Integrating Expert Knowledge into a Model of Land Cover Change: a Case Study from Michigan’s Upper Peninsula

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Motivation
Landscape scenario analysis provides a way to visualize and compare the outcomes of a variety of management strategies and to develop more resilient conservation policies when faced with the irreducible uncertainty associated with changing climate, ecosystem, and socioeconomic conditions (Peterson et al., 2003; Nassauer and Conn, 2004).

We demonstrate the elicitation and integration of expert knowledge to develop, model, and analyze scenarios of landscape change in a collaborative project by the Wisconsin and Michigan Chapters of The Nature Conservancy (TNC) and landscape ecologists at the University of Wisconsin at Madison. This project aims to evaluate the effectiveness of various conservation strategies under conditions of climate change and demand for woody biomass for energy production.

Expert knowledge was infused into the scenario-building and modeling process (Fig. 2) in three key ways: (1) scenario development, (2) model parameterization, and (3) spatial narrative building. A variety of methods was utilized at each of these stages, including in-person workshops with local experts, web-based workshops with regional experts, one-on-one interviews, and an online collaborative tool.

Approach

- **Scenario Development**
  - We developed exploratory scenarios (Carpenter et al., 2006; Gustafson and Crow 2006; Mahmoud et al. 2009; Peterson et al. 2003) in collaboration with local experts in an in-person workshop at the study location (Fig. 2, Workshop 1; Fig. 4).
  - Experts at this workshop included forestry practitioners, land managers from timber operations and the Department of Natural Resources, and academic and agency scientists (Fig. 3).
  - Figure 4. Workshop participants were asked to identify the most important climate variables to consider and management strategies that might be applied in this landscape, and to assess the demand for woody biomass for energy production in the area. Then, they were asked how each of these three components might influence forest dynamics in the study area.

- **Model Parameterization**
  - To define model parameters (Table 1), including ecological pathways of disturbance and succession, influences of projected climate variables and resource demand, and management strategies, we gathered information from local and regional experts in two web-based workshops and a series of one-on-one interactions (Fig. 2, Workshop 2).
  - Although these parameters are based on the principles of forest and landscape ecology, expert knowledge of local and regional dynamics was crucial to capture the details and interactions of disturbance, succession, and management for each scenario.

- **Landscape Scenarios**
  - Landscape scenarios were modeled using the VDDT, TELSA modeling suite (ESSA Technologies Ltd., 2010). State and transition models for each land cover type were developed in VDDT (based on existing LANDFIRE models, LANDFIRE 2007, TNC 2009) and combined with current land cover data in TELSA to generate spatially explicit maps of possible land cover 25, 50, 75, and 100 years into the future.

- **Spatial narrative building**
  - Figures 1 and 5. Simulated land cover maps for each scenario were presented to stakeholders to evaluate the effectiveness of each conservation strategy at protecting biodiversity and ecosystem services targets in the study area.

- **Selection of Experts**
  - The benefits and considerations associated with each method of expert knowledge elicitation employed at each stage of the project are shown below (Table 2). Given the varied types of expert input required in collaborative scenario development and modeling, we anticipate an approach utilizing multiple modes of interaction will be most effective. Carefully planned interactions with experts, combined adaptability and a willingness to follow unexpected leads, can provide a more thorough understanding of the implications of conservation actions.

- **Model parameterization**
  - Multiple workshops for model parameterization
  - Participation is limited
  - Requires access to and comfort with web conference technology
  - Best following in-person interaction

- **Online collaborative tool**
  - Significant time for startup and maintenance, perhaps third-party assistance
  - Maintaining expert participation is challenging
  - Best as supplement to other elicitation modes

- **Selection of Experts**
  - Site visits and coordination with stakeholders
  - Local knowledge base and affiliation with the agencies and organizations responsible for managing the study area.
  - Regional experts: Academic and agency scientists involved in regional forest management and monitoring.
  - Stakeholders: Landowners or others with a local, non-professional land interest.

- **Narrative Building**
  - Simulated land cover maps (Fig. 5) and summary statistics alone do not provide a complete description of the possible future conditions resulting from each scenario. Therefore, a second in-person workshop (Fig. 1, Workshop 3) was held in which experts worked with the project team to build spatial narratives, or storylines, around the projected landscape futures. These narratives describe hypothesized human-ecological dynamics behind the simulated landscape change (Silbernagel et al., 2006).
  - Experts helped distinguish plausible from implausible scenarios and identified the most likely origin of implausible results. In this way, expert input from Workshop 3 guided model revisions to produce more realistic simulations of possible future landscapes.
  - An online collaborative tool, Data Basin, by the Conservation Biology Institute, was used to share spatial and non-spatial data with experts outside of scheduled interactions. With this tool, experts could review model inputs and interactively map results without the need for GIS experience or software.

- **References**

This research was supported by the NSF IGERT Fellowship Program, the Doris Duke Conservation Fellowship Program sponsored by the Doris Duke Charitable Foundation; The Nature Conservancy’s Rodney Johnson and Katherine Ordway Grant, the USDA Forest Service State and Private Forestry Redesign, and the University of Wisconsin at Madison.

**Figure 1.** Local experts and conservation practitioners showing researchers around the study area during an in-person workshop.

**Figure 2.** A flow chart illustrating the collaborative scenario-building and landscape modeling approach.

**Figure 3.** Experts involved in scenario development and modeling can be divided into stakeholders, practitioners, and academic and agency scientists, separable by the scale at which they understand the landscape and the level of their management responsibility.

- Local experts: Practitioners with local knowledge base and affiliation with the agencies and organizations responsible for managing the study area.
- Regional experts: Academic and agency scientists involved in regional forest management and monitoring.
- Stakeholders: Landowners or others with a local, non-professional land interest.

**Figure 4.** Experts were asked how each of these three components might influence forest dynamics in the study area.

**Table 1.** Parameters incorporated into each component of the modeling interface.

**Table 2.** Benefits and considerations associated with each method of expert knowledge elicitation.