ECOSYSTEM SERVICES Assessment Project

WATER PURIFICATION REPORT

OVERVIEW

Ecosystem services are the benefits provided by nature that contribute to our health and wellbeing. Despite the essential role that ecosystem services play in our lives, they're often ignored in decision-making because we don't recognize their value. This project aims to change that by measuring and valuing these services.

The Ecosystem Services Assessment (ESA) project assesses and maps ecosystem services across Alberta. In the first phase of the project (2012-2015), we developed a set of spatially explicit models that can be used to map their supply and economic value, starting with five ecosystem services:

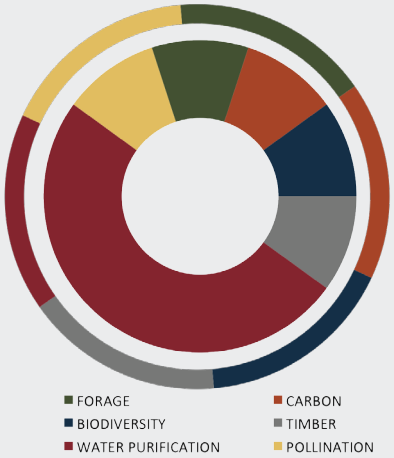
- **Water purification**
- Timber production
- Forage production
- Pollination
- Carbon storage

We've also mapped the ABMI's Biodiversity Index, drawing from the ABMI's extensive province-wide biodiversity data, to estimate how plant and animals species respond to varying amounts of human footprint.

We're interested in how these ecosystem services interact with humans: how they are affected by human activities and change with land management, both positively and negatively. The second phase of the project, beginning in 2015, will demonstrate applications of ecosystem service information for use by land managers, and incorporate this knowledge into marked-based instruments that use monetary incentives and fees to promote desired environmental outcomes, and discourage adverse impacts.

Powered with this information, Albertans can make the best possible decisions about how to manage our landscape and natural resources. Improved knowledge about the provision and value of ecosystem services can support better environmental management through regional planning, market-based approaches, and sustainability reporting.

INTEGRATED PLATFORM



Ecosystem services are linked to one another and do not respond independently to changes in land-use or management practices. Integrating ecosystem service models in a single platform is essential to a comprehensive assessment of ecosystem services – so that the effects of a single management action on multiple ecosystem services can be represented.

> **For example, forest harvesting simultaneously affects carbon storage, water purification, and biodiversity; only by integrating these services in a modelling environment can the inherent trade-offs be understood.**

WATER PURIFICATION

We rely on water for many necessities, from irrigating crops to providing habitat for fish and other aquatic species. At the most basic level, we rely on drinking water for survival. In many places, surface water has to be treated in order to make sure that it's clean for drinking. Purifying water is an ecosystem service that often goes unvalued - until the Ecosystem Services Assessment project!

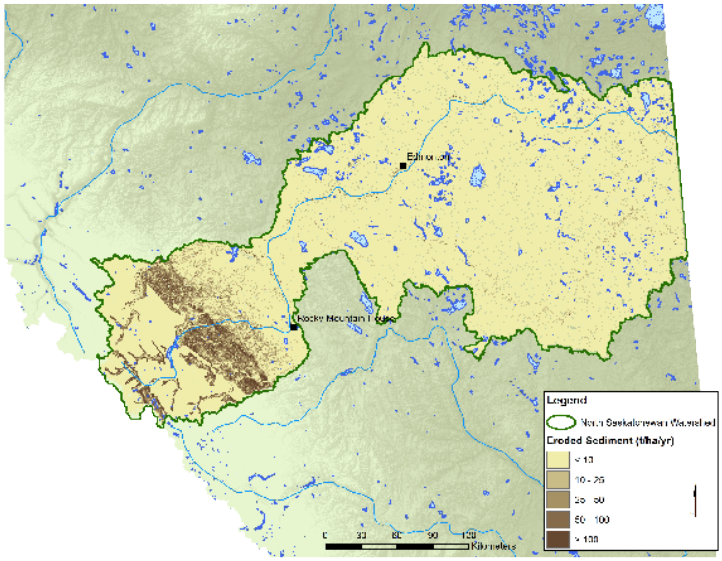
The water purification model estimates water purification services provided by a landscape.[1] When it rains or snows, nutrients and sediment flow off the land and into streams, wetlands, and other water bodies. This is called surface runoff, and is largely governed by topography and soil characteristics. Vegetation also plays an important role in the amount of sediment and nutrients released into surface water bodies through runoff. Wooded areas, for example, are able to reduce erosion and retain much more sediment and nutrients than developed areas, where much less water and nutrients are absorbed. This affects the amount of nutrients like nitrogen, phosphorus, and total suspended solids that end up in downslope streams, rivers, and lakes. Excess nutrients and sediment in these water bodies can lead to decreased water quality, which has a number of costs associated with it. Not only does decreased water quality incur increased costs to treat drinking water and dredge sediment from reservoirs, but it can also cause harm to fish populations, reduce recreation, swimming and fishing opportunities, and decrease waterfront property values.

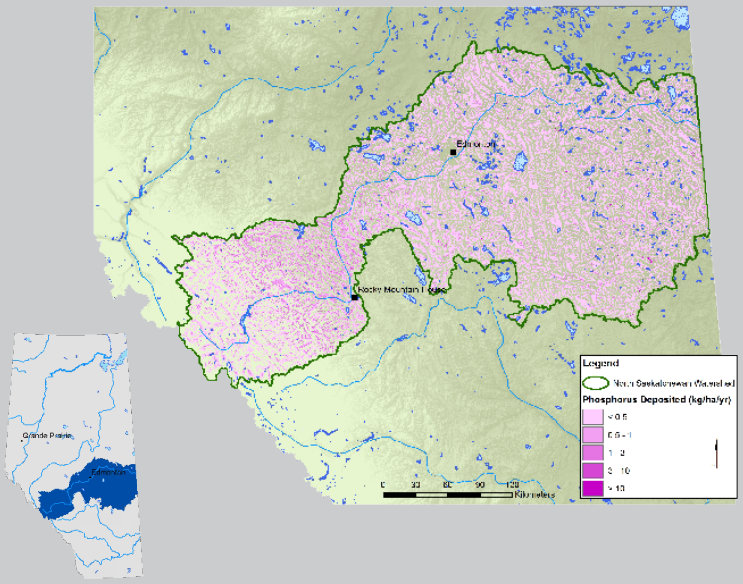
The model calculates the quantity of nutrients and sediment contained in runoff released by different parts of the landscape annually, based on export coefficients for eighteen different landcover and human footprint types.[2] This enables the model to assign loadings for nitrogen, phosphorus, and total suspended sediment (in kg/year) to each cell in the modelled landscape. The amount of eroded sediment that is generated during rainfall is calculated based on the Revised Universal Soil Loss Equation (RUSLE),[3] which calculates sediment generation in tonnes, based on rainfall intensity, soil erodibility, topography, and landcover type (Fig 1). The model also calculates the proportion of nutrients and sediment contained in overland water flow that is retained by each cell, based on estimated rates of removal rate.

Eventually, surface runoff collects into the stream network and moves downriver. We can use the model to see where nitrogen, phosphorus, and total suspended solids are generated, how they travel through the hydrological system, and where they end up (see Fig 2 for phosphorus). In other words, the model identifies which areas of the landscape are sources for nutrients and sediment, based on existing land use and landcover configuration, and thus the areas that can be prioritized for management. The model also identifies which areas remove these substances and therefore contribute to higher water quality.[4] For any given point on the landscape, we can track nutrient source and the impact of landscape change to downstream water users.

The water purification model allows for a lot of interaction with users. Model users can adjust the amount of nutrients and sediment that each land cover type releases into surface runoff, to see how this impacts the overall volume of nutrient and sediment found in downstream water bodies. Visit our mapping portal to try out the models yourself! *http://mapping.ecosystemservices.abmi.ca*

FIGURE 1: *Amount of sediment eroded each year in the North Saskatchewan watershed, in tonnes/ha/year.*





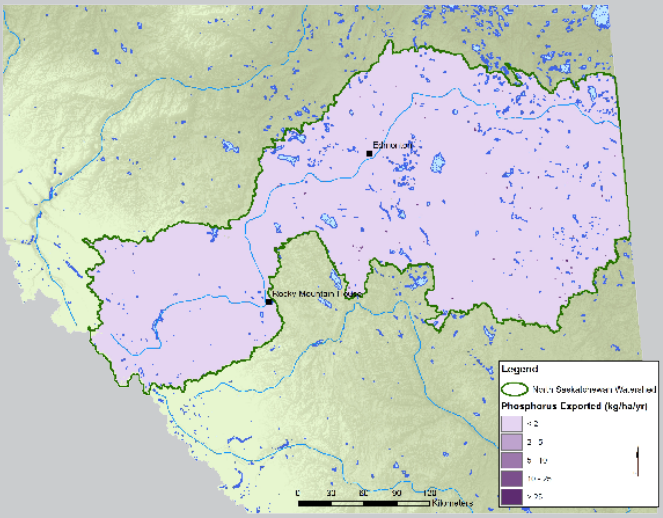


FIGURE 2: *Phosphorus deposited (in kg/ha/year) in the North Saskatchewan watershed (top); and phosphorus exported (in kg/ha/year) from the North Saskatchewan watershed (bottom); boundary of watershed (inset).*

- We successfully assessed and mapped five ecosystem services across Alberta. We're now integrating our five models with a biodiversity model into a single interactive platform – available on our website soon! www.ecosystemservices.abmi.ca

- We have completed a preliminary assessment of how rangeland forage production and soil carbon storage may be impacted by climate change, and evaluated the potential costs and benefits of specific adaptation strategies to respond to those changes. Once complete, this information can support the evaluation and implementation of community climate change adaptation strategies.[5]

- Our research on biodiversity offset priorities was published in Conservation Biology. The goal of biodiversity offsets is to counter the loss of biodiversity from development by conserving or restoring the same type of biodiversity elsewhere. We evaluated alternative offset policies in northern Alberta as a case study. Our work suggests that flexible offset systems tailored to regional conservation priorities (e.g., caribou habitat), can achieve better conservation outcomes at a lower cost compared to systems focused strictly on offsetting the exact same types of ecosystems and biodiversity that were affected by the development.[6]

- We have contributed to initiatives focused on sustainable beef production, including the Food & Agriculture Organization at the UN and the Canadian Roundtable on Sustainable Beef. Our capacity to assess ecosystem services supports sustainable livestock by providing a more complete assessment of the environmental performance of a given piece of land than past approaches.[7]

APPLICATION – PHASE 2

The goal of the second phase of the project (2015-2017) is to promote environmental innovation and competitiveness in Alberta's leading natural resource industries by demonstrating how to apply the systems developed in Phase 1 for assessing ecosystem services and biodiversity.

Understanding the provision of ecosystem services is an essential first step in developing market approaches to conservation, like offsets, sustainability reporting, and certification. We need a full assessment of the benefits we're receiving from the landscape before we can begin to accurately value these services in the marketplace. The ESA project offers Albertans that potential.

This project is part of a province-wide initiative, the Ecosystem Services Research and Innovation Roadmap, funded and led by Alberta Innovates – Bio Solutions, and also receives funding from the Alberta Livestock and Meat Agency. This project is a collaboration with the University of Alberta, Alberta Innovates – Technology Futures, Silvacom, the University of Guelph, and the Alberta Land Institute.

Visit our project website for the most recent reports, products and updates from the project: www.ecosystemservices.abmi.ca

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[1] *The model follows a similar process to that used in InVEST. See: Karieva, P., H. Tallis, T.H. Ricketts, G.C. Daily, & S. Polasky (eds.). (2011). Natural capital: theory and practice of mapping ecosystem services. Oxford University Press.*

[2] *Donahue, W. (2013). Determining appropriate nutrient and sediment loading coefficients for modeling effects of changes in landuse and landcover in Alberta watersheds. Water Matters Society of Alberta.*

[3] *Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, & D.C. Yoder. (1997). Predicting soil erosion by water: a guide to conservation planning with the revised universal soil loss equation (RUSLE). Agriculture handbook 703. U.S. Department of Agriculture, Washington, D.C.*

The process has been updated for specific application in Canada: Wall, G. J., D.R. Coote, E.A. Pringle, & I.J. Shelton. (2002). RUSLEFAC - Revised universal soil loss equation for application in Canada: A handbook for estimating soil loss from water erosion in Canada. Research Branch, Agriculture and Agri-Food Canada, Ottawa, ON. Contribution No. AAFC/AAC2244E.

[4] *Wilson, J., S. Heckbert, C. Aumann, M. Cutlac, W. Donahue, M. Kennedy, Y. Liu, D. Pan & W. Yang. (2013). HydroGeosim: A water purification geosimulation modelling platform. Prepared for the ABMI Ecosystem Service Assessment Project.*

[5] *Nixon, A.E., M. Iravani, T.J. Habib, & S.R. White. (2015). Climate change and the provision of ecosystem services in Alberta. ABMI.*

[6] *Habib, T.J., D.R. Farr, R.R. Schneider, & S. Boutin (2013). Economic and ecological outcomes of flexible biodiversity offset systems. Conservation Biology 27(6): 1313-1323.*

[7] *LEAP FAO Principles for the Assessment of Livestock Impacts on Biodiversity. Available at: http://www.fao.org/3/a-av154e.pdf*

Canadian Roundtable on Sustainable Beef: http://www.crsb.ca