

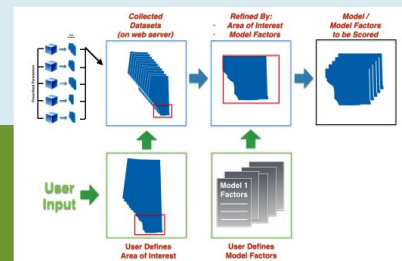
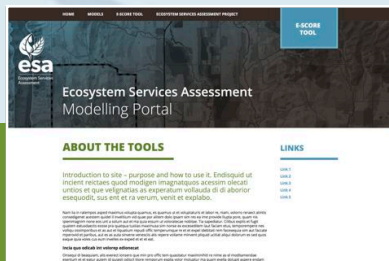
# ESA Modelling Portal and EScore Tool: Conceptual Structure of the Ecosystem Services Assessment Web Portal and Score Card Applications

January 2014

Prepared by Guy Greenaway, Ken Sanderson, Kimberly Good and Greg Chernoff



MIISTAKIS  
INSTITUTE



Prepared for the:

Ecosystems Services Assessment for Environmental Innovation and Competitiveness project

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## Executive Summary

As part of the ABMI-led *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* (ESA Project), the Miistakis Institute is developing two project applications. The *Ecosystem Services Web Portal* is a mechanism for web-delivering information about the project's five ecosystem service models. The *ES Score Card* is a mechanism for integrating and scoring outputs from multiple ecosystem service models run on a common land unit. This report conceptually describes the structure and functionality of those applications, as an interim step to their beta development, and as a proof of concept in anticipation of the final development and synthesis of the ESA project models.

A review of scorecard approaches in the natural resource management, and an analysis of modeller interviews provided numerous technical and thematic information points to advise the scorecard and portal development. The resultant structure sees the *ESA Modelling Portal* linked to the ESA Project web site, with output files from the models stored on a web server, maps generated on a map server, with a seamless user transition. *EScore* is the name for the interactive tool on the *ESA Modelling Portal*, which apply a selection of scoring, rating and threshold parameters to a chosen region of the province, producing both map-based and tabular summaries of the integrated ecosystem service score.

Operationalizing the portal and the scorecard requires standardizing the model outputs in terms of scoring range and map grid, developing pre-processed 'scenario elements', and using the *EScore* tool in relative scenario testing context with scores compared to other scores generated by the tool.

From a user's perspective, one accesses the *ESA Modelling Portal* web site, selects the interactive *EScore* tool, chooses a spatial extent and scenario elements, populates a scoring input, and produces the output table and map. From a technical perspective, there are three steps: Generating Prescribed Model Runs, Integrating Model Outputs (where user choices are made for area of interest, desired scenario elements, and weighting), and Scoring the Integrated Datasets (where user choices are made for model inclusion, weighting, rating scales, and minimum ratings).

As a preliminary step to populating the betas of the applications, scenario elements were proposed for each of the ESA Project models, as a starting point for discussions with the modellers. A number of limitations for use of the tools were identified, and potential expansions on functionality suggested. Near-term next steps include circulating the conceptual structures for modeller comment, developing pre-processed model runs, finalizing the *ESA Modelling Portal*, finalizing the *EScore* structure, launching the application betas, and finally transferring the portal and *EScore* tool to the ABMI web servers.

## Table of Contents

<b>Executive Summary</b> .....	<b>1</b>
<b>Table of Contents</b> .....	<b>2</b>
<b>Table of Figures</b> .....	<b>4</b>
<b>Introduction</b> .....	<b>5</b>
Project background .....	5
Report purpose and structure.....	5
Review of Scorecard Approaches in Natural Resource Management.....	6
Drawing from the Modeller Perspectives.....	6
Analysis Summary .....	7
Design and Delivery Implications .....	8
<b>Web Portal and Score Card Overviews</b> .....	<b>9</b>
ESA Web Portal.....	9
ES Score Card.....	9
“EScore” .....	9
Proof of Concept .....	10
<b>Operationalizing the Portal and Scorecard</b> .....	<b>10</b>
Standardizing the Model Outputs.....	10
Standardizing the Scoring Range .....	11
Standardizing the Map Grid and Resolution .....	11
Developing ‘Scenario Elements’ .....	12
Using the EScore Tool in Relative Scenario Testing.....	13
Cautions in Assigning Dollar Values to Scores .....	15
<b>Overview from the User’s Perspective</b> .....	<b>16</b>
Step 1: Go to the ESA Modelling Portal Web Site .....	16
Step 2: Access the Interactive EScore Tool .....	19
Step 3: Choose spatial extent.....	19
Step 4: Choose scenario element.....	20
Step 5: Populate score card parameters .....	21
Step 6: Produce output (score and map) .....	21
<b>EScore Technical Overview</b> .....	<b>21</b>
Creating Prescribed Model Runs .....	21
Integrating Model Outputs .....	23
Defining Area of Interest.....	23
Choosing Scenario Elements.....	23

Weighting.....	23
Scoring Integrated Datasets.....	24
Selecting Models for Scoring.....	24
Weighting Models .....	25
Setting Rating Scales.....	25
Setting Required Minimum Ratings.....	25
Scoring Summary .....	25
Map Summary .....	26
<b>Preliminary Determination of Scenario Elements .....</b>	<b>26</b>
Biodiversity .....	27
Pollination.....	28
Forest Timber and Carbon .....	28
Rangeland Forage and Carbon .....	29
Water Purification.....	30
<b>Known Limitations .....</b>	<b>31</b>
<b>Moving Forward .....</b>	<b>32</b>
Next Steps.....	32
1. Circulate conceptual structures for comment from the modellers.....	32
2. Work with ESA Project modellers to develop pre-processed runs .....	33
3. Finalize the ESA Modelling Portal.....	33
4. Finalize the Scoring Structure for the EScore Tool .....	33
5. Launch the Beta ESA Modelling Portal and EScore Tool.....	33
6. Transfer <i>ESA Modelling Portal</i> Web Site to ABMI .....	33
Potential Future Functionality .....	33
Additional Models .....	34
Additional Scenario Elements .....	34
Greater Range of Map Outputs .....	34
Saving of User-defined Settings .....	34
Additional Areas of Interest.....	34
<b>References .....</b>	<b>35</b>
<b>Appendix 1: Ecosystem Services Assessment: Model Development Update – January 2013 .....</b>	<b>36</b>
Water Purification.....	36
Rangeland Forage & Carbon.....	36
Pollination.....	37
Forest Timber and Carbon .....	37
Biodiversity .....	38

## Table of Figures

Figure 1: 1000 ha hexagonal grid relative to Land Use Framework regions .....	12
Figure 2: ESA Modelling Portal – Home Page.....	17
Figure 3: ESA Modelling Portal – Sample Models Page .....	18
Figure 4: ESA Modelling Portal – EScore Tool Instructions Page.....	19
Figure 5: ESA Modelling Portal – Sample EScore Model Tab.....	20
Figure 6: Technical Overview Step 1 – ES Model Runs .....	22
Figure 7: Technical Overview Step 2 – Integrating Model Outputs .....	24
Figure 8: Technical Overview Step 3 – Scoring Integrated Datasets.....	26

## Introduction

### *PROJECT BACKGROUND*

In 2010, the Alberta Biodiversity Monitoring Institute (ABMI) initiated the *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* (ESA Project). The purpose of the ESA Project is to establish relevant and credible systems for assessing ecosystem services and biodiversity across Alberta. By advancing this capacity, this program supports a vision of Alberta as an internationally recognized jurisdiction for world-class management of ecosystem services, green growth and sustainable development incented through market-based instruments.

These systems include the biophysical and socioeconomic information used to map biodiversity and ecosystem services across the province, internet-based services to distribute these maps and supporting documentation, and tools that allow people to apply this new capacity to land-use and management decisions. The goal is to establish systems for assessing ecosystem services in Alberta, and to evaluate tools for applying the information derived from these systems to environmental markets and land-use management.

The role of the Miistakis Institute within the *ESA Project* evolved to include two dimensions of the project 'applications': development of an *Ecosystem Services (ES) Score Card*; and development of a project *Web Portal*.

The goal of the *ES Score Card* is to create an ecosystem service scoring system to assess the yield of ecosystem services for a given landscape, and grade that against a defined baseline, in support of a defined resource management decision-making need.

The goal of the *ESA Web Portal* is to facilitate interactive use of the derived data and models, interactive use of the project Applications' information and associated tools, and access to the associated data and information resources. The intent is that all spatial data and maps developed will be made publicly available via a web-based portal.

### *REPORT PURPOSE AND STRUCTURE*

The purpose of this report is to describe, in conceptual terms, the structure and functionality of the *ESA Web Portal* and *ES Score Card* applications, as an interim step to the development of a beta versions of those applications. The feedback on this report will provide the information needed to 1) refine the design, and 2) populate the applications with the necessary model output data.

The report begins with two main context pieces: 1) a summary of the information gleaned from the extensive interviews with the ESA Project modellers regarding the technical and conceptual challenges and opportunities in integrating ES models, score cards and web portals; and 2) a summary overview of the ultimate applications, the *ESA Modelling Portal* and the *EScore Tool*.

The structure of the portal and scoring tool is then provided from two critical perspectives. The first is the perspective of the user arriving at the web-based interface. The second is a description of the data processing and scoring underlying the *ESA Modelling Portal* and *EScore* tool.

To plot the path forward, the report summarizes the proposed model run outputs as needed for the applications, the known limitations, the near-term next steps between now and the launch of the beta applications, and finally potential future functionality that may come to be seen as needed.

### ***REVIEW OF SCORECARD APPROACHES IN NATURAL RESOURCE MANAGEMENT***

To inform the development of the Ecosystem Services Scorecard, a review of scorecarding approaches was undertaken (Greenaway 2014). To scope the review, focus was placed on scorecarding resources and approaches that were either applicable very broadly (providing near universal lessons regarding scorecarding), or those applicable specifically to natural resource management.

The review provided valuable lessons on principles and practice in natural resource management scorecarding. Looking across all of the lessons offered, one theme cut across them, which was pragmatism. That is, a scorecarding mechanism needs to be directed and constrained by the circumstances of the scorecarding effort (i.e., data availability, user need, management context, etc.).

Within that consideration, the model-based structure of the *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* project, combined with the results of the review, highlighted four of the emergent themes from the review: Base on Modelling Exercises, Expert Involvement in Ecological Condition Question, Heed Data and Capacity Constraints, and Graphical Representation. Collectively, these suggested that the most efficient approach to developing a scorecard within the expressed needs of the project was to focus scorecarding efforts on the project models and the modellers.

### ***DRAWING FROM THE MODELLER PERSPECTIVES***

The goals of the *ESA Web Portal* and *ES Score Card* applications work have been to create 1) a web presence for the five ecosystem service models, and 2) a mechanism for integrating the outputs of those models. To support the design and delivery of the portal and score card applications, the modellers were interviewed regarding several aspects of the possibilities and capabilities of the models with regard to these goals (Haddock and Greenaway 2013).



An analysis of the modellers' responses significantly refined the design process in several ways. The following is a summary of that analysis, and the primary corresponding implications for the web portal and score card design (for greater detail, see Haddock and Greenaway 2013).

### Analysis Summary

#### INTEGRATION

- No pre-conceived mechanisms for integrating model outputs
- Significant variability in optimal spatial scales
- On-going focus on standardizing the modelling platform, but some remaining differences
- Limited current opportunities to synchronize model runs, or mechanically synthesize model outputs after the fact (each model's outputs are very different)
- Continued testing was envisioned regarding model integration
- Models are still being developed and opportunities for integration and web-delivery are still evolving

#### MEASUREMENT AND VALUATION

- Ability to tease out measure of ecosystem service value varied considerably
- Supply and demand calculations varied (some allowed for that calculation to happen within the model, while others required a third-party assessment of outputs)
- Ability to provide monetary valuations varied (different methodologies, different philosophies)

#### INTERACTIVITY

- All models contained input variables that could be manipulated
- Most allowed for scenario testing, but in quite different ways (manipulate inputs, use different input data sets, management practices, land use/cover variables, comprehensive scenarios like climate change)
- No intrinsic, native method within models for setting thresholds

#### WEB INTERFACE AND DELIVERY

- Practical inability / inadvisability of running models directly via a web site (aka "on the fly")
- Pre-processing of outputs seen as viable route for integrated web delivery
- Map products seen as the primary web output desired (with access to associated tabular / graphical summaries)

#### SPATIAL AND TEMPORAL SCALE

- All models at least partially optimized for the regional scale
- Consideration of temporal scale varied considerably between models

## WEB-DELIVERING AND SCORING THE MODELS

- All had clear sense of the model outputs which could be scored
- Primary role of portal seen as “animating” score card (i.e., providing interactivity of inputs, provide multiple scoring runs, unsupervised operation as opposed to providing only static outputs or supervised use)

### Design and Delivery Implications

The modeller interviews provided numerous technical and thematic information points to advise the score card and portal development. Collectively, those led to the following primary design guidelines:

- Score card and portal will be integrated
- Map-based interface will be created both for user input and summary output
- Models will not be operated directly through the web interface (i.e., “on the fly”)
- Pre-processed model runs will be requested from each modeller, with resultant grids stored on a web server; outputs will be standardized to a common scale.
- No temporal component to processing or scoring will be incorporated at this point (i.e., scores will be a snapshot in time versus an image of change over a designated time period)
- Operational spatial scale will be “regional” (e.g., basin, natural region, Land Use Framework region)
- Information about each model will be included in the portal allowing users to request/discover more complex model runs, applications, papers, contact information, etc.
- User interactivity will include choosing area of interest, models (and weightings), and scenario elements (and weightings) and scoring parameters for models, scenario elements, and thresholds
- Scenario development will be up to the user to create through the variety of their integration and scoring input choices
- Separate steps will be articulated for :
  - Creating prescribed model runs that facilitate web-delivery (pre-processing, producing output grids); performed by the ESA modellers by request
  - Integrating model outputs; calculations on output data sets stored on web server
  - Scoring integrated datasets; calculations on integrated data sets, creating comparable scores

## Web Portal and Score Card Overviews

### *ESA WEB PORTAL*

The *ESA Web Portal* is a mechanism for web-delivering information about the five ecosystem service models created within the *Ecosystem Services Assessment* project. The portal includes both an interactive component allowing for user interaction with the models, as well as a static component providing model-related reports, summaries, examples, contact information, etc.

The *ESA Web Portal* (the Beta being called the *ESA Modelling Portal*) is separately-conceived, but directly linked to the ESA Project web site. This means output files from the models are stored on a web server, maps are generated on a map server, but the web interface seamlessly takes a user from the ESA Project web site to the *ESA Modelling Portal*.

### *ES SCORE CARD*

The *ES Score Card* tool is a mechanism for integrating and scoring outputs from multiple ecosystem service models run on a common land unit. The *ES Score Card* is a web-based tool, allowing the user to articulate multiple scoring scenarios by modifying a preset selection of scoring parameters.

The *ES Score Card* is embedded within the *ESA Modelling Portal* and forms the basis for the interactive component of the Portal. The *ES Score Card* is the final step in the interactive tool. It takes the results of the model output integration task for a defined geographic area, and scores that region overall, then each model and each scenario element separately.

### *“EScore”*

*EScore* is the name for the interactive tool on the *ESA Modelling Portal*, a combination of the model output integration tasks, the scoring tasks, and the map-based input and output functions.

The *EScore* tool allows a user to first choose a region of the province to score, then select the models/scenario elements to be included (and their relative weightings), then choose from a selection of scoring, rating and threshold parameters. The resultant output is both graphical and tabular, summarizing the integrated ecosystem service score for the models and scenario elements in a table and in a summary map. Users are thus able to compare ecosystem service scores between different spatial units, or between different scenarios on the same spatial unit.

## *PROOF OF CONCEPT*

The development of both the score card (*EScore*) and the web portal (*ESA Modelling Portal*) are presented at this stage as a proof of concept, recognizing that the underlying ecosystem service (ES) models are not yet fully developed and integrated. To the greatest degree possible at this stage, the Miistakis team has sought to ensure that the *ESA Modelling Portal* and *EScore* tool have been developed such that, when the models are complete and integrated, both tools can be updated to incorporate the changes.

The goal at this stage is to demonstrate a workable mechanism for scoring and web-delivering the ES models as they currently are, demonstrating mechanisms for scoring calculation, provisional model integration, web delivery, scoring output structure, user interface, and mapping tool integration. As the models evolve, and they are fully integrated into a single NetLogo modelling platform, the needs and opportunities for scoring and web delivery will change, but the beta structure is intended to accommodate that.

## Operationalizing the Portal and Scorecard

To realize the goals for the *ESA Modelling Portal* and *EScore* Tool as described above, there are three fundamentals that must be addressed to operationalize these tools:

- Standardizing the model outputs
- Developing 'Scenario Elements'
- Using the *EScore* tool in relative scenario testing

## *STANDARDIZING THE MODEL OUTPUTS*

An ultimate goal of the *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* project is to integrate all five project models to provide a synthesized picture of ecosystem service production for any area of interest. Currently, the models are run independently, so synthesis must happen at the output level (i.e., developing mechanisms for integrating resultant output datasets).

Each model's outputs are quite different as they model different ecosystem services, operate at varying spatial and temporal resolutions, and use different valuation philosophies and methods (Haddock and Greenaway 2013). However, at this stage, each output variable in each model can be converted to a standardized resolution, converted to a standardized scoring range, and output to a standardized map grid. Scoring and map-based display can occur based on those standardizations.

### Standardizing the Scoring Range

The conversion of the model outputs to a standardized range involves working with each project modeller to determine the most appropriate conversion factor for each of those output variables or *Scenario Elements* (see *Developing Scenario Elements*, below). For each Scenario Element, models will produce a value for each hexagon in the resultant map grid. A factor will be applied to each value to convert it to a unitless, standardized 0.0 – 1.0 range.

The development of that conversion factor will use either a default process, or a more precise process as directed by the relevant modeller. The default process will be based on an analysis of the output data for a given Scenario Element, and a determination of the minimum and maximum values; the maximum value will be set at 1.0 and the minimum value at 0.0, with all other values scaled evenly between those extremes. The default ratings across the range will be *Poor*, *Fair*, *Good*, and *Excellent*. This can be accomplished by dividing the range into quartiles, or by using the mean and two standard deviations plus/minus to demark the four ratings. In cases where the modeller has a more precise method for converting the outputs to a 0.0 – 1.0 range, that will be used.

Regardless of approach, the process will 1) demonstrate the concept of the standardized scoring, allowing a basis for modification as the model integration evolves, and 2) provide a basis for standardized scoring across the models for a given area of interest for use in the *EScore* tool beta.

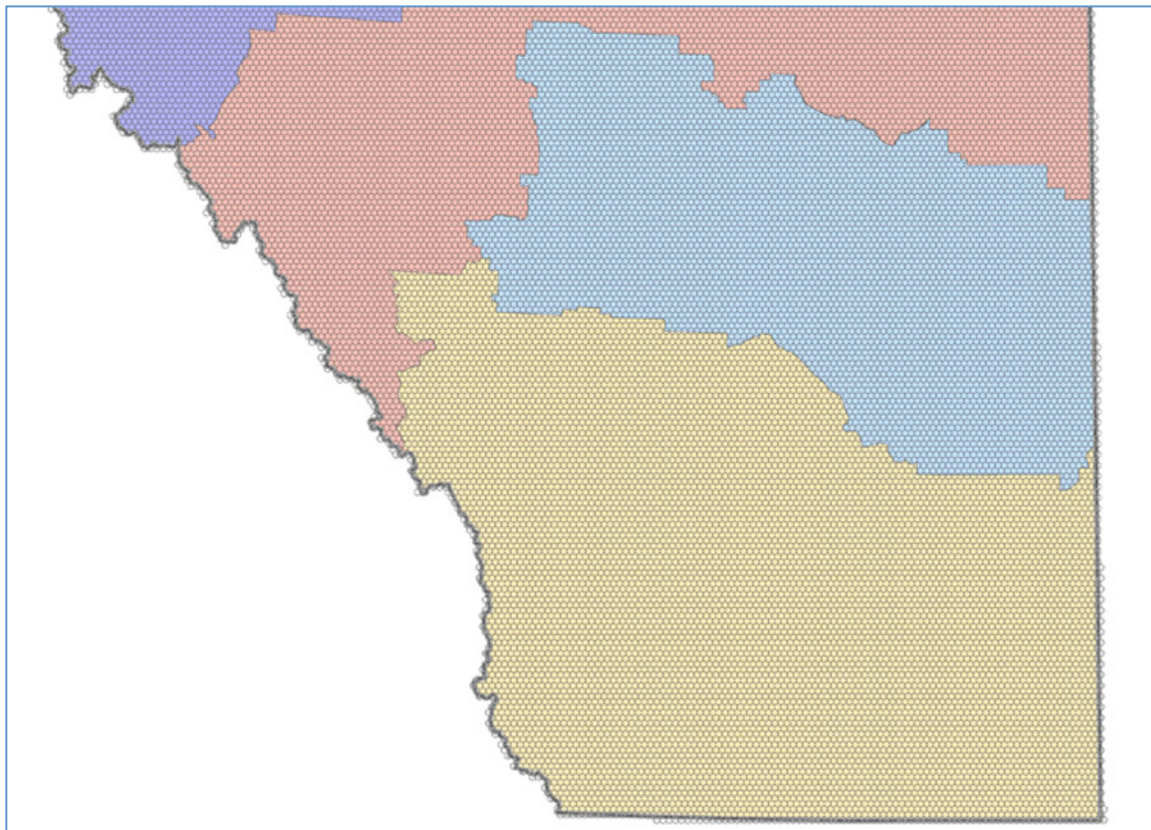
The *EScore* scoring tool uses the standardized outputs as the basis for scaled percentage scores (0.0-1.0) for each *Scenario Element*. The combination of all *Scenario Element* scores represent a unitless, standardized range for that user-defined *Scenario*. As well, through the *EScore* tool, the user will define their concept of the acceptable thresholds (i.e., choosing a 'red flag' level not to be exceeded), and potentially have an ability to slide the boundaries between the Poor/Fair/Good/Excellent ratings. This creates an ability to compare scores and measures between scenarios or between areas of interest chosen for different scoring runs, but not an ability to define an absolute score usable in all contexts (see *Using the EScore Tool in Relative Scenario Testing*, below).

### Standardizing the Map Grid and Resolution

As well as tabular form, the *ESA Modelling Portal* and the *EScore* tool produce results in map form, requiring the model outputs to have a consistent ability to produce map outputs. Standardization of the map outputs takes place at the level of the pre-processed model runs. Each model run, associated with a given scenario Element, produces outputs oriented to the same map grid. Those map grids can then be queried in a consistent fashion and combined by the map server.

The map grids will use a hexagonal pixel to discourage inappropriate consideration of the output maps. The rationale is as follows. All the ES models are optimized to operate at the regional level. Data developed and presented at a regional level cannot be interpolated or scaled down to a lower level without due caution. Land ownership in Alberta is largely based on the rectangular grid of the Dominion Land Survey. Rectangular pixel grids can unintentionally lead users/viewers to assume a correspondence when the map boundaries align with the ownership boundaries. Hexagonal grids visually dissuade map users from making these erroneous connections.

The chosen resolution for the map pixels is one hexagon for every 1000 hectares. The rationale is the same as described above (i.e., regionally-relevant data being presented at an inappropriately fine scale). The illustration below shows a 1000 hectare hexagon grid, overlain by an example regional scale division – in this case, the Land Use Framework regions.



*Figure 1: 1000 ha hexagonal grid relative to Land Use Framework regions*

### *DEVELOPING 'SCENARIO ELEMENTS'*

In order to facilitate web-delivery and scoring of the ES models' outputs, these need to be simplified. Both the modellers (Haddock and Greenaway 2013) and the Miistakis team agree that the computational needs of running these complex models in real time via the web interface would not meet the needs of users seeking to receive results in seconds rather than hours. Each

ES model is capable of providing a large variety of output datasets based on varying spatial extents, modelling parameters (i.e., 'levers' pulled), modified inputs, etc. However, each model is designed to produce outputs around a specific set of ecosystem service metrics (timber production, sediment retention, pollination service, carbon storage, etc.).

To facilitate web-delivery and scoring of the ES model outputs, a series of pre-processed outputs using prescribed parameters or constraints is being developed. Collectively, those constraints on the model run are intended to characterize plausible scenarios, with the output datasets representing the ES metrics as they would appear given the different scenarios. Each model output dataset represents one characterization of one of ES metric based on the prescribed modelling parameters. For example, in the Rangeland Forage and Carbon model, the two *metrics* are 'carbon storage' and 'forage production'. If the *constraints* or *prescribed parameters* used to create the model runs are 'low intensity grazing' and 'high intensity grazing,' the user would have the ability to choose Business As Usual, High Intensity Grazing, or Low Intensity Grazing, and could anticipate outputs (and associated scores) for 'carbon storage' and 'forage production' under whichever of these scenario options was chosen. The score for the area of interest chosen is computed based on the value of each metric under the scenario options chosen.

The term used to describe the resultant output datasets / user choices is '*Scenario Elements*.' Collectively, across all models, these elements combine to represent a single user-defined scenario for the chosen area of interest.

Currently, the models – and their outputs – are not integrated, meaning if (e.g.) each model has three scenario elements, then each model will be required to create three pre-processed runs, for a total of 15. However, the intent is that the models will eventually be integrated. To convert this process to accommodate the integrated model, the single model would need to be run enough times to cover all the permutations of the scenario element combinations. For example, in the case of each model having three options, the model would need to be run 243 times ( $3*3*3*3*3$ ) to account for every combination of three choices in five models. The web server equations would be similar, but need to query 243 output grids instead of 15.

To demonstrate this approach, Miistakis is working with the project modellers to determine representative scenario elements with which to prove the concept for the Beta *ESA Modelling Portal* and *EScore* tool (see *Preliminary Determination of Scenario Elements*, below).

### *USING THE ESCORE TOOL IN RELATIVE SCENARIO TESTING*

The *EScore* structure is designed to facilitate *relative* scoring rather than *absolute* scoring. An absolute score would be one that could be used in any context and used – or easily converted – to any other valuation system. A relative score is dependent on the internal logic of the methodology, and stretches the bounds of credibility when used in other contexts (e.g., using changes in measures of recreational satisfaction associated with an area to suggest increases/decreases in agricultural value).

Functionally, the key restriction in a relative scoring systems is that various output scores from user-directed scenario runs must be compared to other scores and ratings derived in the same manner (i.e., using the *EScore* tool). This allows for three basic types of scenario testing:

*Scoring a single area of interest with variations in user inputs* – In these cases, the user chooses a given area of interest (a spatial extent), makes selections associated with each model via the user inputs (i.e., chooses between *Scenario Elements*), then executes a scoring run. They can then repeat the scoring run, making different selections regarding scenario elements, and compare the resultant scores. This may occur in cases where the user wants to explore different dynamics associated with the same scenario, such as different management suites, different species guilds, etc.

*Scoring multiple areas of interest with the same user inputs* – In these cases, the user chooses a given area of interest, makes selections associated with each model via the user inputs, and executes a scoring run. The user can then repeat the scoring run, choosing a different area of interest, but maintaining the same selections for scenario elements. This may occur in cases where the user wants to explore how outputs in the target ecosystem services vary between different regions.

*Scoring with and without different models included* – In these cases, the user chooses a given area of interest, and identifies the models they wish to be included in the scoring run. They can then repeat the same run, using the same area of interest, but choosing a different collection of the models to be included in the run. This may occur in cases where they feel a given ecosystem service may not be represented on the chosen landscape, or their management mandate does not consider those services.

There are several examples of how relative measures of ecosystem service provision could be employed in land and resource management, including:

- *Selecting candidate conservation areas in regional planning* – The regional planning process in Alberta has indicated a preference for designation of ‘conservation areas’ to achieve overarching conservation goals. The selection of candidate areas which appear in draft regional plans could be based in part on their relative contribution to the provision of ecosystem services/
- *Prioritizing parcels for land securement for land trusts* – Private land conservation charities (land trusts) have limited resources to apply to securing parcels for conservation. Once a list of potential projects is developed, prioritization could be assisted by understanding the relative provision of ecosystem services by each parcel.
- *Comparing the impact of different management regimes on a given land base* – For land managers wishing to improve the ecosystem service provision of a given land base for conservation, regulatory or financial reasons, relative measures allow them to project and compare the impact on ES provision of different scenarios.



- *Establishing regulatory benchmarks* – Environmental regulatory thresholds currently tend to be based on establishing a maximum allowable amount of damage to an ecological system. Regulatory benchmarks could be established based on the provision of ecosystem services, with target levels of provision as well as minimum thresholds of provision.
- *Illustrating implications of land conversion scenarios* – One of the most significant impacts of land conversion from lower to higher intensity uses is the impact on ecosystem service provision. Relative measures of ecosystem service provision (decrease or increase) based on proposed changes can inform planning, visioning, regulatory and other applications. For example, measures could indicate percentage decrease in water purification ability, carbon sequestration and storage capacity, etc.

#### Cautions in Assigning Dollar Values to Scores

Related to the discussion of absolute versus relative scoring is the consideration of converting resultant scores into dollar values. In its simplest sense, this would be straightforward to do as the scores are all converted to a 0.0 – 1.0 range, mirroring a dollar. However, the authors believe that caution should be taken in translating outputs from a variety of modelling contexts into a single valued, monetized, and apparently-commoditized measurement system.

Despite their seemingly-universal application, dollar values are context-specific. Their use in ecosystem service valuation illustrates this. Some ecosystem service program applications seek out valuation, but not monetization (e.g., comparing parcels for potential protected status). Some applications seek out monetization, but not commodification (e.g., showing the relative economic impact of a given land use versus another). Some applications seek to both monetize and commoditize ecosystem services (e.g., payment for watershed service programs).

In the case of the ES models chosen for use in the *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* project, for example, the *Biodiversity* model can value, but not credibly monetize nor commoditize ecosystem services; the *Pollination* model can monetize, but not commoditize (increased yields of canola are the commodity, rather than pollination being the commodity); and the *Timber and Carbon* and *Rangeland Production* models may provide a commoditized value based on potential carbon trading markets and the per unit value of carbon prescribed there. Providing an absolute dollar value measure applicable to all is challenging.

The ES models are currently still under development, and at a future stage, it may be possible for the various valuation approaches to be synthesized, but at this point it would be inappropriate to develop an integrated, absolute scoring system based on dollar value.

## Overview from the User's Perspective

The steps in processing the model outputs for the portal and then scoring them are not necessarily linear. However, viewing the process from the more-linear perspective of the portal / EScore user provides a useful frame for understanding how the tools are intended to function.

### ***STEP 1: GO TO THE ESA MODELLING PORTAL WEB SITE***

The user wishing to access the *ESA Web Portal* and *EScore* tools would access a separate web site via the ABMI *Ecosystem Services Assessment* main project web site. A link would take them to the *Ecosystem Services Assessment Modelling Portal*, but the impression would be a seamless transition to another page on the main site.

The *ESA Modelling Portal* 'home' page would provide the user two main options. The 'Models' link connects to pages providing information about each model for the user's background knowledge, including listings of relevant papers, reports, sample runs, case applications, contact information, etc.

The home page would also include a link to the interactive tool, *EScore*.

Figure 2: ESA Modelling Portal – Home Page

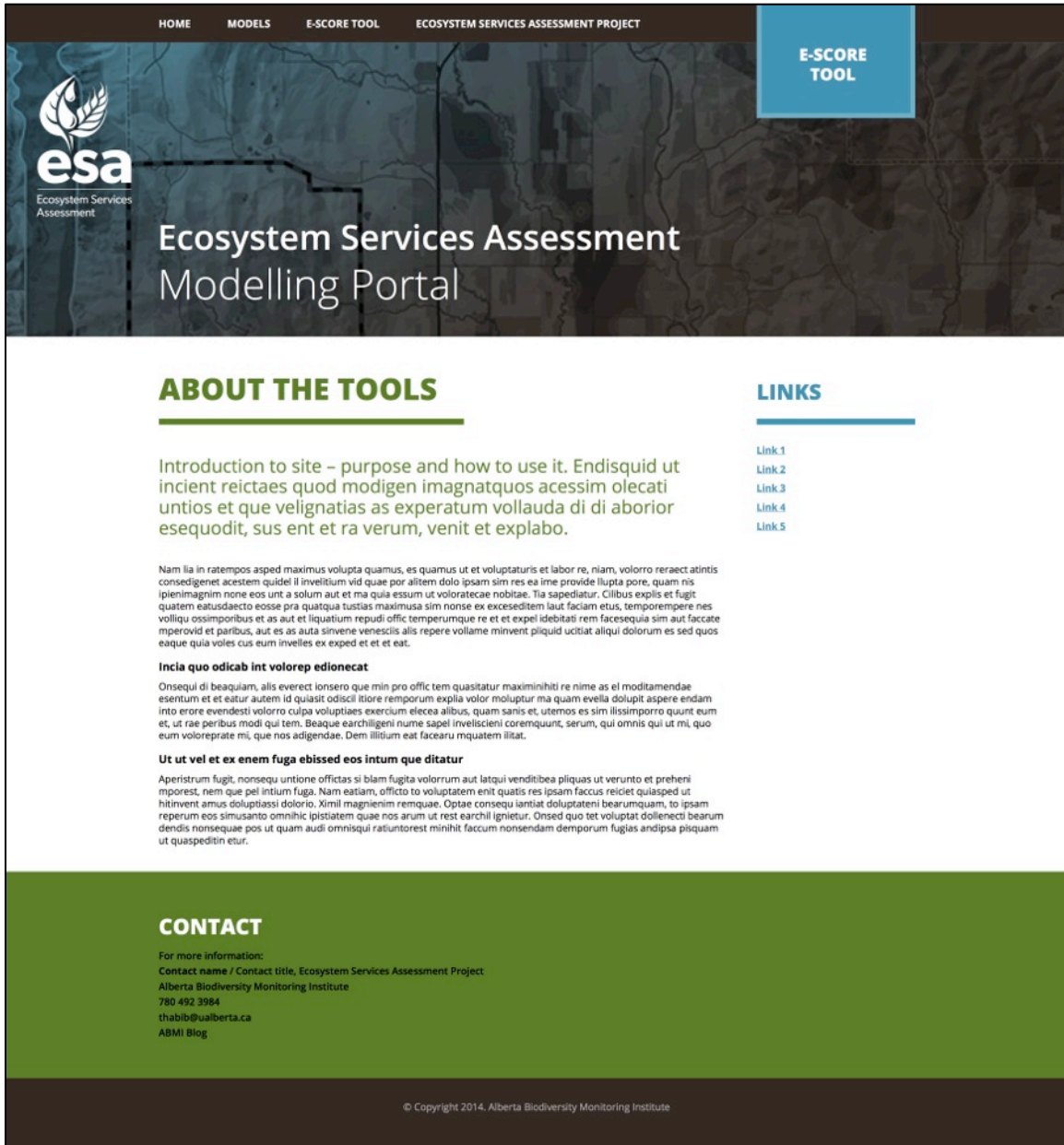



Figure 3: ESA Modelling Portal – Sample Models Page

HOME
MODELS
E-SCORE TOOL
ECOSYSTEM SERVICES ASSESSMENT PROJECT

Biodiversity Intactness
Biomass
Pollination
Rangeland Production
Water Purification



## MODELS

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### BIODIVERSITY INTACTNESS

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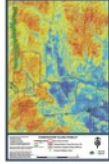
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**Reports and Papers**

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**Demonstration and sample map**

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**Contact and more information**

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## STEP 2: ACCESS THE INTERACTIVE ESCORE TOOL

Choosing the *EScore* link brings the user to the section of the site that allows them to choose and enter a series of prescribed ES modelling parameters and a series of scoring parameters for a given spatial extent. The interface will show tabs for the instructions, one for each model, one for the scoring input, and one for a map and scoring summary.

Figure 4: ESA Modelling Portal – EScore Tool Instructions Page

HOME MODELS E-SCORE TOOL ECOSYSTEM SERVICES ASSESSMENT PROJECT

Instructions Area of Interest Model 1 Model 2 Model 3 Model 4 Model 5 Scoring Input E-Score Summary Map

**esa**  
Ecosystem Services  
Assessment

## E-SCORE TOOL

### INSTRUCTIONS

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## STEP 3: CHOOSE SPATIAL EXTENT

As a first step, the user will select an *Area of Interest* from a map, upon which all calculations will be made, and which will be the basis of the ultimate scoring outputs. The interface will present a map of Alberta, where the user can zoom in, or drag a rectangle across to define a target spatial extent.

## STEP 4: CHOOSE SCENARIO ELEMENT

Each Model tab in the *EScore* tool will contain a list of prescribed choices for the user, each choice representing a different scenario element (e.g., sedimentation, timber production, carbon storage, species assemblage, etc.). Although each Model tab will present different options (as each model produces different outputs), each will provide a list of scenario elements which can be selected, and the ability to weight them differentially, if desired. The matrix of user choices across all models creates a scenario, based on the elements the user wishes to include and the user's weighting of their relative importance.

Figure 5: ESA Modelling Portal – Sample *EScore* Model Tab

The screenshot displays the E-SCORE TOOL interface. At the top, there is a navigation bar with tabs for HOME, MODELS, E-SCORE TOOL (selected), and ECOSYSTEM SERVICES ASSESSMENT PROJECT. Below this, a secondary navigation bar includes links for Instructions, Area of Interest, Model 1 (selected), Model 2, Model 3, Model 4, Model 5, Scoring Input, E-Score Summary, and Map. The main content area features the ESA logo (Ecosystem Services Assessment) and the title "E-SCORE TOOL". Below the title, the section "MODEL 1" is highlighted. The model configuration area includes a "Description" field with placeholder text, a "Factors to include:" section with three checkboxes labeled "Item 1:", "Item 2:", and "Item 3:", a "Range value:" section with a slider control, and an "Input value:" section with a text input field.

### ***STEP 5: POPULATE SCORE CARD PARAMETERS***

After the user moves through (and populates) all five of the model tabs, they move on to the Scoring Input tab. Here they identify the parameters used to guide the scoring. The user can choose which of the models they want to include in the scoring, their relative weightings if desired, whether they want to change the default ratings (corresponding to poor, fair, good, and excellent), and whether they want to set required minimum ratings. All of this would be reflected in the scoring summary for the chosen area of interest.

### ***STEP 6: PRODUCE OUTPUT (SCORE AND MAP)***

The final step of user input is to compile the score, via a single click. The resulting output page would summarize the scores, and provide a summary map for the chosen spatial extent. That summary would provide an overall score (0.0-1.0) and associated rating. That score would also be broken down into the scores for each ecosystem service modelled and their associated rating, a score and rating for each scenario element, and flags for any user thresholds that were exceeded.

## ***EScore Technical Overview***

The technical process underlying what the user sees while navigating the *ESA Modelling Portal* and the *EScore* tool breaks down into slightly different steps than those described above, largely due to an overlap in the tasks involved in creating (and integrating) the *ESA Web Portal* and the *ES Score Card*. The following three steps reflect a design approach based on the feedback from the ESA project modellers captured in the *Finding Common Ground* report (Haddock and Greenaway 2013).

The three steps are:

- Generating Prescribed Model Runs,
- Integrating Model Outputs, and
- Scoring Integrated Datasets.

### ***CREATING PRESCRIBED MODEL RUNS***

Because the user of the *EScore* tool will not directly operate the ESA models via a web interface, the first step in making the *ESA Modelling Portal* and the *EScore* tool functional is to generate a series of prescribed model runs (see Figure 6: *Technical Overview Step 1 – ES Model Runs*). These model runs will be based on a pre-determined set of scenario elements for each model.

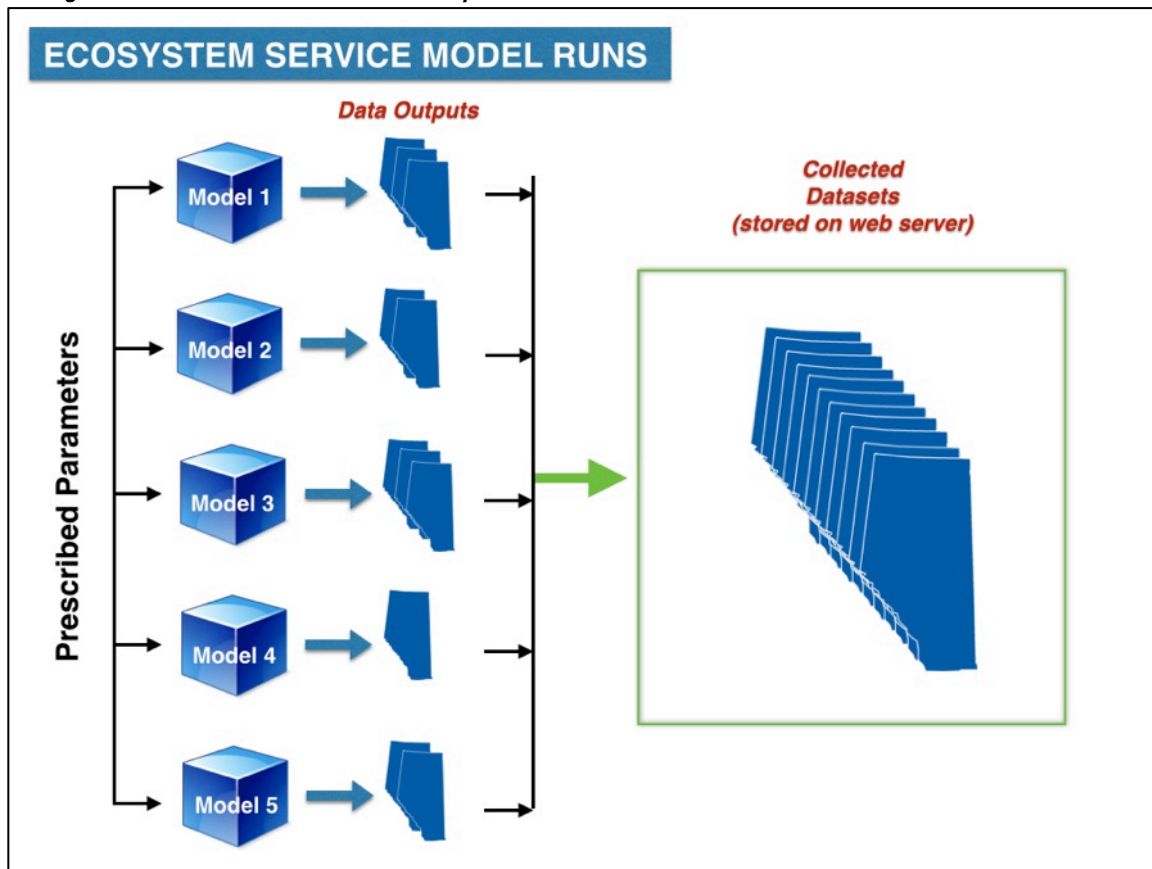
This pre-processing step involves identifying a series of input parameters for each scenario element. For example, with the Biodiversity Model, the scenario element would be *species*

*assemblages*, and the input parameters would be a specific set of species to be included in the model run. In this case, 'Game Species' might be one assemblage, or 'Rare Species' might be another.

The model would be run once for each scenario element, and an output data grid created each time which covers the entire province, using a hexagonal pixel pattern. As the models are all optimized for the regional level, grid cells will have an area of 1000 hectares. All datasets would be gathered in advance and stored on the *ESA Web Portal*'s web server, ready for integration and scoring based on user-directed input.

For the beta of the *ESA Modelling Portal* and *EScore* tool, two to three scenario elements will be identified for each model in collaboration with the modeller. The chosen scenario elements will represent those a user might plausibly want to test in scenarios, and be intended to prove the concept.

**Figure 6: Technical Overview Step 1 – ES Model Runs**





## *INTEGRATING MODEL OUTPUTS*

With the datasets output from the five ES models stored on the web server, the user is now able to refine how they would like the scenario elements integrated in preparation for scoring. They do this by identifying an Area of Interest and making scenario element selections. Those parameters will be used in mathematically integrating the relevant stored datasets. At the completion of this task set, there is a collection of server-stored datasets, refined by spatial extent, and adjusted based on the choice and weighting of scenario elements (see Figure 7: *Technical Overview Step 2 – Integrating Model Outputs*).

### Defining Area of Interest

When the user inputs an Area of Interest, the map server on *ESA Modelling Portal* uses that information to spatially focus all data integration tasks. Put another way, the map algebra combining the datasets as layers will apply only to the identified spatial extent. For the Beta *EScore* tool, the user will be able to define a spatial extent by zooming to a specific area of the map.

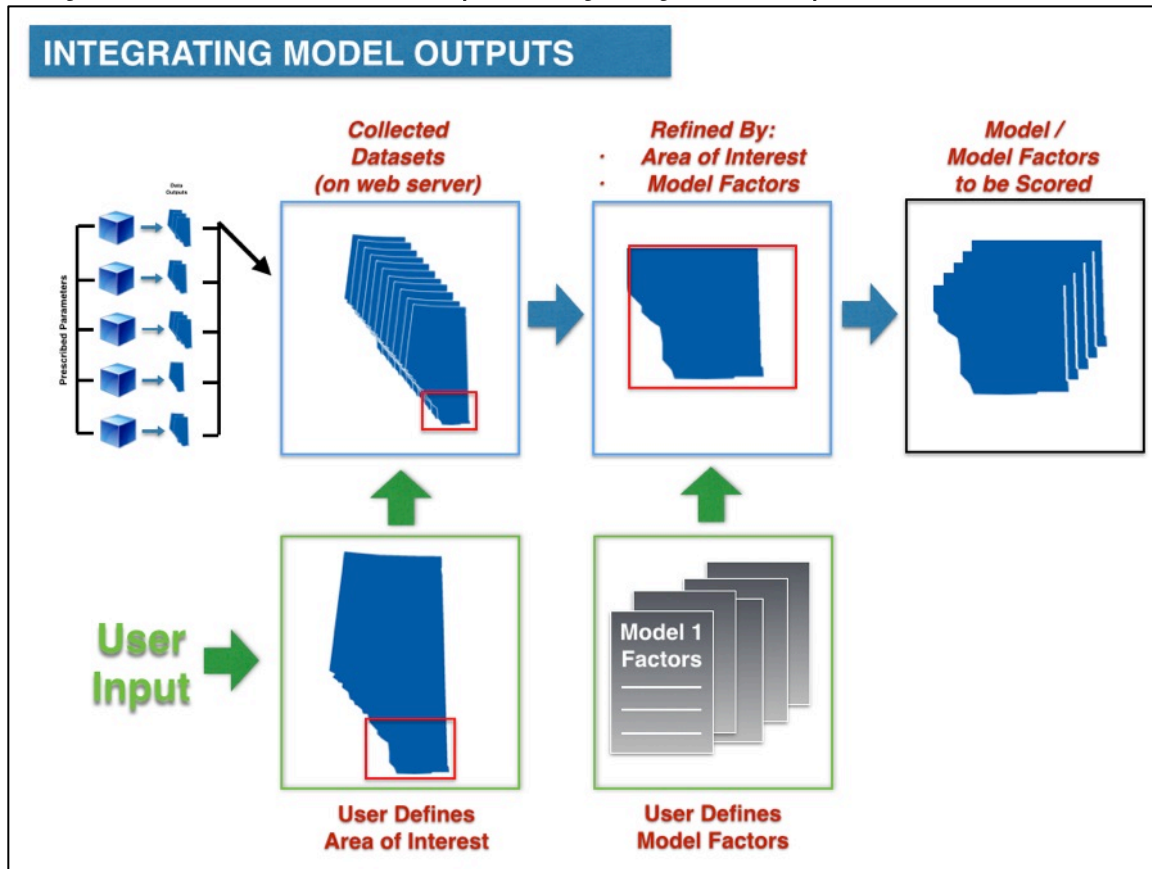
### Choosing Scenario Elements

The list of scenario elements is obviously different from one model to the next. However, each list of scenario elements will have similar characteristics in that the user can choose all or only certain of the elements, and can differentially weight them.

### Weighting

This is the first of two opportunities for the user to differentially weight model components in a way that affects the ultimate scoring. This first one applies at the model output integration level and refines how much importance is applied to different scenario elements as they combine to produce a single dataset representing that model. On each model tab in the *EScore* tool, the user can elect to have all chosen scenario elements weighted the same in the integration, or the user can enter a weighting value for each (from 0.0 to 1.0) which will be used to discount or inflate that element. The sum of weightings will be required to equal 1.0.

**Figure 7: Technical Overview Step 2 – Integrating Model Outputs**



### **SCORING INTEGRATED DATASETS**

Once the model output datasets are integrated based on the user’s input, they are available to be scored. Although the user sees data integration and scoring as a seamless set of actions, the scoring is a separate activity, based heavily on the user’s choice of scoring parameters (see *Figure 8: Technical Overview Step 3 – Scoring Integrated Datasets*).

#### Selecting Models for Scoring

In some cases, a user may wish to integrate the datasets from only certain of the five models. For example, knowing there is no rangeland, canola crops, timber production, etc. in the Area of Interest, the user may choose to leave those model datasets out proactively, to provide greater sensitivity in the derived scores of the relevant models. Through radio button choices, the user can indicate which models to include in the scoring.

### Weighting Models

This is the second weighting option for the user, this time affecting how the different models will contribute to the overarching summary score for the chosen area of interest. For each of the models selected in the preceding step, the user can choose the relative contribution in the scoring. Deviating from the default, which weights all chosen models equally, a user can enter a weighting value for each model (from 0.0 to 1.0) which will be used to discount or inflate that model in the scoring. The sum of weightings will be required to equal 1.0.

### Setting Rating Scales

The assumption behind the *EScore* tool is that raw numbers, even standardized ones, are of only minimal value in a decision-making context (e.g., an alteration in management action may be advisable for a 0.33 rating for one scenario factor, but not necessary until a 0.66 rating for another; the user may want to consider both of those the threshold for “Good”). Therefore, the user has the ability to identify four distinct rating categories along the 0.0 – 1.0 continuum: Poor, Fair, Good, and Excellent. A default will set the boundaries for each category (for example: 0.00-0.29 = Poor; 0.30-0.49 = Fair; 0.50-0.69 = Good; 0.70-1.0 = Excellent).

### Setting Required Minimum Ratings

In some cases, a high summary score may be an incomplete picture if certain scenario elements deemed critical are unacceptably low. The *EScore* tool will include an alert feature to help users explicitly identify those situations. A “Set Required Minimums?” option will be included for each model, and possibly for each scenario element. If checked, the Scoring Summary will report on whether the minimum rating was reached (though not affect the actual score).

### Scoring Summary

The Scoring Summary provides a tabular synopsis of the scores across the entire Area of Interest for each model and each scenario element, and identifies any minimum rating targets that were not met. Roughly, the structure of that table might look as follows:

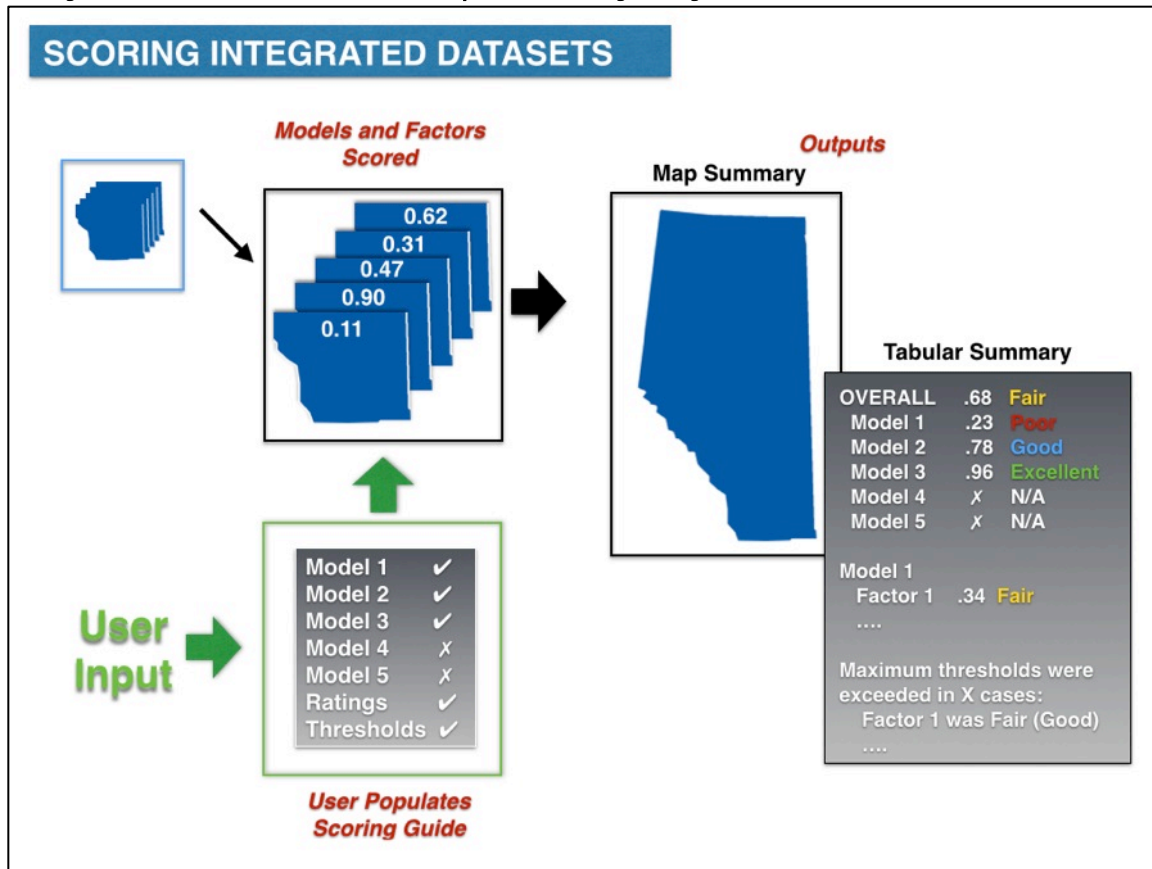
- Summary:
  - Overall: 0.45 – Fair
- Models
  - Model 1: 0.62 – Good
  - Model 2: 0.17 – Fair
  - Model 3: Not included
  - Model 4: 0.56 – Good
  - Model 5: Not included
- Scenario Elements
  - Model 1 – Scenario Element 1: 0.37 – Fair

- Model 1 – Scenario Element 2: 0.96 – Excellent
- ....
- Minimum Ratings: The following minimum ratings were unmet
  - Model 1, Target: Excellent; Rating: Good
  - Model 4, Scenario Element 2 Target: Good; Rating: Fair
  - ....

Map Summary

The results of the data integration and scoring tasks will also be represented on an output map. The map will represent the summary score by hexagonal pixel for the entire area of interest. A colour scale will represent high values/ratings as warm colours and low values/ratings as cool colours.

**Figure 8: Technical Overview Step 3 – Scoring Integrated Datasets**



**Preliminary Determination of Scenario Elements**

As described above, ‘Scenario Elements’ are the user options provided under each model in the *EScore* tool, which correspond to pre-processed outputs using prescribed parameters or constraints (see *Developing ‘Scenario Elements, p.12*). For the beta of the *ESA Modelling Portal*

and *EScore* tool, it will be necessary to choose a set of Scenario Elements for each model, and generate the associated model runs.

Ultimately, these must be chosen based on 1) their utility for users of the *EScore* tool, and 2) the feasibility and practicality based on the relevant model. As the models are still under development, and will ultimately be synthesized into one model, those changes will also significantly influence the ultimate choice of scenario elements. The following scenario elements have been developed for this concept paper by the Miistakis Institute team, and the associated model runs proposed. These are provided as a starting point for discussion with the ESA Project modellers in the context of creating a proof of concept, and will be finalized for the beta tools subsequent to those discussions.

Scenario elements are proposed for each model. The proposal begins with a description of each model in the context of its interface with the *EScore* Tool and the *ESA Modelling Portal* (for a more complete description of the models and their current status, see *Appendix 1: Ecosystem Services Assessment: Model Development Update – January 2013*, p.36). Following that are proposed scenario elements, and parameters for each set of pre-processed model runs.

## ***BIODIVERSITY***

The Biodiversity Model measures how species abundance differs under current conditions (with human footprint present) from what would be expected under reference conditions (if no footprint was present). This difference in current vs. reference abundance is calculated for hundreds of individual species, and then averaged across species to obtain an overall index of biodiversity intactness. For example, the model can explore expected number of species with the current human footprint (e.g., roads, buildings) compared with what would be there in the absence of human footprint. All of the data inputs are obtained from ABMI spatial data sets and the ABMI monitoring system. The species included in the biodiversity measure are weighted by their abundance in the region (e.g., the disappearance of a common species would decrease the index more than the disappearance of a species that was already rare). Intactness declines as species abundances decrease or increase relative to reference conditions (so a declining population and an invasive or overabundant native species all have a negative impact on intactness).

While the Biodiversity Model can provide an intactness score for all the species collectively, the modellers have indicated that the model can be run for assemblages or subsets of species. These assemblages may include mammals, plants, amphibians or some specific subset of these groups (e.g., large game species as a subset of mammals).

For the purposes of developing the Beta *ESA Modelling Portal* and *EScore tool*, Miistakis will suggest six useful assemblages of species. The modellers will provide feedback and select three of these assemblages for which they will run the model and determine intactness scores. These resulting intactness scores and the intactness score of all the species will be the scenario elements that will sit as a collection of datasets on the web server.

Through the *EScore* tool, the user will be able to select *all* species or any combination of the *assemblages* as an input for scoring. The user will provide input about the relative importance by weighting the assemblages of choice based on their overall question. The resultant number will be standardized on a 0.0-1.0 scale for the purposes of integrating and scoring the results of this model with the other models.

### ***POLLINATION***

The Pollination Model focuses on native pollinators and their links to crop yields. The model centers on canola, which is a widespread cash crop in Alberta that benefits from insect pollination. Canola typically self-pollinates; however, native pollinators in the area can also increase crop yields. The model is focused on the landscape context of a canola field as bees typically travel less than a kilometre from their nesting areas to fields. The model presents the opportunity to explore the costs and benefits of changes in pollinator habitat as a land use on crop yields.

The metric representing the pollination ecosystem service is the dollar value of a yield increase per patch of canola as a result of native pollinators. This dollar amount is influenced by the implementation of pollinator-friendly management actions (e.g., reduced insecticide use, maintenance of pollinator habitat patches) and the price of canola. The modellers are also able to change the land use cover layer thereby changing the amount of available pollinator habitat. For example, if canola prices are the same, as pollinator supply increases so should the potential value of pollination.

For the purposes of developing the Beta *ESA Modelling Portal* and *EScore tool*, the modellers will be asked to create three models runs. Using average canola prices for the past three years, the modellers will run the model for 1) current supply of pollinator habitat, 2) increased supply of pollinator habitat and 3) decreased supply of pollinator habitat. Through *EScore* the user will select a scenario. They will be provided information about the types of actions that resulted in the change of supply of pollinator habitat.

As this model only has one output (dollar value of increased yield) regardless of which scenario is selected, there will be no weight applied to the results of the run before it goes into the scoring input tab. The resultant number will be standardized on a 0.0-1.0 scale for the purposes of integrating and scoring the results of this model with the other models.

### ***FOREST TIMBER AND CARBON***

The Forest Timber and Carbon model was initially two separate models (timber production and carbon storage), however it was recognized that they needed to be formally integrated in order to capture the implications of harvesting timber on available carbon stocks (Haddock and

Greenaway 2013). This model simulates forest growth and links it to timber production processes and carbon processes (both sequestration and storage). The model does this to capture how decision-making can impact timber production values on the landscape and how those decisions can affect the spatial and temporal distribution of carbon stocks.

The modellers have indicated that this model can capture how changes over a 50 year time frame in management activities, mill capacity, input costs, wood production costs and/or carbon prices will affect timber production and carbon sequestration and storage. In other words, decisions external to forest growth affect the production of the provisioning ecosystem service of timber production and the regulatory ecosystem service of carbon sequestration and storage.

For the purposes of developing the Beta *ESA Modelling Portal* and *EScore tool*, two scenarios will be described based on one of the external actions – mill capacity. The modellers will be asked to run the model for three scenarios: Business as Usual scenario, Increase scenario (e.g., a 25% increase in mill capacity), and Decrease scenario (e.g., a 25% decrease in mill capacity). Through *EScore*, the user will be able to select the Business as Usual, Increase or Decrease scenario. From here the user will see a timber production metric and a carbon metric. These two numbers, after being standardized on a 0.0-1.0 scale for the purposes of integrating and scoring the results of this model with the other models, will provide an input to the scoring worksheet. In advance of the information going to the scoring input tab the user will provide input about the relative importance by weighting the ecosystem services (timber production vs carbon sequestration) based on the question they wish to explore.

### ***RANGELAND FORAGE AND CARBON***

The Rangeland Forage and Carbon Model includes forage production and carbon storage, using the CENTURY modelling platform (Haddock and Greenaway 2013). CENTURY is a complex model where biological processes are represented using mathematical equations and numerous outputs are possible. In essence, numerous parameters affecting carbon cycling (or forage production) can be included as an input or intermediary variable, and the user can access any of those variables.

As a result of using the CENTURY model there are many possible ways to express forage production and carbon storage. Some examples of how forage production can be shown include annual accumulation of offtake by cattle, either as total annual production or by the difference between the two. Similarly, carbon can be expressed as total carbon storage in the system including above- and below-ground vegetation, above- and below-ground litter, and soil carbon or some part thereof. The Rangeland Forage and Carbon model can be run to explore how land use scenarios and climate change affect changes in the provision of ecosystem services from rangelands.

For the purposes of developing the Beta *ESA Modelling Portal* and *EScore tool*, the modellers will be asked to create two models runs by changing the land use scenarios, specifically related to

grazing intensity. The first will be a scenario of Low Intensity grazing and the second one of High Intensity grazing. Each run will provide forage production as offtake by cattle, and carbon storage as total carbon storage.

Through *EScore*, the user will be able to select the Low Intensity or the High Intensity grazing scenario. From here the user will see a forage production score/number/metric and a carbon storage score/number/metric. These two numbers, after being standardized on a 0.0-1.0 scale for the purposes of integrating and scoring the results of this model with the other models, will provide an input to the scoring worksheet. In advance of the information going to the worksheet the user will provide input about the relative importance by weighting the ecosystem services (forage production vs. carbon storage) based on the question they wish to explore.

### *WATER PURIFICATION*

The Water Purification Model has been designed to capture the ecosystem service provision or supply of water purification services, in particular how precipitation, topography and landscape components affect overland flow and stream flow (Haddock and Greenaway 2013). Overland flow is then connected to water quality variables (Nitrogen, Phosphorus and sediment) to look at how these three pollutants are routed through the hydrological system including: where the pollutants came from, how they are moving through the system and where they end up. The model simulates the physical conditions (precipitation, soil type, etc.) necessary to support projections of the future status of this ecosystem service. The model captures the provision of the water purification, but not water purification itself. It explores how a given landscape generates a level of water purification and how changes in landscape/land cover might affect it. Everything in the model is tied to land cover, so the user could create and test scenarios in terms of ecosystem service degradation/augmentation by changing land cover.

For the purposes of developing the Beta *ESA Modelling Portal* and *EScore* tool, the modellers will be asked to create three model runs by changing the land use, specifically making the surface less permeable. The scenarios will include a baseline, a 25% increase in impermeability and a 50% increase in impermeability. Each scenario will show result of Nitrogen (N), Phosphorus (P) and sediment.

Through *EScore*, the user will be able to select the one of the scenarios and will see score/number/metric for each of Nitrogen, Phosphorus and sedimentation. These three numbers, after being standardized on a 0.0-1.0 scale for the purposes of integrating and scoring the results of this model with the other models, will provide an input to the scoring worksheet. In advance of the information going to the worksheet the user will provide input about the relative importance by weighting the ecosystem services based on the question they wish to explore.



## Known Limitations

There are a series of limitations that are known even at this conceptual stage. These need to be reflected in the instructions tab on the *ESA Modelling Portal*, and communicated to any potential user of the *EScore* tool to ensure maximum utility of these applications. As well, many of these can be addressed in a future iteration based on the intended synthesis of all the project models.

- The *EScore* tool requires the user to define the parameters which constitute a given scenario.
  - With direct operation of the ES models (and, in particular, their input parameters), a user has the ability to define a land use or management practice scenario based on the input parameters, and then run the model. However, using pre-processed datasets which have been output from the model requires that scenario development happens through manipulation of those outputs. Scenarios must be created by the user, through the collective impact of their various model selection, weighting, and scoring choices.
- The *EScore* tool is optimized for the regional level.
  - Because the *ESA Web Portal* and *ES Score Card* seek to integrate the five models, it can only credibly function at scales common to all models. The spatial scale at which the five ES models are all optimized is the regional scale (certain of the models may operate at other scales, but all are optimized at this scale). Caution must be taken in using the *EScore* tool at finer resolutions than that.
- *EScore* is a comparative tool, not an absolute scoring tool
  - The scoring tool provides scaled percentage scores (0.0-1.0) for each scenario element based either on a pre-determined scaling or a mathematical derivation (e.g., lowest modelled value to highest, median +/- two standard deviations). The combination of all scenario element scores represent a unitless, standardized range for that user-defined 'scenario.' As well, the user defines their concepts of the acceptable thresholds, desirable vs. undesirable scores, poor/fair/good/excellent. This creates an ability to compare scores and measures between scenarios or between areas of interest chosen for different scoring runs, but not an ability to define an absolute score usable in all contexts (see, *Standardizing the Model Outputs*, p. 10).
- The *EScore* represents the five ecosystem services and their scenario elements
  - When doing an assessment of a given land unit, it is important to clarify that only those ecosystem services modelled are represented in the *EScore*.
- Not all datasets are genuinely provincial
  - Not all land units across the province contain the circumstances that support production of all five 'ecosystem services.' To address this, the *ESA Modelling Portal* and the *EScore* tool allow users to omit models from the runs, but there is no automatic assessment and subsequent exclusion of inappropriate ES and scenario elements from the scoring.
- *EScore* scores are a snapshot in time

- The *ESA Modelling Portal* and *EScore* tool draw limited common temporal information from the ES models, and therefore have limited predictive capability. The summary score/map shows a land unit based on static circumstances. Some models do operate on a specific time scale (e.g., Forest Timber and Carbon model simulates a 50 year time frame). This has been accounted for by assuming current conditions (management practices, mill capacity) can be varied, and the associated future benefits/detriments to ecosystem service value are scored as a measure of the presumed future result, making them comparable to other models which do not project over that same time period.
- Rating scales of standardized scores must be set by the user
  - A simple 0.0-1.0 measure says little about the relative quality at various points on the scale. For example, for one scenario element, anything above .33 may be Good or Excellent, while for another, anything below .90 may be Poor or Fair. The judgement is necessary for the rating to have management applicability. While it can be informed by the data, that judgement is ultimately a value statement, and thus appropriately left to the user to define. However, the limitation is that different users may judge the same circumstances differently.
- Choice of scenario elements for one model do not affect other models
  - Currently, the five ecosystem service models are operated on separate five separate platforms; the ultimate goal is to have them all operate on one integrated, NetLogo-based platform. At this time, therefore, the pre-processed outputs of a given model stand alone from those of other models. This means that a choice of scenario element within one model (e.g., a change in mill capacity, limitation of water purification metric) will not affect another model, nor its scores.

## Moving Forward

The future activity related to the *ESA Modelling Portal* and *EScore* tool can be divided into two categories. There are a series of near-term 'next steps' all of which collective lead to the launch of a beta version of the *ESA Modelling Portal* and *EScore* tool for March 31, 2014. As well, there are a number of potential expansions to the functionality of those applications which could be contemplated in the future.

### ***NEXT STEPS***

#### 1. Circulate conceptual structures for comment from the modellers

This report and the mock-up of the *ESA Modelling Portal* will be circulated to the ESA Project modellers for review and comment. This discussion will lead to a finalization of the scenario elements to be used in the March 31st Betas.

## 2. Work with ESA Project modellers to develop pre-processed runs

After the final determination of the appropriate scenario elements, Miistakis will work with the ESA Project modellers to acquire the necessary datasets resulting from the associated model runs. These datasets will then be stored on the web server. This task will also include working with the modellers to develop a method for standardizing the model outputs and default ranking range to be used in the scoring tool.

## 3. Finalize the ESA Modelling Portal

Based on the conceptual structure described here and the portal mock up, the necessary background map algebra equations and web scripting will be created to make the *ESA Modelling Portal* functional. This will also involve final web design and creation of the mapping tool.

## 4. Finalize the Scoring Structure for the EScore Tool

Parallel with the finalization of the modelling portal will be the finalization of the scoring equations (as represented on the scoring input tab). This will involve the model and scenario element scoring, weighting, and ranking, and the coordination with the portal functions of integrating the datasets and producing a map-based summary output.

## 5. Launch the Beta ESA Modelling Portal and EScore Tool

The *ESA Modelling Portal* with integrated *EScore* tool will be launched (and be available on line) March 31st, with the functionality described above.

## 6. Transfer *ESA Modelling Portal* Web Site to ABMI

For launch, the *ESA Modelling Portal* (and *EScore* Tool) will be hosted on a web server and a map server which Miistakis regularly use. Once the web site is launched and tested, Miistakis will work with ABMI staff to establish the web site on the servers preferred by ABMI.

### ***POTENTIAL FUTURE FUNCTIONALITY***

As noted above (see *Web Portal and Scorecard Overviews, Proof of Concept*, p.10), the five ecosystem service models created as part of this project are still under development. One of the most significant future changes contemplated is the synthesis of all five models into one integrated model. Both the *ESA Modelling Portal* and the *EScore* tool have been structured with awareness of those evolutions, and an intent that they be able to adapt. The exact nature of those changes is as yet unknown, but the *ESA Modelling Portal* and *EScore* tool can accommodate, at a minimum, the following future expansions in functionality.

### Additional Models

If the ESA Project were to add additional ecosystem service models to the project, the *ESA Modelling Portal* and *EScore* could both be expanded to accommodate the additions.

### Additional Scenario Elements

As well as adding additional models, additional Scenario Elements could be added for each existing model. This would require identifying appropriate additional scenario elements for (that relate to existing elements), creating the associated model runs, and linking these scenario elements with the existing data integration and scoring mechanisms. Additionally, more complex scenario elements could be developed (i.e., more 'choices' within each model input sheet), allowing for more complex user-defined scenarios for scoring.

### Greater Range of Map Outputs

For beta purposes, the map output will be set to represent the summary score for the spatial extent chosen. In future, multiple map outputs could be chosen/created, allowing the user to see a map summary for each model and/or each scenario element, based on the individual derived score.

### Saving of User-defined Settings

In future iterations, the user interface functionality could be expanded to allow the user to save their input settings. This would require modifying the web site to allow for accounts to be created, and the association of saved settings with those accounts.

### Additional Areas of Interest

For beta purposes, the Area of Interest input function will be based on the area chosen when zooming to a specific area of the input map. However, future functionality could include pre-defined areas, such as Land Use Framework regions, natural regions, major basins, larger sub-basins, municipal district boundaries, or any other parsing of the provincial landscape at the regional level, available as a drop down list. Additionally, the interface could use a more specific extent tool defined by the user 'drawing' on the input map.

## References

Greenaway, Guy. 2014. *Scorecard Approaches in Natural Resource Management: Lessons and Paths Forward for the ESA Project Scorecard Application*. Prepared for the Ecosystem Services Assessment for Environmental Innovation and Competitiveness project. Miistakis Institute: Calgary, AB.

Haddock, Rachele and Guy Greenaway. 2013. *Finding Common Ground: An Assessment of the Needs and Challenges in Integrating, Scoring and Web-Delivering Ecosystem Service Model Outputs*. Prepared for the Ecosystem Services Assessment for Environmental Innovation and Competitiveness project. Miistakis Institute: Calgary, AB.

## Appendix 1: Ecosystem Services Assessment: Model Development Update – January 2013

*Tom Habib, Alberta Biodiversity Monitoring Institute*

### ***WATER PURIFICATION***

The water purification model represents hydrological processes in Alberta watersheds. In particular, the model was designed to identify source areas of pollutants, important areas for removing pollutants, and impacts to downstream water users. This dynamic model involves several processes:

- Precipitation, based on mean annual precipitation in Alberta
- Overland and stream flow, in which water moves to adjacent downhill parcels of land according to a digital elevation model, ultimately forming a stream network
- Pollutant loading, in which nitrogen, phosphorus, and sediment enter streams as water flows across the landscape, based on landcover type.
- Pollutant removal, based on landcover type and water flow rates
- Economic valuation of water purification, based on avoided costs to municipal water treatment plants

This model was initially developed for the North Saskatchewan watershed, so the principal next step is to expand the model across Alberta.

### ***RANGELAND FORAGE & CARBON***

Rangeland forage production and carbon storage were modelled simultaneously using the CENTURY ecosystem process model. This model incorporates monthly rainfall and minimum and maximum temperature, soil texture, latitude, soil depth, and fire and management regime. Using the model, we have developed preliminary estimates of aboveground forage production and above- and below-ground carbon storage for native grasslands in the South Saskatchewan Planning Region. We assigned a preliminary economic value of \$416M to forage, based on the cost of supplementary greenfeed (7M tonnes at \$59.10/tonne) needed to replace rangeland forage. The amount of stored carbon was estimated at 167M tonnes, which represents \$2.5B under Alberta's carbon price of \$15/tonne (however, under Alberta's current carbon offset market, payments are only made for additional carbon stored relative to a baseline, and not the total amount of stored carbon). Next steps include extending the model across all of Alberta's agricultural area, and validating model results with external field data. One potential source of data for validation is the ALMA-funded project "Baseline Quantification of Carbon Stored in Alberta Rangelands."

## *POLLINATION*

We have developed a model to assess the annual value of native bees as pollinators of canola grown in Alberta. Canola yield estimates attributable to pollination by native bees was based on empirical relationships developed from canola fields in northwest Alberta. Bee abundance was predicted based on the amount of uncultivated land within 750 m of canola fields, and canola yield was in turn predicted by these estimates of bee abundance. Using 2010 landcover data from ABMI and a 2010 crop map from Agriculture and Agri-Food Canada, as well as the average canola price in 2010, we extrapolated these models across Alberta's agricultural region. Based on these assumptions, we estimated the value of wild pollinators to canola production in 2010 as ranging from \$6,600 to \$28,000 per quarter-section, for a provincial total of \$505,000,000, or approximately 30% of the farm cash receipts for canola in 2010. Principal sources of uncertainty in this estimate include the role of managed pollinators such as honeybees, different strains of canola being used across Alberta, and different pollinator communities and landcover conditions in other parts of Alberta that may influence landscape-pollinator and pollinator-yield relationships. Next steps include refining and validating model outputs by conducting a field study of canola field across Alberta in collaboration with Dr. Jessamyn Manson of the University of Alberta, and expanding the present static model into a dynamic model that accounts for crop rotations from year to year.

## *FOREST TIMBER AND CARBON*

This model has been developed to simulate forest growth and carbon storage in Alberta's Green Area, as well as estimating the economic value of harvested timber and stored carbon. This dynamic model operates at an annual time step, and each step involves several processes:

- Forest growth (and carbon storage) based on established yield curves for forest stands published by Canadian Forest Service. Carbon storage curves were based on a published model, the "Operational-Scale Carbon Budget Model of the Canadian Forest Sector" (CBM-CFS3).
- Timber harvest by forestry companies, accounting for annual allowable cut and other regulations such as stand age and avoiding riparian buffer strips.
- Transport of raw timber to mills for processing and sale.
- Economic valuation of timber, based on the market price of forest products and harvest, transportation, and processing costs.
- Economic valuation of carbon stored across the landscape, based on Alberta's carbon price of \$15/tonne.

### *Earthworms Sub-model*

The effects of invasive earthworms represent a significant source of uncertainty in the estimates of carbon storage predicted by models such as the one developed in this project (see above). To

address this uncertainty, Dr. Erin Cameron of the University of Alberta developed a model to understand the likely impacts of invasive earthworms on carbon storage in the boreal forest. Dr. Cameron parameterized an earthworm-carbon simulation model using outputs from CBM-CFS3, and developed a spatial model of earthworm spread to calculate the total predicted change in carbon storage at the landscape-level resulting from earthworm invasions in northeastern Alberta. After a simulated 125-year period into the future, the forest floor carbon stock was predicted to be 13.2 Mg/ha with earthworms present versus 21.1 Mg/ha when earthworms were absent, representing a 37% decline in stored carbon. Next steps include submitting a manuscript for publication, and incorporating Dr. Cameron's results into the core Forest Timber & Carbon model.

### ***BIODIVERSITY***

In addition to ABMI's core field monitoring activities in 2012 and 2013, funding from ALMA and Alberta Innovates Bio Solutions contributed to the additional sampling of 24 "off-grid" sites in relatively undisturbed southern Alberta rangelands and relatively disturbed regions of the boreal forest. Because of the scarcity of such sites in Alberta, this additional, targeted sampling effort was necessary to develop ABMI's statistical models. Through the data collected from these field efforts, we have extended ABMI's existing biodiversity intactness model to all natural regions of Alberta, including the Grassland and Parkland Natural Regions. Biodiversity intactness is a percentage value, in which areas that are completely untouched by human development are considered to be 100% intact, and sites that have been completely disturbed (e.g. a parking lot or open-pit mine) are considered to be 0% intact. The capacity to represent biodiversity intactness as a function of human footprint present has been built into the NetLogo platform to integrate with the other ecosystem service models.