esa | ECOSYSTEM SERVICES Assessment Project

FORAGE PRODUCTION & CARBON STORAGE 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:

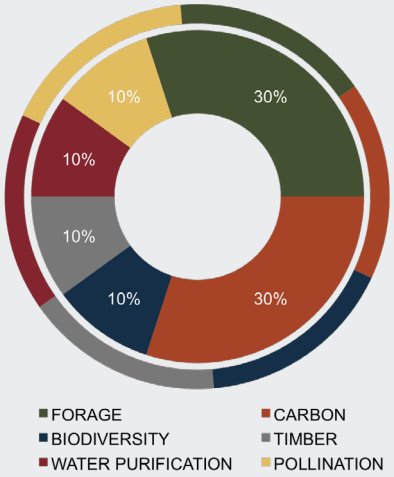
- Water purification
- Timber production
- Forage production
- Pollination
- Carbon storage

We've also mapped the ABMI's Biodiversity Index, drawing from the ABMI's extensive province-wide biodiversity data, to estimate how overall biodiversity responds 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 for environmental management.

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 can be represented for multiple ecosystem services.

> **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.**

RANGELAND FORAGE PRODUCTION AND CARBON STORAGE

Alberta is well known for its beef production and many of the province's 6.5 million hectares of rangelands are grazed by cattle.[1] The production of forage (grass and other plants that cattle eat) depends on local conditions such as soils, climate, and livestock management.

But world-class beef isn't the only benefit Albertans receive from rangelands. Grassland ecosystems store huge amounts of carbon, particularly below ground in their root mass and soil.

The ESA project uses a well-established ecosystem dynamics model, the CENTURY model, to assess these two ecosystem services – forage production and soil carbon storage – across Alberta's grasslands.

The CENTURY model simulates a range of ecosystem processes related to organic carbon dynamics in grasslands, and can be used across many locations to create spatially explicit predictions. The model requires data on the soil properties, climatic conditions, and fire and management regimes (i.e., grazing history) for each location.

We used the comprehensive soils information from the Agricultural Region of Alberta Soil Inventory (AGRASID)[2] database to obtain soil parameters (e.g., soil texture, depth, bulk density, drainage class and pH) for the dominant native soil at each location (Fig 1). We used historical (1901-2011) monthly climate data (e.g., rainfall and minimum and maximum temperature) for each location from the high-resolution spatial climate dataset, ClimateWNA.[3] Because detailed information on historical fire and management regimes at each location isn't available, we specified a fire and bison grazing scenario prior to 1901 and cattle grazing in the summer months for the 1901-2011 period.

We ran the CENTURY model for each location simultaneously to represent the unique combinations of soil and climate data and then mapped the results to produce an assessment map (Fig 2).

For each location, the model provides estimates for the amount of forage biomass produced over the last completed growing season and for the total amount of living and non-living organic carbon stored in grassland soil. This model can be used to assess how different land use scenarios, such as different grazing regimes, can affect soil carbon storage in Alberta's rangelands. For example, the model allows us to determine the potential difference in soil carbon storage between low- and moderately-grazed rangelands.

Grazing management decisions influence the amount of carbon stored in the soil. As an example, if we were to convert a quarter section (almost 65 ha) of native grassland in the Dark Brown Soil of the Mixedgrass soil area (see Fig 1) to annual crops, it would represent the loss of 427 tons of soil carbon![4] The value of this ecosystem service can be estimated based on Alberta's carbon price, currently $15/tonne. The estimated value of the carbon protected by not converting this quarter section of native grassland to annual crops is over $6,000.

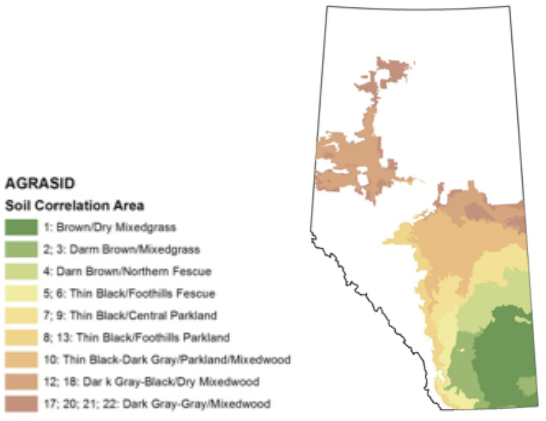
In this way, we have estimated the current value of carbon stored in Alberta's rangelands at over $2 billion. This value represents the total amount of carbon stored, and gives an idea of how important rangelands are as carbon sinks. However, carbon payment systems worldwide often pay for *additional* stored carbon – that is, how much additional carbon is added to the soil as a direct result of a given management action. Our assessment can provide a starting point for this type of calculation.

We can also evaluate the value of forage consumed by cattle (or offtake) for any grazing scenario by estimating the cost of replacement feed that would be required if rangeland grazing was not available. Using this approach, we estimate the replacement value of forage production in Alberta at $392 million annually.

Additional approaches to estimating the value of forage in Alberta combine the amount of forage needed per acre to sustain an animal unit with grazing rates for provincial leases or pasture rental rates for privately owned land. This calculation estimates the annual direct value of pasture for grazing in Alberta at $349.8 million.[1]

These quantitative assessments allow us to understand the value of the ecosystem services being provided by Alberta's rangelands – both forage production and soil carbon storage. Rangelands also support water purification and contribute to biodiversity – there's a lot to account for in our rangelands!

FIGURE 1: *Distribution of soil correlation areas used to define regional models of rangeland carbon dynamics for Alberta.*



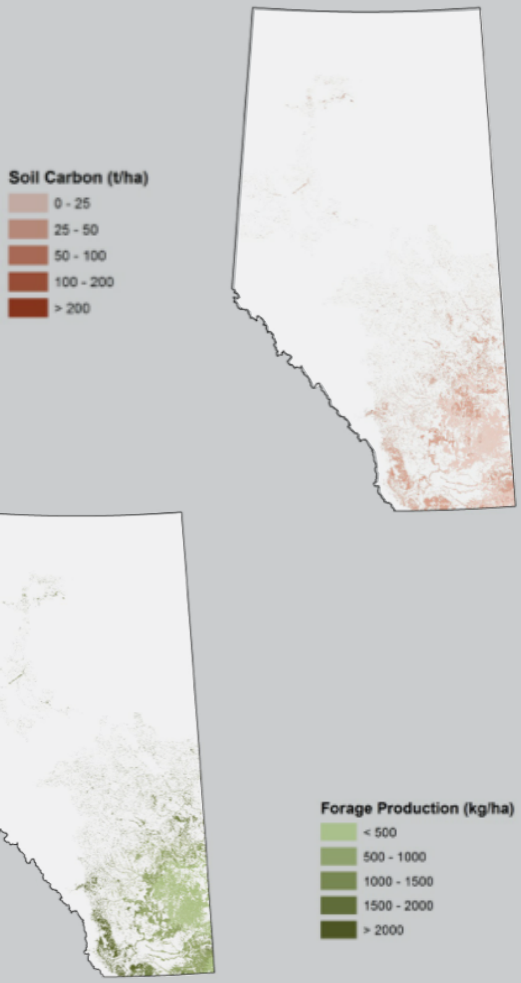


FIGURE 2: *Forage production (left; measured in kg/ha/yr) and soil carbon storage (right; measured in t/ha) modelled under low-to-moderate grazing using CENTURY model, across native grassland in Alberta.*

- 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! 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 complete assessment of the environmental performance of a given piece of land.[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.

ALMA Alberta Livestock and Meat Agency Ltd. | Alberta Innovates Bio Solutions | Alberta Innovates Technology Futures | University of Alberta

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

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[1] *Kosinski, S. (2012). The value of Alberta's forage industry. Alberta Agriculture and Rural Development. Edmonton, Alberta.*

[2] *Agricultural Region of Alberta Soil Inventory Database*

[3] *Wang, T., A. et al. (2012). ClimateWNA – high-resolution spatial climate data for western North America. Journal of Applied Meteorology and Climatology, 51:16-29.*

[4] *Based on an average loss of 25% of soil organic carbon when native soil is converted to agricultural land, as per: VandenBygaart, A. J. et al. (2003). Influence of agricultural management on soil organic carbon: A compendium and assessment of Canadian studies. Canadian Journal of Soil Science, 83(4): 363-380.*

[5] *Nixon, A.E., et al. (2015). Climate change and the provision of ecosystem services in Alberta. ABMI. Edmonton, Alberta.*

[6] *Habib, T. J., Farr, D. R., Schneider, R. R., & Boutin, S. (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.*

Canadian Roundtable on Sustainable Beef.