Using agent-based models to map ecosystem services

Tom Habib & Dan Farr, Alberta Biodiversity Monitoring Institute, Edmonton, AB

Alberta Biodiversity Monitoring Institute

The Alberta Biodiversity Monitoring Institute (ABMI) is an independent, non-profit research organization that provides information on the status and trends of Alberta's biodiversity to support responsible land-use management. ABMI has established a permanent 20-km sampling grid of 1656 sites across the province (Fig. 1), with each site being visited approximately once every 5 years. In addition to site visits, ABMI uses aerial photography and remote sensing to monitor >2000 species, habitats, and human land-use footprint.

In addition to its core monitoring program, ABMI demonstrates the use of biodiversity data in environmental management and land-use decisions through applied research projects. Ongoing projects include:

- Monitoring ecological recovery of reclaimed industrial sites
- Biodiversity management and climate change adaptation
- Advancing capacity for monitoring and conserving rare and at-risk species in Alberta's oil sands region
- **Assessing ecosystem services across Alberta**

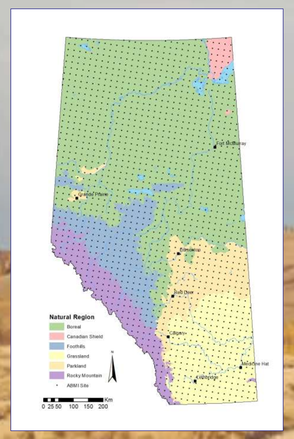


Fig. 1. Permanent 20-km sampling grid of 1656 sites monitored by ABMI in Alberta, Canada

Modelling Biodiversity Intactness

ABMI has developed a Biodiversity Intactness Index to express current ecological health as a percentage value relative to undisturbed reference conditions (Nielsen et al. 2007). Intactness is calculated in a 3-step process:

1) Use field data to develop species abundance vs human footprint relationships, accounting for environmental covariates (geographic location, soil type, vegetation type, and stand age).
2) Apply models to Alberta-wide layer of human footprint (agriculture, residential areas, forestry cutblocks, petroleum developments, and linear features).
3) Average the predicted absolute difference between current and reference (*i.e.* "de-footprinted") conditions across species to obtain an overall intactness metric (Fig. 2).

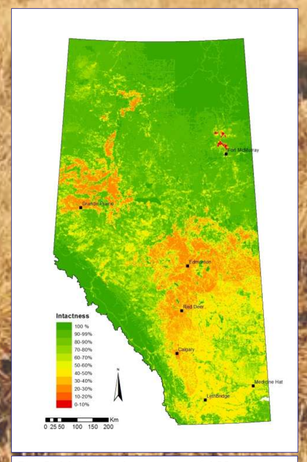


Fig. 2. Modelled intactness of 169 vascular plants, birds, and mites in Alberta, Canada.

Ecosystem Services Model Development

ABMI's Ecosystem Services Assessment project is building models to quantify and map the provision and value of 5 ecosystem services across Alberta, plus an indicator of biodiversity intactness (Fig. 2). Target ecosystem services include

- Water purification
- Rangeland forage production
- Timber production
- Pollination
- Carbon sequestration & storage

We are using the dynamic, spatially-explicit, agent-based modelling platform NetLogo (Wilensky 1999). NetLogo models can be run and controlled via a graphical user interface, allowing users to alter management practices and view the results in real time, both visually on a map, and through graphs and summary statistics (Fig. 3). Advantages of using an agent-based modelling platform to model ecosystem services include the ability to

- Track multiple services and indicators simultaneously to understand trade-offs among services
- Represent heterogeneous behaviour of land managers and their management decisions
- Be deployed as a web app for public accessibility

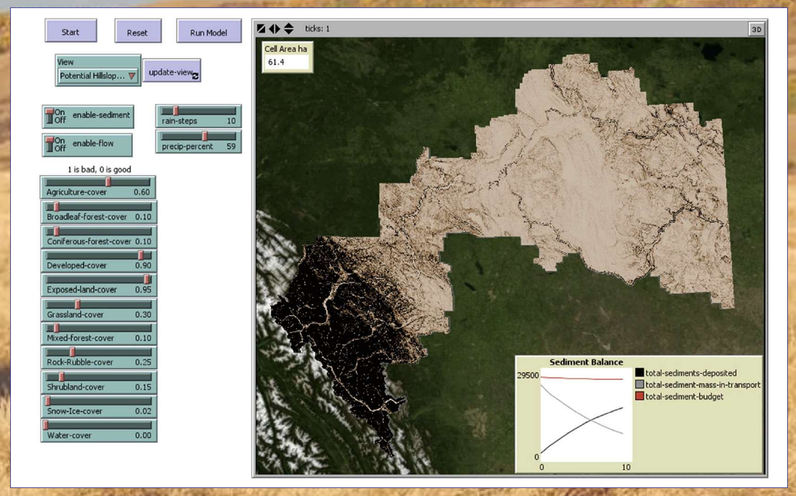


Fig. 3. Prototype sediment retention model displayed for the North Saskatchewan River watershed in Alberta, Canada.

References

Nielsen, S.E., E.M. Bayne, J. Schieck, J. Herbers, and S. Boutin. 2007. A new method to estimate species and biodiversity intactness using empirically derived reference conditions. Biological Conservation 37:403-414.

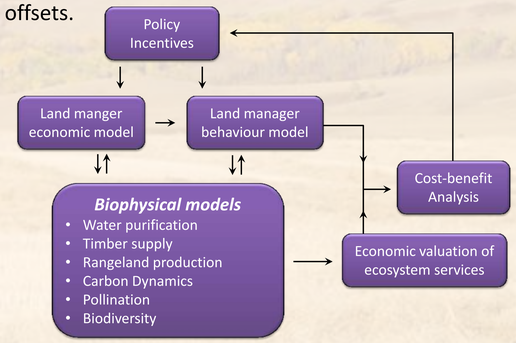
Wilensky, U. 1999. NetLogo. ccl.northwestern.edu/netlogo. Center for Connected Learning and Computer-Based Modeling, Northwestern University. Evanston, IL.

Yang, W., A.N. Rousseau, and P. Boxall. 2007. An integrated economic-hydrologic modeling framework for the watershed evaluation of beneficial management practices. *Journal of Soil and Water Conservation* 62:423-432.

Fig. 4. Candidate BMPs for modelling. Clockwise from top left: riparian management, rotational grazing, wetland restoration, and no-till agriculture.

Cost-benefit evaluation of BMPs

Agent-based ecosystem service models can assess the costs and benefits of implementing beneficial management practices (BMPs; Figs. 3-4). Individual land managers who control parts of the landscape can be represented in agent-based models and used to test how alternative policies would influence their decisions, and subsequently ecosystem service provision. Policies may include regulation or market-based instruments such as payments for ecosystem services or conservation offsets.



Adapted from Yang et al. 2007

Tools & Applications

Ecosystem service information generated by models will be used to develop three applications:

1. Scorecards of ecosystem service provision for given jurisdictions or industries
2. Developing infrastructure for conservation offsets
3. Scenario modelling under alternative land management policies

Funders & Collaborators