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Human dimensions of state-and-transition simulation model applications to support decisions in wildland fire management

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Abstract:
The State-and-Transition Simulation Model (STSM) is a common tool used for supporting land management decisions. While the modeling algorithms and software tools for STSMs are relatively simple and easy to use, there are some key components to the model building process that are critical to its success in supporting decisions. In this paper, we use a case study from the Bodie Hills in California to illustrate the human dimensions of applying a STSM to support decision-making. The goal of the Bodie Hills project was to work with stakeholders to develop a scientifically based resource management plan acceptable to all parties that would reduce fire danger to communities and protect and enhance the ecological integrity of the area while maintaining livelihoods (Provencher et al. 2009, Low et al. 2010). STSMs provided a scientific framework to inform and guide vegetation management projects in the area.

A STSM provides a framework for representing vegetation dynamics over time. States (e.g. succession stages) and transitions (e.g. disturbances or management actions) among them are defined for an ecosystem and assigned rates (probability per time step) and effects (Figure 1). A simulation applies these inputs and returns outputs such as the percent of the landscape in a state over time and the rate of transitions. Modeling tools, such as the Vegetation Dynamics Development Tool (VDDT; ESSA Technologies Ltd. 2007) and Path Landscape Tool (Daniel and Frid in press, Daniel and Frid 2012) offer a structured environment for creating STSMs, which can be used to engage both specialists and lay people in vegetation management planning activities, such as the Bodie Hills project.

The 188,946-acre Bodie Hills project area north of Mono Lake in eastern California is a largely undeveloped landscape managed primarily by the U.S. Department of the Interior Bureau of Land Management (BLM) and private landowners (Figure 2). This landscape includes a diversity of Great Basin ecosystems and one of the largest bi-state populations of the Greater Sage-grouse. Major fires and invasive species have not yet overtaken the sagebrush ecosystems as they have done elsewhere in the Great Basin.

In 2007, following successful litigation of a proposed fuel hazard reduction project, the BLM Bishop Field Office partnered with The Nature Conservancy in Nevada to initiate a science-based planning process (Figure 3) that would involve interested stakeholders and lead to a more robust planning document to guide management for the area. The resulting planning process took approximately 18 months and relied on three primary inputs:

1. STSMs built with the VDDT software by LANDFIRE (LANDFIRE 2012) and modified with local knowledge and data;
2. Spatial data representing potential vegetation types (i.e. Ecological Systems) and their current vegetation classes mapped from satellite imagery; and
3. Stakeholder input to refine models and maps, and to generate management scenarios.

Initial mapping and modeling efforts were conducted by The Nature Conservancy and BLM prior to a series of three stakeholder workshops. Stakeholder workshops were used to review and refine the maps and STSMs, define management goals, review findings and identify potential vegetation management scenarios. Following the workshops, models were run and results were statistically analyzed and compiled in a final report (Provencher et al. 2009).

Based on our experience in the Bodie Hills and elsewhere, we found that a successful STSM application must meet the following criteria:

1. include enabling regulatory, economic, or social conditions that bring diverse stakeholders together,
2. involve a skilled facilitator, ecological experts, local land managers, decision makers, modeling experts and, sometimes, past litigants,
3. have access to maps and local ecological knowledge accurate enough to meet anticipated management objectives,
4. undergo a series of workshops that define management concerns, objectives, management alternatives, available resources and involve stakeholders in the development and testing of STSMs representing alternative management scenarios,
5. report results that directly support regulatory processes of implementation, especially the National Environmental Policy Act (NEPA),
6. implement and monitor management actions.

Challenges of STSMs include uncertainty in model inputs, maintaining a level of model complexity appropriate for achieving the modeling objectives, multiple and conflicting objectives, and disagreement and lack of cooperation between stakeholders. Using STSMs as a framework for planning helps meet some of these challenges by allowing for sensitivity analysis to test model inputs and to explore potential outcomes of alternative management scenarios.

Facilitation is the key to resolving disagreement between stakeholders on general land management objectives.

In the Bodie Hills, the successful application of STSMs led to development of a cost-effective natural resources conservation plan (Provencher et al. 2009, Low et al. 2010), NEPA-compliant documentation and completion of monitored restoration projects on private lands important to Greater Sage-grouse. The planning process initiated at the Bodie Hills is now called Landscape Conservation Forecasting™ (previously Enhanced Conservation Action Planning in Low et al. 2010) and has been replicated on 13 other landscapes including lands managed by the BLM, U.S. Department of the Interior National Park Service and the U.S. Department of Agriculture Forest Service.

Fig. 1. A State-and-Transition Simulation Model (STSM) represents a given ecosystem using states and transitions between them. This STSM model diagram generated in the Vegetation Dynamics Development Tool depicts states (or succession stages) with a green box, deterministic (or succession) transitions with a green arrow and probabilistic (or disturbance) transitions with a blue arrow. Each state has an age range shown in the center of the box and each transition has an associated probability, which is not shown.

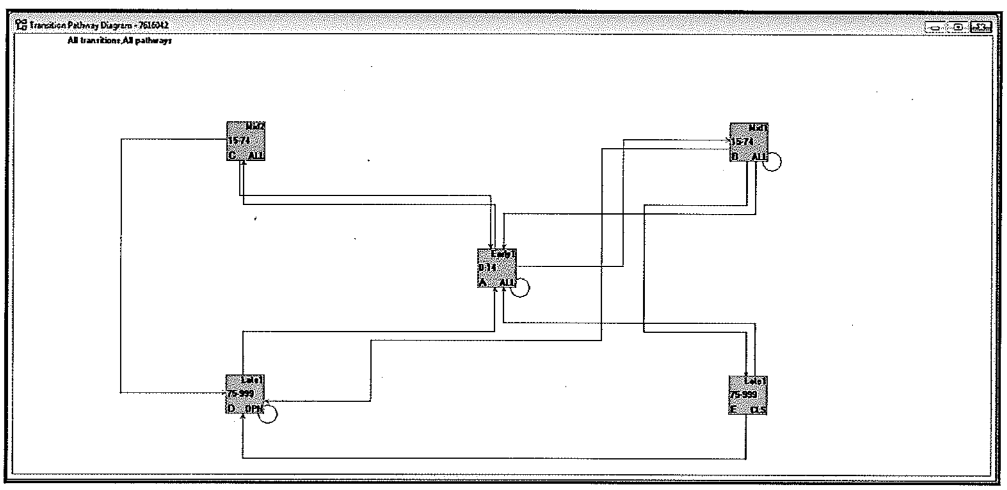

Fig. 2. The 188,946-acre, Bodie Hills study area in eastern California included land managed by the Bureau of Land Management, private land-owners and the State of California.

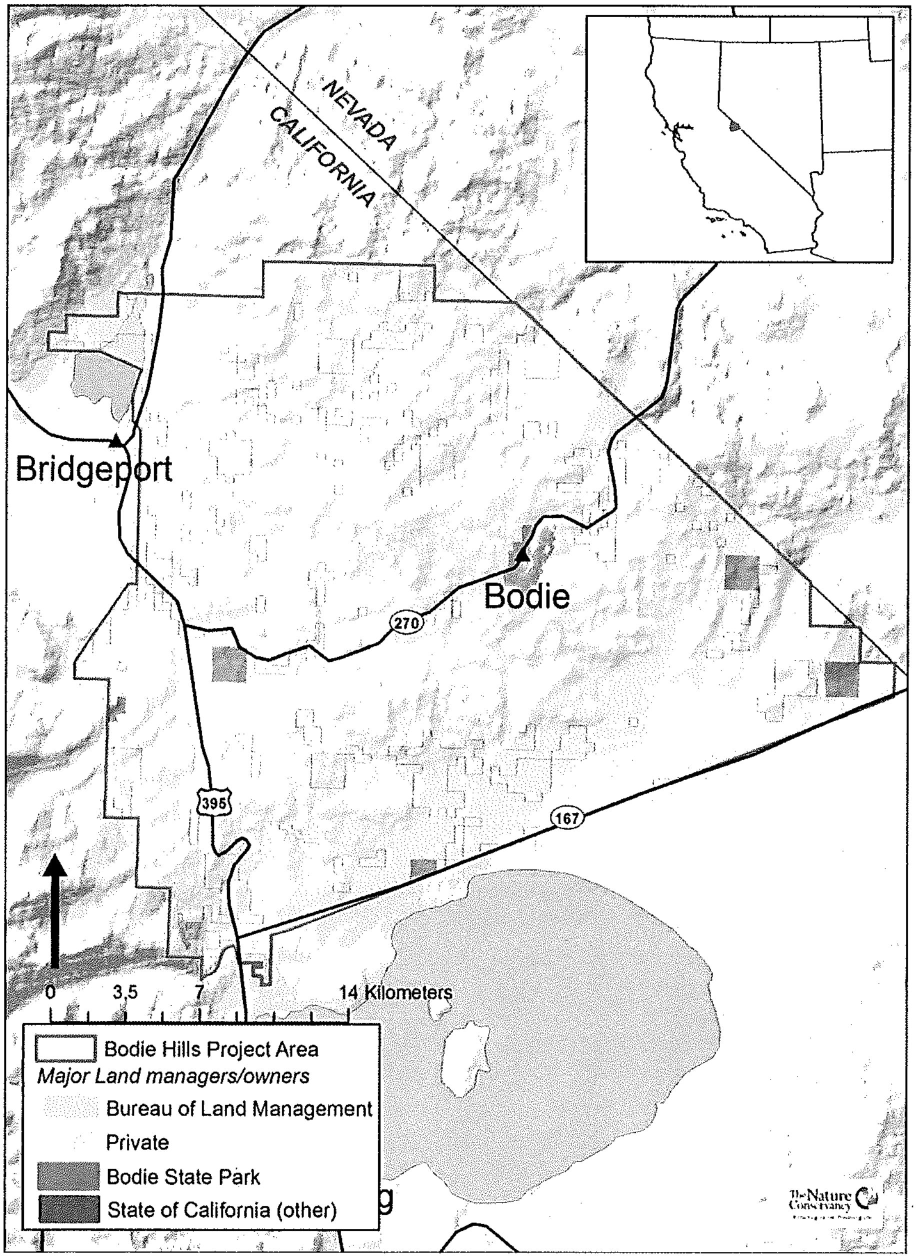

Fig. 3. The Bodie Hills Project planning process involved development of maps and models, a series of stakeholder workshops and statistical analysis of modeling results. Figure modified from Low et al. 2010, Figure 2, page 42.

Pre-Workshops: Mapping & Assessment of Ecological Condition
October 2007-February 2008 -- by The Nature Conservancy and BLM, prior to 1st workshop
- Obtained satellite imagery; conducted remote sensing
- Obtained and refined state-and-transition ecological models
- Mapped biophysical settings
- Compared current vegetation classes with biophysical settings and calculated departure from natural range of variability

Stakeholder Workshop II –Future Threats & Initial Strategies
May 2008
- Determined key conservation and restoration objectives
- Used computer simulations to identify ecosystems likely to suffer future impairment
- Selected focal ecosystems for treatment
- Developed initial conservation strategies and estimated costs
- Developed management scenarios to be tested for each ecosystem

Stakeholder Workshop I – Current Condition & Ecological Models
March 2008
- Reviewed ecological systems and refined vegetation classes
- Reviewed each ecosystem's current condition using ecological departure metric
- Reviewed and further refined state-and-transition ecological models

Stakeholder Workshop III – Outcomes of Management Scenarios
June 2008
- Reviewed 20-year outcomes of computer simulations for each management scenario
- Refined management scenarios, emphasizing high ecological returns for low cost

Post Workshops: Statistical and Cost-Benefit Analyses
Fall 2008
- Statistically evaluated modeling results
- Applied return-on-investment metrics to evaluate scenarios

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