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[Notes from the Field]

An International Workshop on Lake Hövsgöl Area Ecosystem Modeling

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Introduction

A ten-day international workshop on Lake Hövsgöl area ecosystem modeling was held at Hustai National Park May 14 - May 23, 2006. The workshop was organized by and for the Dynamics of Biodiversity Loss and Permafrost Melt in Lake Hövsgöl National Park, Mongolia Project (hereafter Hövsgöl GEF/WB Project, http://www.hovsgolecology.org) with the aim to develop a functional ecosystem model that can be used for addressing research and management questions studied by the project. The goal of the Hövsgöl GEF/WB Project is to identify impacts of climate change, permafrost dynamics, grazing and forest cutting on the ecosystem dynamics, including forest, steppe, riparian zones and streams, and to determine the sustainable resource use practices. The Hövsgöl GEF/WB Project conducts its research in six stream valleys at the northeastern corner of Lake Hövsgöl National Park. It is the first program for the Mongolian Long Term Ecological Research (MLTER) Network.

In a modeling effort, relationships among components of the ecological system need to be found by statistical analyses of data. Then, the system components and their relationships can be brought together with simplifying assumptions about the ecosystem to develop an integrated ecosystem model. The Hövsgöl GEF/WB Project has placed a great deal of emphasis on appropriate experimental design and statistical analysis in all its research efforts. Developing an ecosystem model was the next logical step not only for scientific and management purposes, but also for evaluating potential consequences of future management policy changes and possibly predicting environmental changes that will have significant impact on local and national economy.

During the workshop, scientists and experts from national and international institutions worked together to develop an ecosystem model consisting of an array of submodels that would facilitate our understanding of the ecosystem function. This workshop was the second half (Phase II) of a two-phase ecosystem modeling workshop organized by the Hövsgöl GEF/WB Project. Phase I was held as a one-week model formulation workshop in April 2005. In these two phases of the workshop, Hövsgöl GEF/WB Project researchers worked through a 16-step modeling process starting from modeling issues, identifying key factors (a.k.a. system drivers), determining spatial and temporal resolutions, identifying system performance indicators, and formulating conceptual models in Phase I to submodel designs and development; then in Phase II testing submodels as stand-alone models, and synthesis of submodels based on an information flow matrix defining interactions among model compartments.

Participants. The main forces in the workshop were all Hövsgöl GEF/WB Project researchers. The workshop was coordinated and run by Dr. Martyn Murray, Director of MGM Environmental Solutions Ltd., Edinburgh, Scotland, UK and Dr. Julian F. Derry, Research Fellow at the School of Biological Sciences, University of Edinburgh, Edinburgh, Scotland, UK. Dr. Anthony Whitten (Biodiversity Specialist of the World Bank) and the Hövsgöl GEF/WB Project Director Dr. J. Tsogtbaatar (Director of Geoecology Institute, Mongolian Academy of Sciences) were present. Managerial supports for organizing the workshop were provided by Munhtuya Goulden. Other international advisors on model development included Dr. Clyde E. Goulden (International Consultant for the Hövsgöl GEF/WB Project and Director of Institute for Mongolian Biodiversity and Eco-

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logical Studies, Academy of Natural Sciences of Philadelphia, USA), Dr. Jayne Belnap (Research Ecologist, Biological Resources Division, United States Geological Survey, Moab Utah, USA), Dr. Ingrid Burke (Professor, Department of Forest, Rangeland and Watershed Stewardship, Colorado State University, Ft. Collins, Colorado, USA), Dr. Scott Greene (Assistant Professor and Associate Director of Environmental Verification and Analysis Center, College of Geosciences, Department of Geography, University of Oklahoma, Norman, Oklahoma, USA), Dr. Michael L. Jones (Professor, Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan, USA), Dr. William K. Lauenroth (Professor, Department of Rangeland Ecosystem Sciences, Colorado State University, Fort Collins, CO, USA), Derek Ludlow (Management School and Economics, University of Edinburgh, Edinburgh, Scotland, UK), Dr. Michael W. Sears (Assistant Professor, Department of Zoology, Southern Illinois University, Carbondale, Illinois, USA) and Bazartseren Boldgiv (Department of Biology, University of Pennsylvania, Philadelphia, PA, USA).

Representatives from different academic institutions in Mongolia, such as the Ecology Department of the National University of Mongolia, Hustai National Park, Geoecology Institute, Institute of Biology, Institute of Geography and Institute of Hydrometeorology also contributed to and benefited from the workshop.

Preliminary outcome of the workshop. Participants agreed on the following main purposes of the model:

a. to assess the effect of environmental change (whether arising from climate, management actions, policy directions or external human influence) on biodiversity, habitat and water quality, and ecosystem stability within the six valleys of Lake Hövsgöl;

b. to assess the effect of environmental change in the six valleys of Lake Hövsgöl as a World Heritage site;

c. to assist in the development of sustainable solutions for natural resource use; and

d. to assist in understanding the dynamics of the ecosystem.

Although modeling is not a new concept for Mongolian researchers, many academics and professors lack sufficient knowledge about modeling concepts and their importance in ecological research. As such, ecology programs in this country do not have an acceptable level of introduction to ecological modeling in their curriculum. Therefore, the workshop had to inherently include a training component, even though the development of a working model was the targeted outcome. In this context, programming and simulation of models in MS Excel and Visual Basic environments were demonstrated. They were important exercises as they illustrated that ecological processes are dynamic by nature, not static snapshots in time. Choice of model implementation software is also an important consideration in modeling effort. At the outset of Phase II, it was decided that using Visual Basic was the best approach due to its accessibility and its less steep learning curve.

The 2005 Phase I of the workshop was devoted to introducing modeling concepts to the Hövsgöl GEF/WB Project researchers and to developing conceptual maps of interactions. As a result, the overall "box-and-arrow" model for the Hövsgöl ecosystem was constructed, submodels for each ecosystem compartment were defined, data were revisited, data gaps identified and some of the directions for the 2005 field season were determined to fill in the gaps and to further our understanding about the system. Six main compartments of the Hövsgöl area ecosystem were identified by habitat during Phase I, and this ecosystem partitioning was kept in Phase II (Figure 1). In this conceptual model, the atmosphere and permafrost compartment and the human and livestock compartment affect, and are affected by, all habitats. For example, the weight gained by livestock depends on time spent in terrestrial habitats and biomass available, which in turn is dependent on other environmental factors, such as weather and soil characteristics.

Sub-model teams worked on formal submodel constructions under the direction of external scientists: a submodel on climate and permafrost (Dr. Scott Greene), submodel on forest, steppe, and riparian systems (Drs. Ingrid Burke and William Lauenroth), submodel on land use of herders and livestock (Drs. Martyn Murray and Michael Sears), and submodel on stream systems (Dr. Michael Jones). All these submodels included a matrix of simultaneously interacting models (Figure 2). For example, the stream compartment of the ecosystem model included fish population size, fish bioenergetics model, dissolved nitrogen model, base cation model, hydrology model, diatom bioindication model, aquatic insect (based on EPT

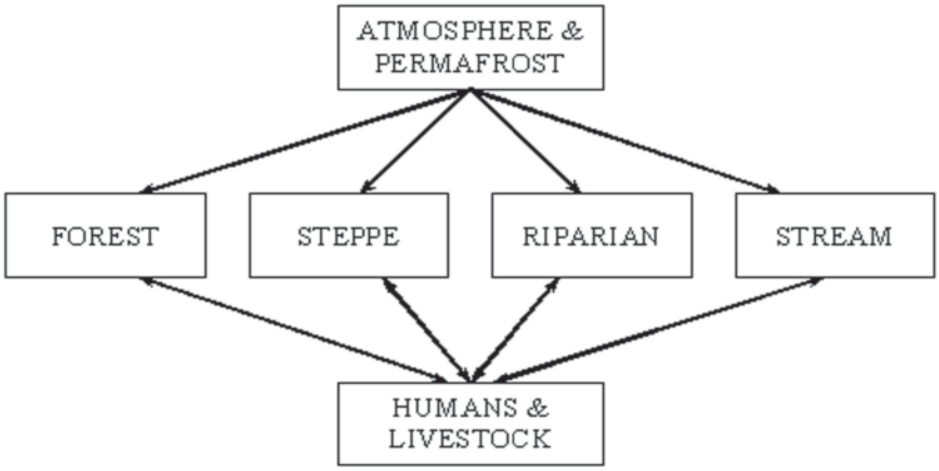

Figure 1. Main compartments and their linkages in the Hövsgöl ecosystem model.

taxa) bioindication model and so on.

Although some parts of the model, such as net primary productivity and human population dynamics needed to be on a seasonal or annual basis, it was decided that the model should be developed for a single generalized valley in a spatially-implicit fashion with mostly daily temporal resolution. Once modeling of such a generalized valley is done, it is possible to define any of the six valleys by simply changing model parameters and variables and to validate the model against data. At the end of the workshop, submodels for ecosystem components were developed. Some of the models were tested against data, e.g.: the model predicting soil thawing depth, and the model using diatom species for water quality indicators by

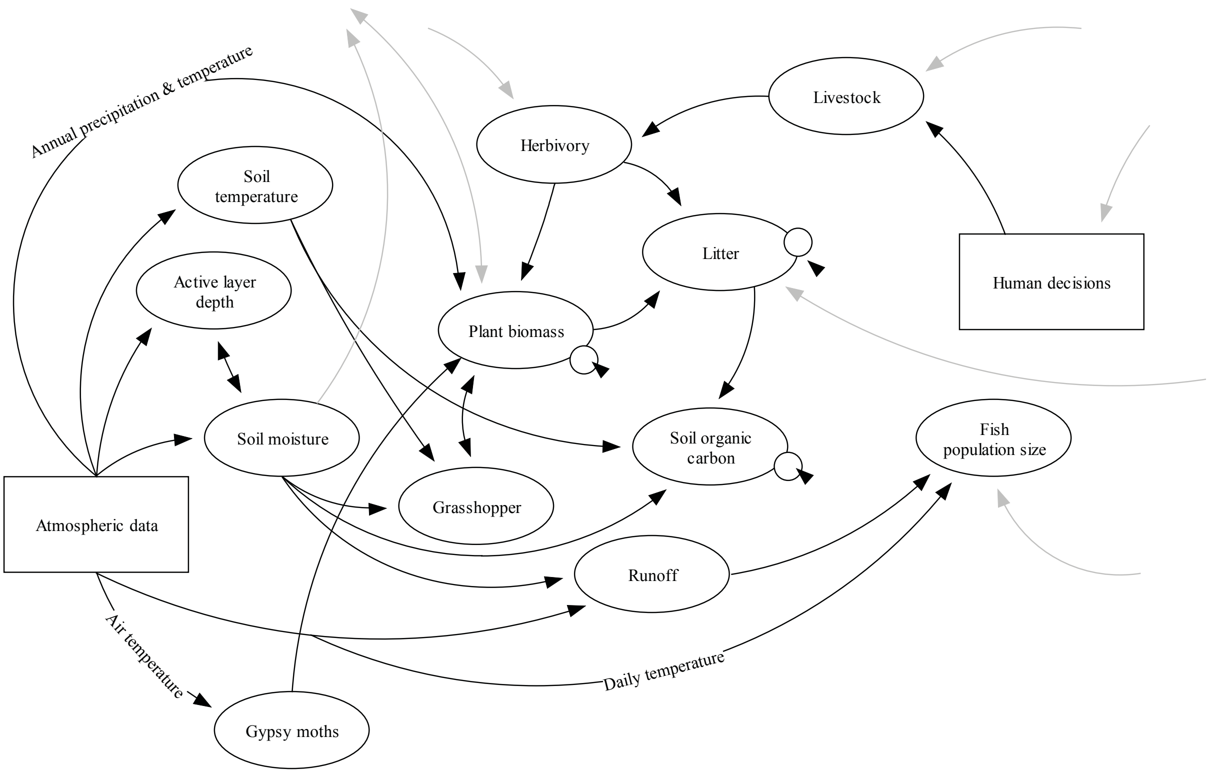

Figure 2. An example of data pathways connecting separate components of the Hövsgöl ecosystem model. Arrows indicate the direction of effects and grey arrows indicate external sources that are not included in this particular example.

training an artificial neural network, appeared to work remarkably well based on data-validation. Soil thawing depth was predicted from three main variables (soil bulk density, soil moisture and air temperature) and other variables derived from the three. Actual data and model-predicted values were almost perfectly correlated (Figure 3).

Incorporating permafrost dynamics in the Hövsgöl ecosystem model was important. Effects of permafrost dynamics, while scientifically interesting, were shown to have a great deal of implication on management of the area. In the model, permafrost was not only one of the system drivers, but also one of the system performance indicators. Permafrost condition is affected not only by climate change, but also by land use practices such as grazing pressure and herd composition. Permafrost degradation in turn has adverse effect on biodiversity and primary productivity of the area as it leads to overall soil moisture loss. Such a negative feedback of permafrost on carrying capacity and biodiversity via intermediate mechanisms requires more attention if conservation and sustainable use of natural resources are the long term goal for the region (especially if Lake Hövsgöl is to be considered as a World Heritage site).

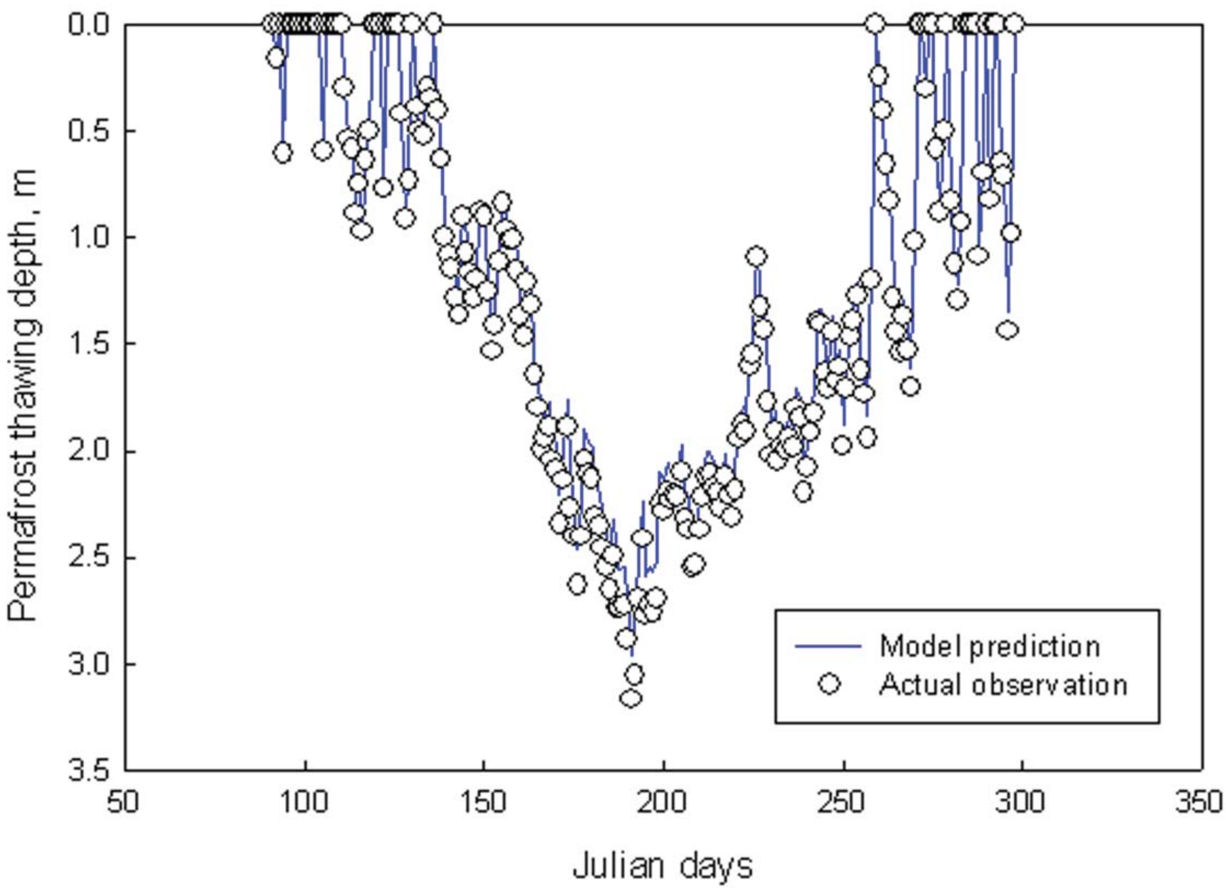

Figure 3. Prediction of permafrost thawing depth as an example of models developed during the workshop. There is a very tight correlation between predicted and observed values (r=0.9998, P<0.0001).

To conclude, all the submodels were developed and fully coded. Unfortunately, there were some issues that became apparent in the programming stage of the Hövsgöl ecosystem model when interfacing these submodels together. The problems arose due to disparity between submodels, such as inconsistency in temporal resolutions, difference in measurement units, and data gaps. Although these problems were sufficient enough to slow down the programming progress, they are not fatal to development of the overall ecosystem model and can be solved with some targeted effort. Given the success of submodels and great deal of progress made during Phase II, we do expect that the ecosystem model will be fully developed and used for research, as well as for management purposes.

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