Projecting Future Effects of Land Management, Natural Disturbance, and CO_2 on Woody Encroachment in the Northern Great Plains in a Changing Climate

A proposal for the North Central Climate Science Center's
Pilot Project with the NOAA National Climate Predictions and Projects Platform

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Management Target

The World Wildlife Fund (WWF) identified the Northern Great Plains (NGP) as one of the 238 most biologically significant places on Earth because it harbors exceptional and distinctive biodiversity (Olson and Dinerstein 2002). Furthermore, WWF considers the NGP as one of its 19 priority conservation areas (http://www.worldwildlife.org/what/wherewework/ index.html) because it still contains vast expanses of native grassland. Overall, this region has a high potential for landscape-scale conservation. Although the days of huge herds of bison and elk roaming freely over the landscape are gone, current management of a large part of this region as rangeland continues to provide habitat for many grassland specialists. Despite its obvious conservation value, this landscape is threatened by a wide range of human activities, ranging from sod-busting to energy development and climate change (Forrest et al. 2004). Consequently, the species it supports are also threatened. Grassland-nesting birds, for example, have been declining more than any other avian guild in North America (Peterjohn and Sauer 1999).

The Plains and Prairie Potholes Landscape Conservation Cooperative (PPP LCC), which includes most of the NGP (Fig. 1), seeks information on emerging landscape-level threats to conservation and on how decision-makers should prepare for those threats (PPP LCC Fiscal Year 2012 Request for Proposal Information). The encroachment of native woody species (trees and shrubs) into NGP grasslands is one of these threats. Expansion of woody species in areas where they were previously minor components is well documented on the edges of the NGP (Grafe and Horsted 2002, Eggemeyer et al. 2006, Spencer et al. 2009, references in Barger et al. 2011), where encroachment rates are some of the highest in North America (Barger et al. 2011). In these and other semi-arid areas of the world, the conversion of grasslands into shrublands and forests has resulted in changes in carbon cycling and storage (Barger et al. 2011) and in the capacity for commercial livestock production (Burkinshaw and Bork 2009). In the NPG, woody encroachment would directly threaten conservation efforts by reducing the suitability of habitat for grassland specialists, which avoid areas with shrub and tree cover (Cunningham and Johnson 2006 and references therein, Milne-Laux and Sweitzer 2006). It would also indirectly affect conservation efforts by making uneconomical the ranching that maintains much of this habitat, driving new land-use changes that would likely be less favorable for native grassland species.

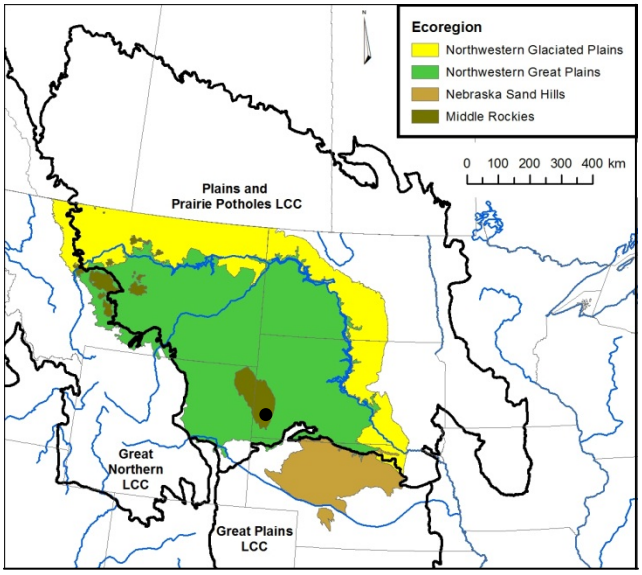

Figure 1. For our purposes, NGP includes three EPA Level III ecoregions (http://www.epa.gov/wed/pages/ecoregions.htm) and the portions of the Middle Rockies ecoregion they surround. Wind Cave NP is indicated by •.

Current understanding of how climate and other stresses influence woody encroachment on NGP

Woody encroachment may result from changes in climate, altered grazing and/or fire regimes, increasing atmospheric CO_2 concentration, or more likely a combination of all of these factors. For example, a wet period in the late 1700s increased tree establishment in the forest-grassland ecotone of the Black Hills of South Dakota (Brown 2006). Fire suppression and reduced competition from grasses due to intensified grazing has increased the germination and survival of woody species in the Great Plains and throughout the world (Archer et al. 1995, Briggs et al. 2005, Van Auken 2009). Tree and shrub expansion in former grasslands during the 19th and 20th centuries has also been correlated with the observed 35% increase in

atmospheric CO_2 concentration. Greater post-1950 growth rates in ponderosa pine, particularly on dry sites in the Pacific Northwest, and the decreasing sensitivity of bur oak growth to drought in western Minnesota are both consistent with the expected CO_2-mediated increase in water use efficiency by tree species (Soulé and Knapp 2006, Wyckoff and Bowers 2010). Furthermore, research has shown that the biomass of fringed sage, a subshrub common throughout the NGP, can increase 40-fold in response to doubled CO_2 in the shortgrass prairie of Colorado (Morgan et al. 2007). Together, these observations confirm that direct CO_2 effects are likely to play a substantive role in future tree-grass dynamics and should be included in vegetation response models.

On the other hand, woody encroachment in the NGP may be hampered by increasing temperatures and associated declines in soil moisture (Notaro et al. 2007) as well as by management practices such as prescribed fire and mechanical shrub removal. Our dynamic vegetation model (MC1; Daly et al. 2000, Bachelet et al. 2001; details below) projected the expansion of savannas across much of the Great Plains by 2099 if fires were suppressed but a contraction of woodlands when they were not (Lenihan et al. 2008).

All of these factors combined will impact the absolute and relative productivity of C_3 (cool-season) and C_4 (warm-season) grasses and therefore the structure and seasonal production of grassland vegetation – the commodity that ultimately supports wildlife and much of the human economy of this region. **Understanding the relative importance of CO_2, land management practices, and changing climate in shaping future NGP vegetation is critical for determining what management approaches will be most effective in protecting grassland habitat and the ecosystem services it renders in the NGP.**

Description of MC1, our Ecosystem Response Model

Recent improvements of the MC1 vegetation model, as well as progress in regional climate projections, allow us to address this need. The MC1 model consists of three interacting modules. The biogeography module uses physiologically-based rules derived from the static biogeography MAPSS model (Neilson 1995) to simulate spatial and temporal shifts in the relative dominance of individual life forms (deciduous needleleaf tree, evergreen needleleaf tree, deciduous broadleaf tree, evergreen broadleaf tree, C_3 grass, and C_4 grass)[1] as well as changes in vegetation class (23 classes) in response to atmospheric CO_2, temperature, and precipitation. In each year of the simulation, climate data are smoothed over a decade to avoid unrealistically fast vegetation shifts and then tested against thresholds relevant to individual life forms. When a threshold is crossed, the vegetation type changes. The biogeochemical module, which is derived from the CENTURY model (Parton et al. 1994), simulates monthly carbon and nutrient dynamics for ecosystems composed of interacting grasses and trees. Net primary production is calculated for each life form with unique functions of temperature, soil available water, nitrogen availability, and atmospheric CO_2. Grazing is simulated by removing a user-stated fraction of grass production on a user-stated schedule. The fire module simulates fire occurrence, behavior, and effects (e.g., tree mortality, fuel consumption, emissions) as functions of fuel moisture, fuel loads (derived from carbon pool values), and fuel characteristics (size and vertical structure). The model can be run in a "natural fire" mode, in which fire occurs whenever weather, fuel load and moisture meet the built-in thresholds. A "prescribed fire" mode allows the user to determine when and at what intensity each grid cell is burned. In "fire suppression" mode, only "catastrophic" fires that are above user-defined intensity and area thresholds are allowed to burn.

Protocol to run our Ecosystem Response Model and description of our downscaling method

The protocol we follow to run the MC1 vegetation model is as follows. A detrended historical time series (1895-2000) of climate data (monthly PRISM-generated historical data at 30 arc-second – ~800 m –

[1] MC1 does not explicitly simulate shrubs, but instead considers them short-stature trees.

resolution) is used for the MC1 model spin-up phase to initialize vegetation and other variables such that ecosystem productivity nears equilibrium at the start of the historical run. The spin-up climate data are manipulated so that their means match those of the first decades of the historical period to avoid a mismatch between the spin-up phase and the historical run. Future climate projections are generated by calculating, for every month, the anomaly for each climate variable, which is the change in the climate variable between future conditions (2012-2100) and a historical baseline period (1971-2000) as simulated by the climate model. Anomalies in temperature are differences [i.e., (monthly future temperature) – (1971-2000 mean of simulated temperature)], whereas anomalies in precipitation and vapor pressure are calculated as ratios. The anomalies are then downscaled using linear interpolation and used to modify a historical gridded climate baseline (30 arc second resolution) generated by the PRISM model, based on observations. The 30 arc second spatial resolution is a reasonable compromise between providing spatially detailed information dear to land managers and the constraints of soils and climate input data availability, processing time, and data storage for large-area simulations. We assume that the historical baseline provides a reliable representation of interannual and decadal climate variability and the anomaly method of transformation is a reasonable correction for potential bias in climate model results.

Improvements to our Ecosystem Response Model based on lessons learned in current project
Our current simulations of vegetation dynamics at Wind Cave National Park (in southwestern South Dakota) identified fire frequency and fine fuel loads as key factors affecting the projected distribution of woody plants. In applying the model to Wind Cave NP we made a number of alterations to more accurately simulate the dynamic ecotone between forests and grasslands. Changes to the model include adjustments to the partitioning of litter and downed wood among fuel classes, lowering the sensitivity of tree growth to soil moisture deficits, as appropriate for the dominant tree species (ponderosa pine), as well as adjusting surface runoff and tree access to deeper soil water. The last of these enabled us to match the average gauged streamflow of Beaver Creek, the largest watershed feeding into the Park. To better simulate the observed competition between trees and grasses at Wind Cave NP, we also reduced the minimum tree leaf area assumed in the model for otherwise treeless areas (a remnant from the original "savanna mode" of the CENTURY model), thereby sharpening the dynamics of the forest-grassland ecotone. These changes improved our calculations of fuel load and the resulting simulations of fire intensities, making them more appropriate to NGP conditions.

Current and future work with climate projections

We started simulating climate change effects on the vegetation of Wind Cave NP using statistically downscaled climate projections from the CSIRO Mk3, Hadley CM3, and MIROC 3.5.Medres general circulation models (GCMs), under the A2 emission scenario. These GCM projections were chosen as representative of the range of projections from the 4th assessment report (AR4) to the Intergovernmental Panel for Climate Change. These simulations yielded only slight changes in plant productivity by 2100, as direct effects of CO_2 on production and water-use efficiency in the model mitigated the increased water loss associated with higher temperatures. However, the C_4 proportion of grasses generally increased, which is consistent with CO_2 fertilization results for Great Plains grasses (Morgan et al. 2011). As expected, the projection of tree biomass throughout the park varied considerably in the future with different fire regimes (Fig. 2). Fire suppression promoted the expansion of trees throughout the park while frequently prescribed (10 year intervals) fires reduced tree biomass. Interestingly, when we simulated natural fire frequency, it was also high because of abundant, dry, fine fuels. Consequently, in this simulation tree biomass declined almost to the same extent as with a 10-year prescribed fire regime.

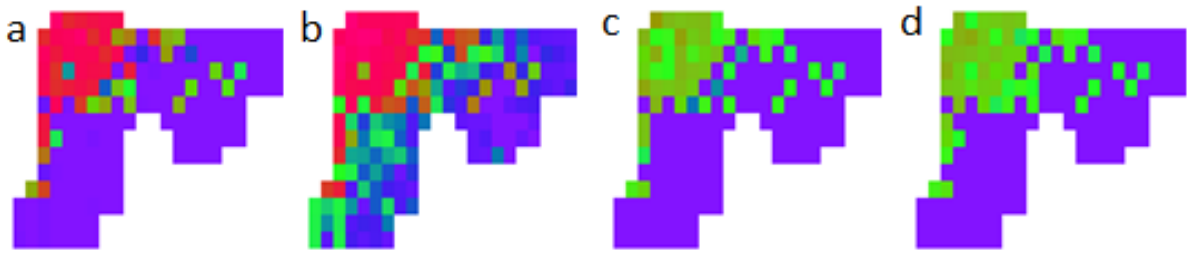

Figure 2. MC1-projected live aboveground forest carbon for Wind Cave National Park using historical (a) and future (b-d) climate conditions (Hadley GCM, A2 emissions scenario, yr 2100). Future projections made using (b) fire suppression, (c) 10-year prescribed fire interval, and (d) natural fire scenarios. Range: 0 (violet) – 4500 (green) – 9000 (red) g/m^2.

The experience we have now gained in simulating the Wind Cave NP ecosystem makes us well positioned to simulate tree-grass dynamics over the broader NGP region using a number of land management scenarios. However, our future simulations would benefit greatly from the use of regional climate model (RCM) projections. The dynamic downscaling of future climate provided by RCMs does not presume that the relationship between local climate and macroclimate will remain unchanged under further greenhouse gas forcing (Wilby et al. 2004: Tabor and Williams 2010). RCMs can simulate mesoscale processes and orographic effects that are largely absent from coarse-scale GCMs (Hostetler et al. 2011), thereby allowing decoupling between local climate and macroclimate.

Future work with new climate datasets

One set of climate projections we will use for this project comes from our Wind Cave project colleagues at the USGS South Dakota Water Science Center (SDWSC). They are using the Advanced Research WRF Version 3 model (Skamarock et al. 2008) with CCSM3.0 (under the A2 emissions scenario) boundary conditions, with physics package combinations optimized for the central United States (WRFc). The CCSM3 GCM was chosen by SDWSC because its historical temperature and precipitation simulations agreed well with the PRISM-generated historical climate for the Missouri River watershed, which encompasses the NGP (J. Stamm, USGS Rapid City, pers. comm.). The WRFc climate projections are provided through the NCAR supercomputing center at 36 km x 36 km spatial resolution on a Lambert Conformal projection centered at 97.5º E, 35.0° N, for a domain covering all of the continental United States, all of Mexico, and the southern third of Canada.

We will also use climate projections from the RegCM3 model, which we have already been using to evaluate the response of our vegetation model to statistically vs. dynamically downscaled GCM projections. Steve Hostetler (USGS, Corvallis) provided us with RegCM3 historical simulations with NCEP boundary conditions as well as future projections with boundary conditions from three GCMs (GENMOM, Echam5 and GFDL, all under the A2 emission scenario). RegCM3 projections have a 15 km x 15 km spatial resolution on a Lambert projection (Hostetler et al. 2011; ftp://regclim.coas.oregonstate.edu).

We have only used climate projections under the A2 emission scenario because 1) it includes some of the highest CO_2 concentrations and is therefore consistent with actual emissions to date (Raupach et al. 2007, Le Quéré et al. 2009), 2) the A1Fi scenario run results with all the necessary climate variables for the MC1 model have not been made as available as the A2 results, and 3) because the A2 scenario was chosen by the North American Regional Climate Change Assessment Program. We are open to considering other climate projections (e.g., new products based on AR5 results with RCP emission scenarios), but we are somewhat limited in that 1) MC1 requires a full time series of climate data for the

projected future period (e.g., 2000-2070), not just the endpoint of the future period (2060-2070), and 2) MC1 requires maximum and minimum monthly temperature, monthly precipitation and vapor pressure, variables that are not provided by all the climate models.

Lessons learned from current work with regional climate projections

Our initial evaluation of the RegCM3 data has already made us fully aware of the need for translational climate information for this and other RCM projections. Historical simulations from the Southern Rocky Mountains domain of RegCM3 (with NCEP boundary conditions) do not agree well with historical data for the Wind Cave area. Simulated precipitation values are 60% higher than PRISM-generated or Climatic Research Unit (CRU) historical data (Fig. 3). We also found that climate projections from the southern vs. northern Rocky Mountains RegCM3 domains differ where these domains overlap. Working with NCPP would provide us, and others, a means to determine which climate projections are appropriate for what specific region and purpose rather than having to contact the individual modeling teams. NCPP may also provide valuable translational information regarding protocols for transforming climate projection data into usable products for both ecosystem response models and natural resource decision-making.

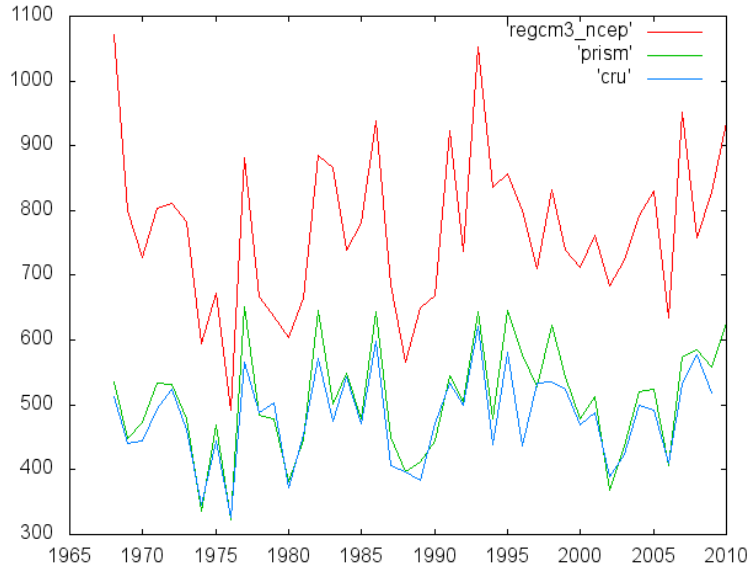

Figure 3. Simulated monthly precipitation (mm) over the state of South Dakota using NCEP-driven RegCM3 regional climate model compared with PRISM generated and CRU historical gridded precipitation data.

Proposed improvements to the Ecosystem Response Model requiring new climate data

One shortcoming of dynamic vegetation model (DVM) projections of climate change effects is their simplistic calculation of potential evapotranspiration (PET), the upper limit on actual evapotranspiration. As in other DVMs, PET in MC1 is based on the standard Penman–Monteith equation, which includes a term involving net radiation, the energy that drives evapotranspiration (Campbell 1977). Because comprehensive, long-term, historical net radiation records are not available (Maurer et al 2002), MC1 uses an empirical relationship between net radiation and temperature derived by Linacre (1977) to estimate the net radiation term. This relationship is liable to change with greenhouse gas forcing (Scheff 2011). While temperature increases with increased greenhouse gas emissions, global net radiation will either show little increase because it is overwhelmingly influenced by incoming solar radiation, or it may even decrease because of increased aerosols in the atmosphere. Consequently, future regional evapotranspiration may be overestimated by using the current net radiation-temperature relationship rather than using net radiation simulated by climate models (Milly and Dunne 2011). Our preliminary work investigating this possibility at Wind Cave illustrates the types of biases that are likely to occur in

the NGP. Annual PET calculated by MC1 based on temperature only was slightly higher than that derived by including RegCM3 net radiation (Hostetler et al. 2011), and there was a noticeable difference in fall vs. spring PET, reflecting the seasonal lag between temperature and radiation (Fig. 4). This means that with the current model configuration we may overestimate drought effects due to projected global warming, a bias that could have substantive consequences for our assessment of woody plant encroachment potential in the NGP. Therefore, this project will use net radiation output from appropriate RCMs to improve projections of future climate effects on tree and grass production in the NGP.

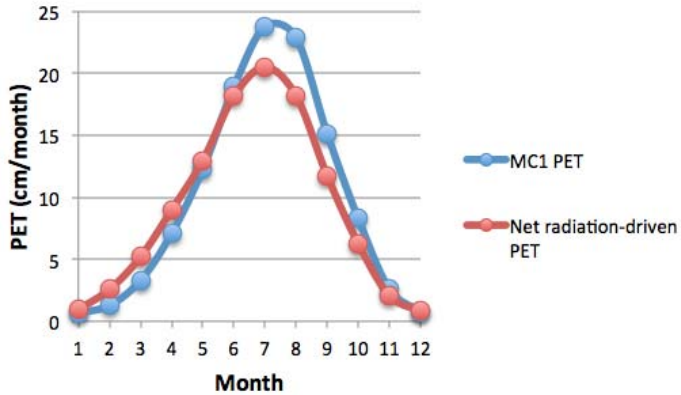

Figure 4. Mean monthly potential evapotranspiration (PET) for Wind Cave National Park predicted by MC1 using monthly minimum and maximum temperatures vs. PET derived by inserting net radiation into the Penman-Monteith equation.

In addition to climate input, MC1 requires annual atmospheric CO_2 concentration, as well as soil depth, texture, bulk density, and rock content. To date we have generated these datasets ourselves (e.g., by converting the vector Soil Survey Geographic Database to a raster format) and have not been concerned with matching the equivalent information used by coarse-scale GCMs. As we start using regional climate model projections with finer spatial scales, we are interested in obtaining the soil information and exact CO_2 concentrations used by the RCMs and hope that NCPP staff could help us identify sources for these data.

Strategy for incorporating translational climate information with our Ecosystem Response Model

Our strategy for incorporating translational climate information in the MC1 ecosystem response model to identify the vulnerability of NGP grasslands to woody encroachment will involve two main components. The **first component** includes working with NCPP staff to identify appropriate RCM projections in the NGP. We expect this process will begin with a face-to-face **workshop** with NCPP staff to clarify overall goals, produce a list of potential RCM projections to evaluate, and discuss the types of translational climate information needed to evaluate these. This process will continue with regular (e.g., monthly) conference calls/WebEx sessions in which we plan to work through the translational issues identified in the initial workshop and others as they arise. A second workshop near the end of the project would focus on developing and documenting a repeatable, standardized procedure for determining appropriate climate data for a given region and purpose. This workshop may include 1-3 participants from land management agencies (e.g., from the Fish & Wildlife Service or National Park Service) or advisors (e.g., Natural Resource Conservation Service or Extension Service) to provide the end-user perspective.

The **second component** includes **customizing and running** MC1 for the NGP region with a woody encroachment focus. Customizing involves refined calibration – comparing simulated current vegetation classes with existing vegetation (e.g., USGS National Land Cover data sets); ensuring simulated grass production matches published, measured values; and using available data to apply appropriate values to parameters such as rooting depth and fuel load partitioning. For example, although MC1 does not work at the species level, we will use parameters characteristic of the woody species most likely to spread into grasslands in the NGP (ponderosa pine, Rocky Mountain juniper, and sagebrush in the west, bur oak and eastern red cedar in the east). We will then run MC1 using the selected RCM projections, a small number

of realistic land management scenarios (e.g., fire suppression, specified prescribed fire regimes, or natural fire coupled with light, moderate, or heavy grazing) selected after consultation with land managers (via the PPP LCC and team member contacts). We will also run MC1 with or without the water use efficiency enhancement of increasing atmospheric CO_2. The primary output of interest will be the spatial distribution of vegetation classes (deciduous and evergreen forest, woodland, or savanna, shrubland, C_3/C_4 grassland) under these different scenarios. Other important output will include fuel loads and the carbon sequestration potential of projected vegetation. Model results will help identify portions of the NGP most susceptible to woody encroachment and severe fires, land management practices that might affect this susceptibility, and the role of rising CO_2 (independent from the climate changes it causes) in projected vegetation changes in the NGP.

Schedule and Anticipated Deliverables

Task	Activity Period	Outcome or Deliverable (bold)
Project begins	August or September 2012 (earliest expected given time needed to finalize contracts)	CESU agreement between USGS Northern Prairie Wildlife Research Center and Oregon State University
Initial NCEP workshop	September 2012	goals, potential projection list, information needs
Customize MC1, build management scenarios, select climate projections	September 2012-April 2013	Final vegetation model, management scenarios and climate projection list
Second NCEP workshop	Spring 2013	**1) Product guiding climate projection selection***
Run MC1, prepare scientific products	May-August 2013	**2) Manuscript submitted to peer-reviewed journal; 3) presentation at Ecological Society of America or other national meeting**
Prepare and deliver outreach products	August 2013 – February 2014	**4) USGS fact sheet (1-2 pages); WebEx presentation to NGP National Park Service and Fish & Wildlife Service units; 5) in-person presentations at Society for Range Management chapter meetings and as other opportunities arise**

*NCPP will complete this product (Andrea Ray, NCPP, pers. comm).

Symstad is a member of the Great Plains Fire Science Exchange, a consortium funded by the Joint Fire Science Program to strengthen ties between fire scientists and those who use fire for land management. This consortium is developing an online resource center, will publish periodic newsletters, and will develop workshops specifically for transferring fire science information to land managers in the Great Plains. We expect to use this consortium to disseminate information from this project.

Bachelet is directly involved in the development and use of Data Basin (www.databasin.org), a mechanism for organizing, publishing, and disseminating spatial datasets and associated information related to conservation. It has been publically available for 17 months and has more than 3,500 registered users. Using datasets housed by Data Basin, users can assemble their own maps and animations to visualize spatial and temporal data relevant to their interest, then download these images or animations, without specialized software or training. At the end of this project (August 2013-February 2014), we will post to Data Basin selected datasets that illustrate the project's most important results and implications. Their availability will be publicized through the outreach products described above.

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Wyckoff, P. H. and R. Bowers. 2010. Response of the prairie-forest border to climate change: impacts of increasing drought may be mitigated by increasing CO_2. Journal of Ecology **98**:197-208.

Project Title: Projecting Future Effects of Land Management, Natural Disturbance, and CO_2 on Woody Encroachment in the Northern Great Plains in a Changing Climate

Data Inputs – Existing Data Collections

1	**PRISM 30arc second**
Description:	Observed monthly historical gridded climate (Tmin, Tmax, PPT, VPR) data for the conterminous USA, at 30 arc-second spatial resolution, provided by Chris Daly and the PRISM Group at Oregon State University for the period 1985-2009. Average monthly values [average minimum monthly temperature (tmin), average maximum monthly temperature (tmax), and average total monthly precipitation (ppt)] for the 1961-1990 period were calculated from the PRISM data to create a historical baseline.
Restrictions:	We recommend other users contact the PRISM group directly to obtain the most recent 30 arc-second climate dataset.

2	**Future Climate Scenarios (GCM-based)**
Description:	The PRISM historical baseline was modified using the delta/anomaly method to generate future climate scenarios at 30 arc-second spatial resolution. Three general circulation models (with all required variables for our vegetation model) were chosen to bracket the range of AR4 scenarios. The CSIRO-MK3.5 model from Australia (T63 grid: 1.875° lat (approx.) x 1.875° lon, model dates from 2001), the Hadley CM3 model from the UK (2.5° lat x 3.75° lon, model dates from 1997) and the MIROC 3.2 medium resolution model from Japan (T42 grid: approx. 2.8125° x 2.8125°), model dates from 2004). We only used the A2 high emission scenario (SRES).
Restrictions:	Publically available upon request.

3	**Future Climate Scenarios (RCM-based)**

Description:	The PRISM historical baseline was modified using the delta/anomaly method to generate future climate scenarios at 30 arc-second spatial resolution. The anomalies for all required variables of our vegetation model were calculated using RegCM3 results with boundary conditions from ECHAM5, GenMOM and GFDL. We only used the A2 high emission scenario (SRES).
Restrictions:	We recommend users contact Steve Hostetler (USGS), swhostet@usgs.gov.

4	**Soils dataset**
Description:	The original soils dataset was created by Jeff Kern (1995) for VEMAP (Vegetation Ecosystem Model Project) and later updated (Kern 2000) based on the available STASGO and SURGO data. The original spatial resolution was 1km. The soils data were aggregated at various scales by the MAPSS team. Data include: texture, % rock fragment, bulk density and soil depth. Kern JS (1995). Geographic patterns of soils water-holding capacity in the contiguous United States. *Soil Science Society of America* 59(4), 1126-1133. Kern JS (2000). Erratum for Geographic patterns of soils water-holding capacity in the contiguous United States. *Soil Science Society of America* 64(1), 382-382.
Restrictions:	Publically available upon request

Data Inputs – New Data Collection

1	**WRFc Regional Climate Projections**
Description:	WRFc future climate projections (36 km x 36 km spatial resolution, monthly averages); higher spatial resolution (27 km, 9 km) proposed but not yet produced
Data Management Budget:	Provided free by current Wind Cave NP project collaborators
Protocols:	We created an account on the UCAR supercomputer to get access to datasets
Quality Checks:	Validation against historic PRISM values. USGS peer-review process.
Exclusive Use:	We recommend direct contact with John Stamm, USGS, for access to the data
Restrictions:	We recommend direct contact with John Stamm, USGS, for access to the data
Contact:	John Stamm, jstamm@usgs.gov

Data Outputs – Deliverables, Datasets and Products

1	**MC1 Model Output**
Description:	MC1 model output
Data Management Budget:	Budget for data storage, data organization and formatting support, backup, replication, and archive represents 21% of the requested funds, included in Ferschweiler's contract.
Format:	NetCDF
Quality Checks:	Validation done via Perl scripts
Exclusive Use:	No exclusions
Restrictions:	Publically available
Contact:	David King, David.A.King@oregonstate.edu

2	**Data Basin Visualization**
Description:	animations, maps, charting time series, and reporting on MC1 model inputs (e.g. http://bit.ly/H4UUoN) and outputs (e.g. http://bit.ly/H51Eaq)
Data Management Budget:	data storage, data organization support, backup, replication, and archive
Format:	databasin.org
Quality Checks:	Software engineers at CBI in charge of site upkeep and tool development
Exclusive Use:	No exclusions
Restrictions:	No restrictions
Contact:	Dominique Bachelet, dominique@consbio.org

3	**MC1 WICA code version**
Description:	C and Fortran code with associated parameter sets
Data Management Budget:	25% of requested funds (included in Ferschweiler's contract), includes storage, programming support, use of publically available Oregon State University - BEE subversion repository, backup, and archive.
Format:	C and Fortran files as well as ascii parameter files
Quality Checks:	Code review; regression tests of periodic releases

Exclusive Use:	Publically available; any new update to code are provided through Google groups for MC1 users and developers
Restrictions:	No restrictions
Contact:	David King, David.A.King@oregonstate.edu; Ken Ferschweiler, ken@consbio.org

Curriculum Vitae – Dominique Bachelet

Conservation Biology Institute, Corvallis, OR
bachelet@fsl.orst.edu / (360) 870-5782

Education

1980-1983	Ph. D.; Colorado State University, Botany and Plant Pathology,
1978-1979	DEA; Université de Paris XI (France), Plant Ecology.
1977-1978	MS; Université de Lille I (France), Plant Biology.

Professional experience

2009-current	Senior Climate Scientist; Conservation Biology Institute.
2007-2008	Director of Climate Change Science, The Nature Conservancy.
1999-current	Associate professor Senior Research, Dept of Bioengineering, Oregon State University
1989-1999	Assistant professor Senior Research, Dept of Bioengineering, Oregon State University

Selected peer-reviewed journal articles

Shaw, M.R., L. Pendleton, D.R. Cameron, B. Morris, D. Bachelet, K. Klausmeyer, J. MacKenzie, D.R. Conklin, G.N. Bratman, J. Lenihan, E. Haunreiter, C. Daly, P.R. Roehrdanz. 2011. The impact of climate change on California's ecosystem services. Climatic Change DOI 10.1007/s10584-011-0313-4.

Rogers, B. M., R. P. Neilson, R. Drapek, J. M. Lenihan, J. R. Wells, D. Bachelet, and B. E. Law. 2011. Impacts of climate change on fire regimes and carbon stocks of the U.S. Pacific Northwest. J. Geophys. Res. 116, G03037, doi:10.1029/2011JG001695.

Wiens, J. and D. Bachelet. 2010. Matching the Multiple Scales of Conservation with the Multiple Scales of Climate Change. Conservation Biology 24(1):51-62.

Allen, C.D., A.K. Macalady, H. Chenchouni, D. Bachelet, Nate McDowell, M. Vennetier, T. Kitzberger, A. Rigling, D.D. Breshears, E.H. Hogg, P. Gonzalez, R. Fensham, Z. Zhang, J. Castro, N. Demidova, J-H Lim, G. Allard, S.W. Running, A. Semerci, N. Cobb. 2010. A Global Overview of Drought and Heat-Induced Tree Mortality Reveals Emerging Climate Change Risks for Forests. Forest Ecology and Management 259:660–684.

Bachelet D., J. Lenihan, R. Drapek, R. Neilson. 2008. VEMAP vs VINCERA: A DGVM sensitivity to differences in climate scenarios. Global and Planetary Change 64:38-48.

Bachelet D., J.M. Lenihan, R. P. Neilson, R.J. Drapek, and T. Kittel. 2005. Simulating the response of natural ecosystems and their fire regimes to climatic variability in Alaska. Canadian Journal of Forest Research 35:2224-2257.

Synergistic Activities

Contributor to 2000 National Assessment: Chapter 17. Potential consequences of climate variability and change for the forests of the United States. In: National Assessment Synthesis Document. 2000. http://www.cgrio.org.NationalAssessment/

Contributor to Intergovernmental Panel on Climate Change (IPCC) Assessment Reports: Chapter 13. Agriculture in a changing climate: impacts and adaptation. In: Watson et al., Climate Change 1995: Impacts, adaptations and mitigation of climate change: scientific-technical analyses. Published for IPCC 1996, Cambridge University Press.

Expert reviewer for 2007 Intergovernmental Panel on Climate Change (IPCC) Working Group II Fourth Assessment Report. http://www.ipcc-wg2.org/

Curriculum Vitae – Ken Ferschweiler

Conservation Biology Institute, Corvallis, OR
ken@consbio.org / (541) 752-0581 x3

Education

1979	BS; University of Portland, Electrical Engineering

Professional experience

2010-current	Senior Architect/Modeler; Conservation Biology Institute.
2008-2010	Principal Architect, iComprehend, Inc.
1997-2005	Technical Coordinator, Northwest Alliance for Computational Science and Engineering, Oregon State University

Selected publications

Ken Ferschweiler, Scott Harrah, Dylan Keon, Mariacarla Calzarossa, Daniele Tessera, and Cherri Pancake, The Tracefile Testbed - A Community Repository for Identifying and Retrieving HPC Performance Data. Proceedings of the International Conference on Parallel Processing, August 2002, pp 177-184.

Ken Ferschweiler, Mariacarla Calzarossa, Daniele Tessera, Dylan Keon and Cherri M. Pancake, "A Community Databank for Performance Tracefiles," in Recent Advances in Parallel Virtual Machine and Message Passing Interface, ed. Y. Cotronis and J. Dongarra, Springer-Verlag, 2001, pp. 233-240.

Activities

Development and application of computer vegetation models. Development of downscaling software and other software for preparation and management of climate and ecological data. Development of cloud-based modeling code.

Development of muli-threaded, scalable client/server image classification system.

Development and implementation of databases and related access tools for management of images and other image-classification data.

Development of collaboratory software to support research in earthquake engineering. Development of database system for maintenance of earthquake test and simulation data.

Work with climate scientists to improve performance, workflows, and user interfaces in use of high-performance computing resources.

Development of software to provide scientists with web access to large scientific databases.

Curriculum Vitae –David King

Biological and Ecological Engineering, Oregon State University, Corvallis, OR
David.A.King@oregonstate.edu

Education

1979 Ph. D.: University of Wisconsin, Madison, Botany (Plant Ecology)
1974 MS: California Institute of Technology, Geology (Geophysics)
1972 BS: University of Wisconsin, River Falls, Physics

Professional Experience

2011-current	Postdoctoral Research Associate, Biological and Ecological Engineering, Oregon State University
2010	Postdoctoral Research Associate, Forest Ecosystems and Society, Oregon State University
2003-2005	Research Fellow, Center for Tropical Forest Science, Harvard University
1994-1997	Research Fellow, Research School of Biological Science, Australian National University
1991-1994	Research Fellow, School of Biological Science, University of New South Wales
1990-1991	Senior Postdoctoral Associate, Smithsonian Tropical Research Institute, Panama
1988-1990	National Geographic funded tropical research
1983-1987	Research Associate Professor, University of Portland
1981-1983	Postdoctoral Associate, University of California, Davis
1979-1981	Postdoctoral Associate, Stanford University

Selected peer-reviewed, model-based publications

King, D. A., D. P. Turner and W. D. Ritts. 2011. Parameterization of a diagnostic carbon cycle model for continental scale application. Remote Sensing of Environment **115**:1653-1664.

King, D. A. 2005. Linking tree form, allocation and growth with an allometrically explicit model. Ecological Modelling **185**:77-91.

Kirschbaum, M. U. F., B. E. Medlyn, D. A. King, S. Pongracic, D. Murty, H. Keith, P. K. Khanna, P. Snowdon and R. J. Raison. 1998. Modelling forest-growth response to increasing CO_2 concentration in relation to various factors affecting nutrient supply. Global Change Biology **4**:23-41.

King, D. A. 1996. A model to evaluate factors controlling growth in *Eucalyptus* plantations of southeastern Australia. Ecological Modelling **87**:181-203.

King, D. A. 1995. Equilibrium analysis of a decomposition and yield model applied to *Pinus radiata* plantations on sites of contrasting fertility. Ecological Modelling **83**:349-358.

King, D. A. 1993. A model analysis of the influence of root and foliage allocation on forest production and competition between trees. Tree Physiology **12**:119-135.

King, D. A. and W. L. Nelson. 1987. Assessing the impacts of soil moisture stress on regional soybean yield and its sensitivity to ozone. Agriculture, Ecosystems & Environment **20**:23-35.

Curriculum Vitae – Amy Symstad

U.S. Geological Survey, Northern Prairie Wildlife Research Center, Hot Springs, SD
asymstad@usgs.gov / (605) 745-1191

Education

1998	Ph. D.; University of Minnesota, Ecology
1992	B.S.; Massachusetts Institute of Technology, Environmental Engineering Science

Professional experience

2003-current	Research Ecologist, USGS Northern Prairie Wildlife Research Center
2001-2003	Prairie Restoration Ecologist (Associate Research Scientist), Illinois Natural History Survey
1998-2001	Prairie Restoration Ecologist (Assistant Research Scientist), Illinois Natural History Survey

Selected peer-reviewed publications

Symstad, A. J. and J. L. Jonas. 2011. Incorporating biodiversity into rangeland health: Plant species richness and diversity in Great Plains grasslands. Rangeland Ecology & Management **64**:555-572.

Symstad, A. J., R. A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2011. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network: Version 1.00. Natural Resource Report NPS/NRPC/NRR--2011/291, National Park Service, Fort Collins, CO.

Jackson, L., T. Rosenstock, M. Thomas, J. Wright, and A. Symstad. 2009. Managed ecosystems: biodiversity and ecosystem functions in landscapes modified by human use. Pages 178-194 *in* S. Naeem, D. E. Bunker, A. Hector, M. Loreau, and C. Perrings, editors. Biodiversity, Ecosystem Functioning, and Human Wellbeing: An Ecological and Economic Perspective. Oxford University Press, New York.

Brown, P. M., C. L. Wienk, and A. J. Symstad. 2008. Fire and forest history at Mount Rushmore. Ecological Applications **18**:1984-1999.

Synergistic Activities

Keynote Speaker: Bridging Boundaries: Adaptation Planning for Grasslands and Forests in the Black Hills and Plains, April 20-21, 2011, Rapid City, SD

Project Lead for "Quantitative Forecasting of Above-and Belowground Climate Change Impacts at Wind Cave National Park": Three-year research project funded by the National Park Service Climate Change Response Program to provide quantitative projections of climate, streamflow, cave lake level, and ecosystem functioning, under various management scenarios, for Wind Cave National Park.

Co-Investigator on "Karst and climate change: Understanding linkages between climate, water resources, and ecosystems": Four-year research project funded by the USGS Central Region Integrated Science Program assessing the vulnerability of plant and animal species associated with karst-influenced water resources in the Madison (Black Hills, SD & WY) and Edwards (TX) aquifers.

Core Team Member, Wind Cave National Park and Assateague Island National Seashore Scenario Planning for Park Management in a Changing Climate: Served as vegetation subject expert and Wind Cave NP coordinator for scenario planning workshop, April 28-29, 2009, Denver, CO.

Principle Investigator for "Develop Vegetation Component of National Park Service's Northern Great Plains Inventory and Monitoring Network's Vital Signs Monitoring Plan": Worked with resource managers in 11 NPS units, as well as quantitative ecologists and fire ecologists, to design and write the long-term monitoring protocol for vegetation composition and structure now being used in these parks.