Chapter 6: Summary and Conclusions

By Andrea Woodward, S.P. Finn, and D.M. Miller

The goal of GBILM is to develop landscape monitoring approaches, including methods for monitoring environmental stressors and responses at the landscape level, and methods for scaling from plot-level data collected by land managers to larger spatial extents to describe cumulative effects. The need for a landscape approach primarily stems from the increasing impact from regional and global stressors (such as climate change, water withdrawal, invasive plant species, and air pollution), which affects areas larger than those under the authority of individual land managers. In addition, anthropogenic stressors (such as urbanization, off highway vehicle use, land treatments, and wildfire) that often are considered to be local are becoming more numerous and pervasive such that their aggregated impacts affect broad regions. Stressor effects accumulate and interact with each other in complex fashions that require understanding and assessment at the landscape level. For example, responses of biota to environmental change depend on inherent biophysical potential, in addition to past and current conditions of the individual sites and surroundings, and the responses may be directly and indirectly related to stressors. Streamflow, soil erosion, and water temperature in springs also respond to local and regional stressors and in turn drive changes in biota. In particular, changes in the Great Basin are threatening extinction of species whose habitat requirements span multiple management jurisdictions and require a landscape perspective for effective protection. The highly varied topography, strong climate gradients, and effective isolation of many biotic zones in the Great Basin compound these challenges and make the design of monitoring systems difficult.

Land managers often are charged with conserving environments within well-defined spatial and temporal bounds even though natural processes and disturbance regimes extend beyond those boundaries. Jurisdictional boundaries and duration-specific resource management plans place somewhat arbitrary hindrances on fully understanding and managing resources experiencing multiple interactions ranging from short-term and site-specific to long-term and regional. Our landscape perspective provides managers with perspectives and conceptual tools for evaluating external and antecedent inputs into their system of interest and applying landscape-context management principles to local resources. Furthermore, the conceptual models in this report can help land managers understand how individual management actions interact with one another and how these interactions may lead to the emergence of impacts unlike those of single actions.

Conceptual models should be the foundation for all products GBILM aims to provide to land managers. Fundamentally, conceptual models describe the most salient components of ecosystems and the interactions among them. They express current understanding and hypotheses regarding system function, by integrating information from disparate sources including research results and expert opinion and experience. They facilitate communication to create agreement on, and common vision of, the system in question. Having a common perception insures that land managers, researchers, and other interested parties agree on the important components and processes related to the issue being addressed. A compilation of information sources insures that mechanistic models are as accurate as possible. The conceptual models can illustrate the relevant interactions and functions for any given problem or situation. The models provide a foundation for developing quantitative spatial models that will enable the integration of multiple stressors acting at various spatial scales to give managers a landscape context.

In this document we presented a hierarchy of conceptual models, beginning with a framework model that describes the relationships among the major biotic and abiotic systems in the Great Basin: the atmospheric system, the human social system, and the dry and wet ecosystems. Each of these systems is described in more detail in separate general system models. The atmospheric system model describes how atmospheric processes are fundamental drivers of Great Basin ecosystems, hydrology, and geomorphology; the human-social system model describes social and cultural factors resulting in patterns of land and water use and their evolution; the dry and wet system models describe the broad landscape patterns and relationships among the subsystems. For the dry and wet systems, we developed more detailed models for high-priority subsystems that describe components, their functional relationships, and potential effects of key stressors. Dry subsystem models are differentiated by biophysical potential on the landscape (biomes) and include sagebrush steppe, pinyon-juniper woodlands, mixed conifer forest, and alpine tundra. Wet subsystem models distinguish fundamental hydrologic entities, and include the groundwater system, stream and riparian systems, and wetland and spring systems.

We have not yet developed subsystem models for salt desert scrub, aspen forests, freshwater lakes and saline lakes and marshes, as well as for specialized environments such as dry playas and sand dunes, but these models are needed for complete evaluation of the Great Basin. Descriptions of each subsystem model identify knowledge gaps and research needs to acknowledge what is not understood and provide direction to future work.

In addition to the models in this report, GBILM is creating information products and analytical techniques that will assist with reinterpretation of the models in conjunction with the development of a long-term regional monitoring strategy. For example, we are creating a regional map of phreatophytic vegetation communities to identify areas that might be most responsive to groundwater development. Such products will have multiple applications, which our conceptual models will help scientists and managers to visualize. In this case, a manager interested in the effects of overland flow and erosion might use the phreatophytic vegetation layer to evaluate the combined effects of water withdrawal and erosion (for example, fig. 5.8). We believe these and other data products can be used effectively with our conceptual models to increase a manager's ability to evaluate multiple actions and better understand the broader context within which management decisions are made.

Ultimately, this group of conceptual models will contribute to GBILM's goal of developing a comprehensive landscape-level monitoring strategy for the Great Basin. Initially, conceptual models will identify elements of ecosystems that are predicted to respond to stressors based on our current understanding of system function. These elements are potentially valuable to monitor. Eventually, predictive spatial models, built according to the concepts presented in Chapter 5, can focus attention on ecosystem components and processes that will manifest the effects of multiple stressors and drivers. Predictive models also can combine conceptual models with empirical data to explore predicted stressor impacts. This modeling effort helps to visualize ecosystem responses and interactions, which can lead to identification of efficient or sensitive monitoring indicators.

Our Great Basin conceptual models remain incomplete because we focused our limited resources on high priority subsystems and we lacked the expertise to fully develop some models. Furthermore, the models we present here are subject to modification in an adaptive management context. Because management priorities change and scientific understanding increases, all models are expected to undergo episodic development and increased scrutiny, particularly as new threats emerge. To have maximum effect, these models require data for validation and testing by targeted field studies. A logical step is to mine historical data to validate the models, an effort that GBILM has begun with promising early results (Land Treatments Digital Library project, accessed June 24, 2009, at http://www.usgs.gov/features/greatbasin/projects/treatments.html). After assembling and cataloging the data, analysis can follow. Analyses will feed back to the appropriate conceptual models for validation and application, help to identify data gaps and research needs, and help parameterize integrative predictive models.

We expect the conceptual models in this report to stimulate and inform efforts to build efficient, comprehensive monitoring plans. When combined with programs that collect a body of data for trend evaluation, collect needed baseline data, and conduct field studies to investigate knowledge gaps, the conceptual models provide the basis for a comprehensive investigation of Great Basin landscape threats, on which comprehensive monitoring programs can be constructed. GBILM investigations provide long-term value over large extents, yielding benefits to society but only through sustained commitments from the U.S. Geological Survey and its land-management partners.