Climate Science Connections to Vulnerability Assessments Project Proposal

Project Title: The value of climate information for supporting management decisions within the Plains and Prairie Potholes LCC

Principal Investigators:

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Introduction

Climate scientists often develop models to predict how climate may change in an effort to inform other models that predict how these changes may impact conservation targets. However, these models are not often translated into information that is accessible and useful for land managers and conservation decision-makers. Climate scientists need better information about what climate information is desired by decision-makers so that their outputs will more effectively meet decision-maker information needs; and conversely, decision-makers need better information about how a changing climate may affect their management alternatives and conservation objectives. Land managers within the Plains and Prairie Potholes Landscape Conservation Cooperative (PPP-LCC) must make complex decisions that impact multiple conservation objectives in the face of considerable uncertainty. Thus, members of the PPP-LCC need decision-relevant information about how climate will change and how these changes will affect their conservation objectives. These needs can be met by the North Central Climate Science Center (NC CSC) and the NOAA Climate Prediction and Projection Pilot Platform (NCPP). The objectives of this project are to (1) build connections between the PPP-LCC, the NC CSC, and the NCPP to facilitate a link between the end users and the producers of climate information, as well as to identify gaps between available and desired information, and (2) develop an understandable and transportable framework that will enable the PPP-LCC to prioritize their climate science needs and articulate those needs to the NC CSC and the NCPP.

We propose to use a decision analysis process to bring together members of the PPP-LCC and climate experts from the NC CSC and the NCPP to develop an integrated conceptual model of the interactions between climate change, land use change, and conservation and adaptation in the Plains and Prairie Potholes (PPR) region of the PPP-LCC. Land use change (e.g. oil and gas development, wind energy development, and the Farm Bill) is one of the prevailing issues in the PPR region and carries considerable risk and uncertainty for decision makers in the region, which is only exacerbated by climate change. As climate changes, human systems also change, and in turn, affect local land use patterns. Conservation and habitat management decisions in the region must be guided by both conservation objectives for species and landscapes and by social and economic objectives. Our model will articulate relationships, interactions, and uncertainties between socioeconomic and ecological systems in the PPR and how they are impacted by climate change. Climate prediction and response models predominately focus on physical and ecologic changes. By relating climate uncertainties to the prevailing land use and socioeconomic issues in the region, our model will produce a framework that will enable climate scientists to (1) guide the PPP-LCC toward currently available climate information and present this information in a way that will be useful to decision makers within the LCC, and (2) design future research to address remaining key uncertainties affecting conservation decisions in the region.

Climate in the Pothole Region of the PPP-LCC

Despite considerable uncertainty about the impact of climate on management objectives, partners within the PPP-LCC are well aware that climate drives the dynamics of ecosystems within the region. Millett et al. (2009) characterized both the spatial and temporal patterns of climate in this region during the twentieth century. They showed an increase in precipitation moving west to east across the region, as well as an increase in temperature moving from north to south. They also showed that the precipitation gradient steepened over time, leaving the

western portion of the region warmer and drier and the eastern portion warmer and wetter. An increase in temperature without a consequent increase in precipitation is likely to lead to a decrease in the number of palustrine wetlands in the western portion of the region (Johnson et al. 2005). Likewise, an increased frequency of both drought and deluge are expected that could have drastic impacts on wetland hydrology (Johnson et al. 2004). Precipitation has been shown to be positively correlated with waterfowl abundance in this region (Forcey et al. 2011). Additionally, altered hydrologic cycles are expected to result in a loss of wetland resilience (Johnson et al. 2010), which could have stark negative population level impacts on representative species, such as waterbirds (Sorenson et al. 1998). However, the potential impacts of climate change on these systems are extremely uncertain. This uncertainty is at least partially driven by the complex way climate interacts with resources of interest. For instance, within grasslands associated with the PPR, drought conditions can lead to decreased productivity, which can subsequently lead to lower bird abundance (George et al. 1992). But some of this uncertainty can also be driven by societal reactions to climate. During drought conditions, landowners may also take grasslands that are normally enrolled in conservation programs and hay or graze them, which could also impact grassland dependent species (Niemuth et al. 2008). Similarly, for wetlands, land use decisions, such as wetland consolidation, may have impacts on wetland hydrology that might confound climate effects (Anteau 2012).

Workshop and modeling

To being building our integrated conceptual model, we will hold a workshop to define management goals and objectives, develop alternative decisions linked to those objectives, and identify uncertainties that are key barriers to assessing the impact of decisions on management objectives. The key participants invited to this workshop will be 5-10 members of the PPP-LCC technical committee that work most closely with land use decisions, subject matter experts such as agriculture economists and a climate expert from NCPP and other experts from the NC CSC university consortium as needed.

We will use techniques from multi-objective decision analysis (e.g. Keeney and Gregory 2002) to clearly identify the key elements of the decisions made by LCC partners. We will hold the workshop over three days, with the first day focusing on identifying and structuring management objectives and decisions. On the second day we will build a conceptual model for identifying and structuring the uncertainties that most strongly impact decisions. On the third day we will begin the process of building a quantifiable version of our conceptual model, which will require that we utilize the climate and other technical experts invited to the workshop. Further refinements of the model will be made at future workshops or in small working groups as needed.

We will build a quantitative version of our conceptual model using the software Netica (Norsys 2003). Netica allows users to build Bayesian network models in an intuitive graphical format that can be used to express causal relationships between sets of variables (called “nodes”) in a decision problem (Marcot et al. 2001). For each node, a user typically specifies states that correspond to levels of a variable. Thus, nodes can be discrete or continuous. Users can also inform these states with data, an underlying probability model, or with expert belief. The causal relationships between nodes are expressed with arrows. States for nodes that accept input (“children”) from other nodes (“parents”) are updated via conditional probability distributions. That is, these distributions represent parametric uncertainty about the states of a node

conditioned on the other nodes connected to it. This format is particularly well suited for dealing with situations when one must rely on expert opinion about potential relationships. Figure 1 shows an example of a Bayesian network model for a habitat acquisition decision that could be impacted by future climate change and land use decisions of private land owners.

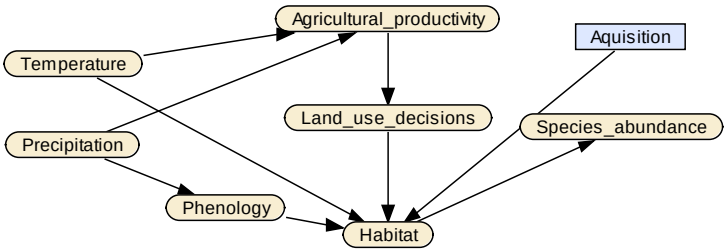

Figure 1. Bayesian belief network for an acquisition decision (blue node). The value of this decision is measured in terms of how well it meets a species abundance objective or target. The remaining nodes represent a response model that predicts changes in species abundance as a function of habitat, which is in turn impacted by land use and climate change.

This model is grossly simplified and is for demonstration only. In practice, such models often have multiple objectives that must be traded off with one another. The objective of our example model is to maximize an abundance target for a species of conservation concern (species abundance node) by choosing the appropriate acquisition decision. However, the effectiveness of this decision is influenced by possible climate change (temperature and precipitation nodes) both directly and indirectly. In the direct case, climate change could impact plant phenology, leading to a change in habitat quality. In the indirect case, climate change may impact the quality of agricultural land, which might influence land owners to change production strategies. This could also lead to a change in habitat quality. This model would then allow us to predict changes in species abundance as a function of climate variables, socio-economic responses to climate and more direct impacts of climate on habitat quality. In that sense, the model above is similar to a linear statistical model, such as a Generalized Linear Model, except that it is described graphically. Another key difference between this type of model and a linear statistical model is that the former is directly linked to a decision. Thus, the predictions about species abundance can be used to compare how different decisions perform under parametric uncertainty about climate change.

By linking this type of model with explicit decisions, we can also compare how uncertainty about model structures influence decision-making. Consider that the model in Figure 1 may only represent one possible set of causal relationships between habitat, species and climate change. Another model might have a causal link between the climate variables, a process such as hydrology and then phenology. Both parametric and model uncertainties are integral parts of model analysis. But when linked with decision outcomes, these uncertainties provide us with an opportunity to compare how valuable certain parameters or models are in the decision making process. That is, we can prioritize how important a particular set of uncertainties are by measuring how sensitive a decision outcome is to reducing those uncertainties.

Within the field of decision theory, this kind of sensitivity analysis is typically referred to as value of information (VOI) analysis (Clemen and Reilly 2001). VOI analyses operate by comparing outcomes from different decisions both with and without necessary information. The degree of improvement in the outcome of a decision with information is the value of that information. We will utilize two VOI methods from classical decision theory, the expected value

of perfect information (EVPI) and the expected value of partial information (partial EVPI) to quantify the value of focusing on specific climate uncertainties to management decisions in the PPP-LCC. We should point out that this analysis is not really meant to reflect the case where perfect information can actually be collected. It is simply meant as a type of sensitivity analysis. With that said, an alternative calculation that we will consider is the expected value of imperfect information (EVII), which considers the quality and variability of information in the analysis.

EVPI is typically used to prioritize which uncertainties one should focus on reducing. Calculating EVPI requires a set of alternative predictive models, predictions of the outcome of decisions under each model, and a priori weights (or probabilities) that each of the alternative models are the true model (Runge et al. 2011). Partial EVPI can then be used to compare the expected value of reducing subsets of the structural and parametric uncertainty (Runge et al, 2011). For example, partial EVPI could be used to determine if it is more important to reduce uncertainty about how forecasted precipitation will impact land use decisions or plant phenology. A significant portion of our work in the workshop will be focused on developing these alternative models and eliciting the model weights from the participants.

Anticipated Deliverables and Schedule

We will produce a model that can be used and updated repeatedly into the future. Additionally, we will submit at least one peer-reviewed publication to a journal such as Biological Conservation. Finally, we will produce a report to the NC CSC describing our main findings and the expected interface between the PPP-LCC and the NC CSC. This report will serve as a planning document outlining the main science needs of the PPP-LCC with regard to climate information. Below is our proposed schedule:

July 2012 – Plan the first workshop

September or October 2012 – Hold the first workshop

December 2012 – Complete the first model prototype working with NCPP and NC CSC

February 2013 – Present model to PPP-LCC technical committee and NC CSC staff; Refine the model if needed

April 2013 – Submit report on climate science needs to NC CSC

June 2013 – Submit journal publication(s)

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Data Management Plan

Project Title: The value of climate information for supporting management decisions within the Plains and Prairie Potholes LCC.

Data Inputs – Existing Data Collections

1	Daymet
Description:	Daily climate metrics for North America (US, Canada, Mexico)
Restrictions:	None. Distributed by Oak Ridge National Lab

2	PRISM climate group
Description:	4 km monthly data for continental US
Restrictions:	None. Distributed by PRISM Climate Group (www.prism.oregonstate.edu)

3	IPCC4 datasets
Description:	To be determined with input from NCPP
Restrictions:	None that we know of. Distributed by WorldClim (www.worldclim.org)

Data Inputs – New Data Collection

No new collections will be developed.

Data Outputs – Deliverables, Datasets and Products

1	Bayesian Network Models
Description:	Bayesian Belief Network Model (Expert Model)
Data Management Budget:	50% of overall project budget is dedicated to developing these models, refining and storing them
Format:	.neta
Quality Checks:	Performed via group review
Exclusive Use:	No exclusions
Restrictions:	No restrictions
Contact:	Max Post van der Burg, maxpostvanderburg@usgs.gov

MAX POST VAN DER BURG

Research Ecologist, USGS Northern Prairie Wildlife Research Center

BACKGROUND

Max Post van der Burg is a quantitative ecologist with experience working with complex wildlife management problems that require sophisticated modeling approaches, decision theory and uncertainty analysis. His research employs a wide range of modeling approaches including numerical optimization, frequentist and Bayesian analysis, spatial statistics, classical and statistical decision theory and information-gap decision theory. He has participated as a consultant in the Structured Decision Making workshops at the National Conservation Training Center and currently works with the Plains and Prairie Potholes Landscape Conservation Cooperative to lend technical support to their science and information needs.

EDUCATION

Ph.D. in Applied Ecology, 2008, University of Nebraska- Lincoln
M.S. in Natural Resource Science, 2005, University of Nebraska- Lincoln
B.A. in Anthropology and Sociology, 2000, University of Maine at Farmington

CURRENT POSITION

Research Ecologist, USGS Northern Prairie Wildlife Research Center
8711 37th Street Southeast, Jamestown, North Dakota 58401, April 2011–present

SELECTED PUBLICATIONS

Post van der Burg, M., B.L. Bly, T. VerCauteren and A.J. Tyre. 2011. Making better sense of monitoring data from low density species using a spatially explicit modeling approach. Journal of Applied Ecology 48: 47–55.

Post van der Burg, M. and A.J. Tyre. 2011. Integrating information-gap decision theory with robust population management: a case study using mountain plovers. Ecological Applications 21(1): 303-312.

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CATHERINE M. CULLINANE THOMAS

Economist, Policy Analysis and Science Assistance Branch, USGS Fort Collins Science Center

BACKGROUND

Catherine Thomas is an economist with the Policy Analysis and Science Assistance Branch of the U.S. Geological survey. Catherine specializes in the fields of natural resource economics and decision analysis, and her work with the USGS includes analyzing the economic impacts of management alternatives on public lands for Fish and Wildlife Service Comprehensive Conservation Plans (CCPs) and for the Secretary of the Interior's annual report on the economic contribution of Department of Interior lands and programs. Catherine also has experience developing bioeconomic models and decision tools to address complex land management and natural resource decisions and to address the spread and control of invasive species, and has worked with federal partners to lead decision analysis workshops and trainings. She was a facilitator for the Western Alaska LCC State of the Science Workshop and is working with the Fish and Wildlife Service National Conservation Training Center as an instructor for their Structured Decision Making courses.

EDUCATION

Master of Science in Natural Resource Economics, May 2010, Colorado State University
Bachelor of Science in Mathematics and Statistics, December 2003, Colorado State University

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August 2010–present

AWARDS

Western Agricultural Economics Association: Outstanding Master's Thesis Award, 2011

SELECTED PUBLICATIONS

Thomas, C., C. Bond, and C. Goemans. 2010. The Costs and Benefits of Preventative Management for Zebra and Quagga Mussels. Colorado Water 27(5). 10-15.

Thomas, C. 2010. A Cost-Benefit Analysis of Preventative Management for Zebra and Quagga Mussels in the Colorado-Big Thompson System (Master's thesis). Available from Colorado State University Digital Repository (http://hdl.handle.net/10217/39343).

Thomas, C.M., C. Huber, W. Gascoigne, and L. Koontz. 2012. Socioeconomic Issues for the Bear River Watershed Conservation Area Land Protection Plan: US Geological Survey Open-file report 2012-1039. 15 p.

TRACY R. HOLCOMBE

Ecologist, Invasive Species Science Branch, USGS Fort Collins Science Center

BACKGROUND

Tracy Holcombe is an Ecologist with the United States Geological Survey in Fort Collins, CO. She studies distribution modeling with a focus on invasive organisms. Her PhD research focused on distribution models of invasive plants, and examined the potential change in their distributions with climate change.

Holcombe's recent research on the spread of buffelgrass (*Pennisetum ciliare*) in Arizona using decision support models has earned the Partners in Conservation Award from DOI. A focus of this research has been on resource allocation between inventory, treatment and maintenance.

EDUCATION & TRAINING

Ph.D., Ecology, 2009, Colorado State University, Ft. Collins, CO
MS, Forestry, 2006, Colorado State University, Ft. Collins, CO
Interdisciplinary Graduate Certificate in Geospatial Science, 2004, CSU, Fort Collins, CO
Bachelor of Arts, Biology, 1998, Augustana College, Rock Island, IL

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AWARDS

DOI Partners in Conservation Award. 2011. Decision Support System for Southern Arizona Buffelgrass Coordination Center.

SELECTED PUBLICATIONS

Frid, L., **T. Holcombe**, J. T. Morisette, A. D. Olsson, L. Brigham, T. M. Bean, J. L. Betancourt, and K. Bryan. (provisionally accepted). Using state and transition modeling to account for imperfect knowledge in invasive species management. Invasive Plant Science and Management.

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