are used to define the vegetation state; they are affected by the process, environmental, and decision nodes.

Current and future work:

Currently, we are examining data available from project partners to develop model structure and associated parameters based on expert knowledge and roughly 20 years of monitoring data. We plan to provide our first round of management recommendations this spring, and continue to refine and improve the model throughout the summer and fall of 2018. Completing the model is just the beginning of adaptive management. Each year, the model will be used to produce optimal and sub-optimal management recommendations which will be based on predicting which management actions would have the highest probability of improving vegetation conditions while minimizing costs. Those actions will hopefully be applied, monitoring data will be collected and input into the model, and the model will be updated to provide improved predictions of management action effects. This long-term protocol for continued learning is unique in the NPS, and it provides an example of how this type of approach could be applied to other complex management issues in parks across the nation.

Figure 5. Large annual brome infestation at Scott's Bluff National Monument.

Acknowledgements:

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