Using a Global Vegetation Model to Plan Local Natural Resource Management in a Changing Climate

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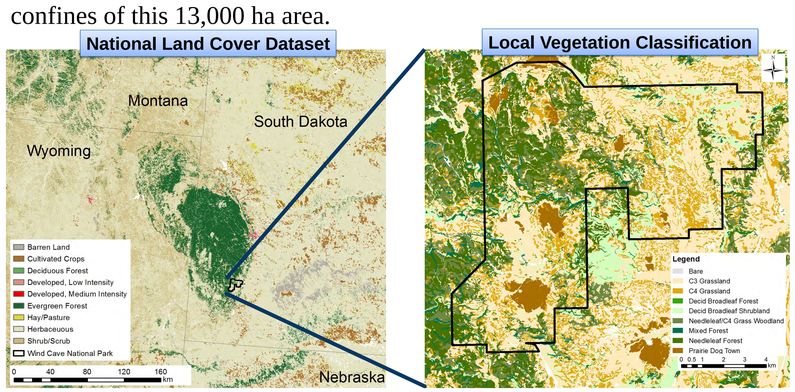
Resource Management at the Park Scale

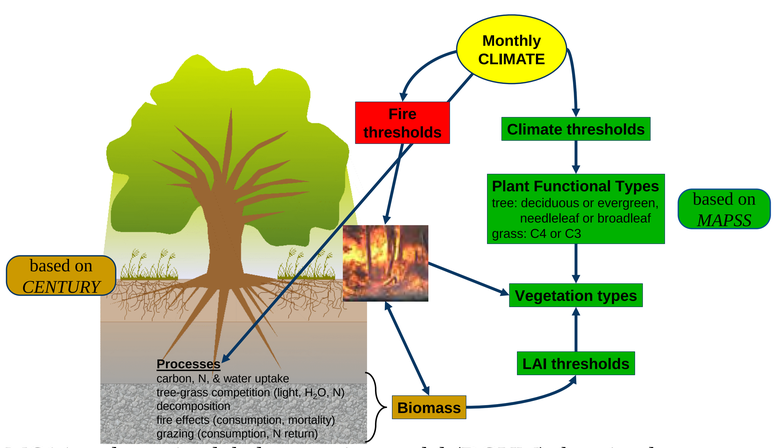
Wind Cave National Park (WICA) management goals include maintaining viable populations of bison, elk, pronghorn, and prairie dogs. These animals depend on the park's mixed-grass prairies, and an important part of the park's scenery is its transition from ponderosa pine forest to grassland. **The nature and extent of prairie and forest are strongly influenced by climate, fire, grazing pressure, and their interactions.**

Prescribed fire and population control of bison, elk, and prairie dogs are the main natural resource management tools available for maintaining the vegetation required to meet the park's goals within the relatively small confines of this 13,000 ha area.



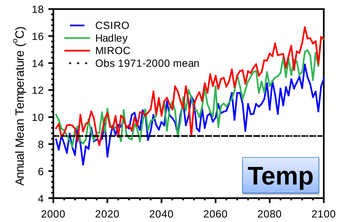
- **What impacts will climate change have on the ability of the park to achieve its goals using these management tools?**
- **Will new management practices be needed?**

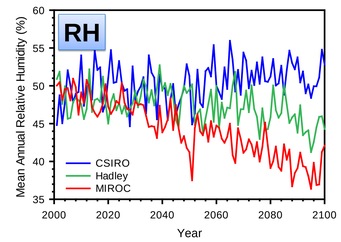
Apply a DGVM at the Local Scale

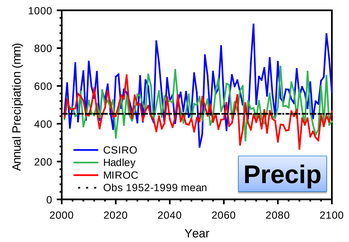


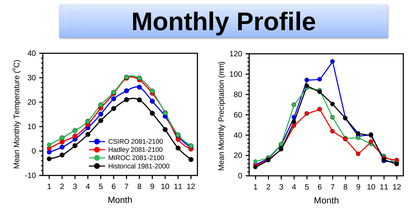
MC1 is a dynamic global vegetation model (DGVM) that simulates vegetation distribution, carbon, water and nutrient cycling, and fire in a highly interactive manner using climate and soil drivers. This dynamic approach allows the testing of management-climate interactions. We applied MC1 at the local scale by adjusting parameters to fit local species (ponderosa pine) and to achieve process values (fire frequency, primary production) and vegetation distribution that match measured values at WICA.

Future Climate Scenarios





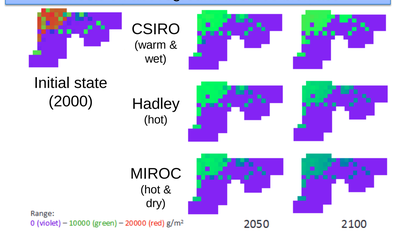




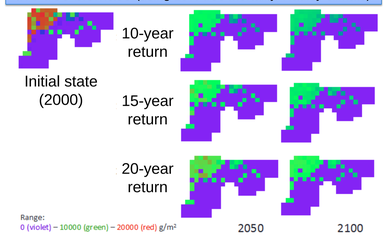
Three climate projections (statistically downscaled from GCMs, A2 emissions scenario) bracket AR4 futures for the WICA area.

Impacts of and on Fire

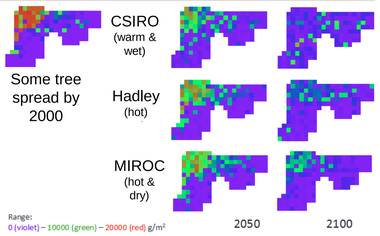
Prescribed fire (10 year interval, 20% tree mortality) effects on aboveground live tree biomass

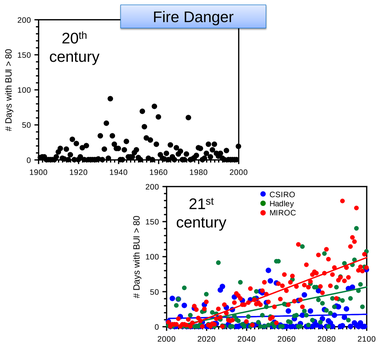


Prescribed fire return interval effects on aboveground live tree biomass (using 20% tree mortality, Hadley climate)



Aboveground live tree biomass simulated with fire suppression beginning in 1941 (only the most severe fires occur)





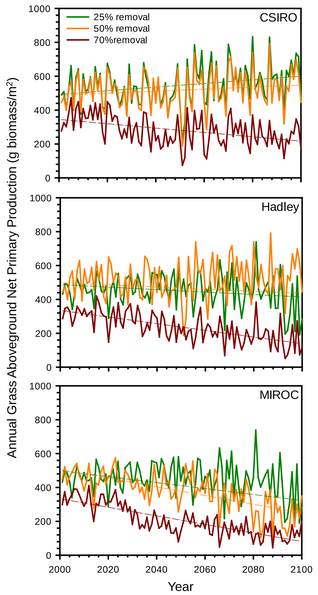
Reasonable prescribed fire scenarios (top) reduce tree biomass but leave distribution of forest vs. grassland relatively unchanged.

Trees invade grassland under fire suppression, but severe fires kill many trees in currently forested cells by 2100 (left).

Limitations of MC1's fire effects simulations make its fire danger projections as useful as simulated climate+fire effects on vegetation. High fire danger occurrence, represented by the build-up index (BUI) exceeding MC1's ignition threshold of 80, increases from 12 day/yr in the 20th century to 60 or 100 day/yr by 2100 for two climate scenarios (bottom).

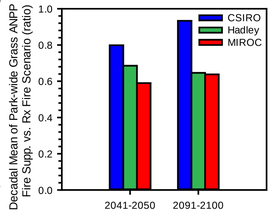
Impacts of and on Grazing

Annual Grass Production

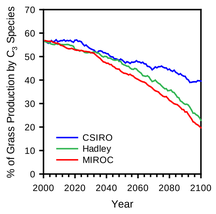


Under light to moderately heavy grazing (25 and 50% removal), grass production in a grassland cell goes in opposite directions depending on the climate scenario. Very heavy grazing (70% removal), as might occur in prairie dog towns, substantially reduces grass production in all climate scenarios (left).

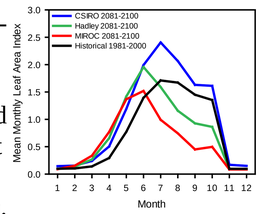
Fire suppression reduces park-wide grass production compared to 10-yr prescribed fire (below right) due to tree incursion into grasslands and fire's short-term stimulation of grass production.



Seasonality and Composition of Grass Production



Increasing temperatures decrease C_3 (cool-season) grasses (left). In two climate scenarios grass cover peaks earlier in the growing season and is greatly reduced in July-Oct (right), which could impact soil erosion and grazer health.



Management Implications

- **Regardless of future climate, maintaining the woodland-prairie ecotone landscape should be possible with current fire management practices. Fire management will become more difficult, however, because of drier fuels.**
- **Different climate scenarios produce varying implications for grazer management. Rigorous evaluation of the likelihood of particular climate scenarios is needed. Regardless, warmer temperatures will increase the need for wildlife drinking water.**
- **Continuing current vegetation monitoring will evaluate changes in composition and cover in late June, but tracking changes in seasonality of production may be more important for sustainable grazer management.**

Acknowledgements

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