Finding Common Ground:

An Assessment of the Needs and Challenges in Integrating, Scoring and Web-Delivering ES Model Outputs

December 2013

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MIISTAKIS INSTITUTE

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Executive Summary

Ecosystem services are fast evolving to be a core consideration in our use and conservation of the landscapes we inhabit in Alberta. As part of the Alberta Biodiversity Monitoring Institute (ABMI) *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* project, the Miistakis Institute is developing an *Ecosystem Services Score Card* and an *ESA Project Web Portal*. This report summarizes the information gathered by the Miistakis Institute through two series of interviews with key stakeholders, intended to inform the development of those applications.

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. The goal of the *ESA Web Portal* is to facilitate interactive use of the derived data and models, and associated resources. It was decided that at this stage the best use of *ES Web Portal* effort was to focus on 'animating' the *ES Score Card*.

To inform the design and delivery of the portal and the score card, a two-part process was undertaken, first canvasing key informants on perceptions of the ultimate end use of the project applications, and second interviewing ESA Project modellers to explore the connections between the models and the *ES Score Card* and *ESA Web Portal*. The results informed the questions of what is scoreable, what is integrateable, and what opportunities and limitations exist for web delivery.

After providing overviews of the model, modellers provided input on integration with other models, data inputs and access, measurement and valuation, interactivity, web interface and delivery, scale, and scoring and web delivery functionality. As well as informing the ESA Project, broadly applicable lessons learned centred on the implications of varying degrees of clarity around use/user/goals, the need to consider spatial and temporal scales, considerations for integrating multiple models, and the desirability of map-based outputs.

Though there are significant challenges in integrating the form and outputs of the five ecosystem service models, *ESA Project* modellers feedback was very instructional, the models integrative capacity appears robust, and identified issues are manageable. In moving forward, circumstances to manage include: differences in model platforms, stage of development, valuation methods, perceived utility, and desired interactivity; need for functionality to evolve; limitations in real-time modelling; identification of workable spatial scales; and integrating/separating score card and portal.

This report will inform the ES Score Card and ESA Web Portal regarding pre-processing of modelling outputs, scoreability of models, interactivity options, integration of model scores, setting spatial resolution, accommodating future project evolutions, and integrating the web portal and the score card into a single tool.

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Introduction

Ecosystem services are fast evolving to be a core consideration in our use and conservation of the landscapes we inhabit in Alberta. Ecosystem services represent the benefits people get from ecosystems, and those contributions may be recognized as supporting (e.g., soil formation, wildlife habitat), regulating (e.g., water and air purification, flood regulation), provisioning (e.g., food and fibre, fuel, water), or cultural (e.g., aesthetic, recreation).

As part of the Alberta Biodiversity Monitoring Institute (ABMI) *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* project (see *Project Background*, below), the Miistakis Institute is developing tools and applications to mobilize the knowledge gathered and created within the project. Specifically, those are an *Ecosystem Services Score Card* and an *ESA Project Web Portal*.

This report 1) summarizes the information gathered by the Miistakis Institute through two series of interviews with key stakeholders, and 2) provides resultant data, conclusions and analysis intended to inform the development of the *ES Score Card* and *ESA Web Portal*.

Project background

Ecosystem Services Assessment for Environmental Innovation and Competitiveness

The purpose of *Ecosystem Services Assessment for Environmental Innovation and Competitiveness* (ESA Project) project is to establish relevant and credible systems for assessing ecosystem services and biodiversity across Alberta. This includes 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 Score Card*; and development of a project *Web Portal*.

ES Score Cards

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. Ultimately, this approach will take a twin focus on a higher-level methodology and a localized proof-of-concept. Initial tasks are focused on identifying an appropriate score card structure.

Due to the wide variety of potential score card audiences and purposes, this objective requires a balance between creating a broadly-applicable method and localized effective applications. This involves a scan of existing resource management score carding initiatives, identifying/working with score card applications to determine needs, clarifying the necessary ecosystem services and modelling/data supports, and drafting a conceptual score card structure.

Future tasks will include refining the score card structure and interface, exploring methodologies to incorporate derived data from ecosystem service and biodiversity models and other relevant information, testing score cards with target users, and identifying web-delivery options.

ESA Web Portal

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. Additional functionality may be added as the project evolves. The intent is that all spatial data and maps developed will be made publicly available via a web-based portal. This effort is cost-shared with ABMI's *Biodiversity Management and Climate Change Adaptation* project, *Full-coverage Biodiversity Mapping* project, and other related projects.

A detailed understanding of the audiences for the portal is expected to evolve as the project progresses, but initial target audiences include decision makers, other ecosystem service academics and modellers, and Government of Alberta personnel (in particular Alberta Environment and Sustainable Resource Development and Alberta Agriculture and Rural Development).

As the *ESA Project* evolved, the complexity of defining the role for the *ESA Web Portal* increased, as ABMI redeveloped their own web-based data-delivery portals, at least one of the *ESA Project* partners developed their own web-based portal, and the *ESA Project* evolved to the point of needing a dedicated web site (which became the obvious and capable place to host/serve reports and static data sets). As well, the project models development and integration would not be at a point where they would be seeking advanced web-serving and model-integration functions within the time line established for the delivery of the *ESA Web Portal*.

It was decided that at this stage the best use of *ES Web Portal* effort was to focus on 'animating' the *ES Score Card*, using that set of actions to both increase the potential functionality of the *ES Score Card* and lay the groundwork for future advanced web-based capability of the ES models. This approach would tie directly to the models/modellers, provide a proof of concept, help understand/prescribe approaches to future model web delivery as functionality and demand increases, facilitate integration with the other portal efforts, and provide a value-added component to the *ESA Project* web site.

Methods

In order to inform the design and delivery of the *ESA Web Portal* and the *ES Score Card*, the Miistakis Institute sought to understand the ultimate end use of the ecosystem service model outputs. This was undertaken in a two-part process.

In the first stage, the goal was to canvas input on the perceptions of the ultimate end use of the ESA Project models and applications. The dilemma which ultimately arose is how to divine the motivations and needs of users before those users (and the associated uses) have been identified. A standardized set of questions was created and posed to members of the project team and representative Government of Alberta staff, and was then combined with preliminary feedback from the project Advisory Committee (see this report's appendices, under separate cover, for details on those questions).

Results from that first stage indicated a strong sense of broad potential user groups (e.g., government agencies, municipalities, landowners, conservation groups). However, there was limited specificity, making identification of specific users (i.e., those who could be interviewed) challenging.

At the same time, it became apparent that there was a strong sense of the *modelling* need. Five ecosystem service models (and their key parameters) had been chosen by the project team at the outset. This indicated that 1) a consideration of potential uses/users had driven those selections, and 2) second-guessing those choices was neither appropriate nor viable at this stage. Also, the form of the score card and portal from a technical perspective would need to be driven by the capabilities and limitations of the ESA project models.

For the development of the score card and the web portal, the logical approach was, therefore, to focus on the models, and by extension the modellers as a proxy for the users. Their approach, assumptions and choices would reflect an inherent sense both of who might use the raw materials of the project, and of the impact desired from the users wielding this information.

For the second stage of the process, the focus continued to be on supporting design and development of the *ES Score Card* and *ESA Web Portal*, with a greater level of detail. The ESA Project modellers were given a standardized set of questions developed to explore the connections between the models and the *ES Score Card* and *ESA Web Portal* (see this report's appendices, under separate cover, for details on those questions). These investigated:

- Opportunities and challenges to the conceptual and technical integration of the models and/or their outputs with each other;
- Valuation philosophy, models and methods underlying the models;
- Modeller knowledge and desires regarding model functionality and interactivity; and
- Technical considerations in connecting the ES models with the *ESA Web Portal* and the *ES Score Card*.

The results of the information from these two exercises will allow the Miistakis Institute to understand:

1. *What is scoreable* – Which facets of the models lend themselves to scoring, and how the different outputs, valuation philosophies, supply/demand calculations, and scaling approaches affect scorability.

2. *What is integrateable* – Which characteristics of the models support or confound a synthesized consideration of the input data, representation of model scores, and production of summary maps.

3. *Opportunities and limitations for web delivery* – Which features of the models lend themselves to interactivity, what challenges exist in web-delivering data, and what needs may exist for pre-processing model outputs for the web environment.

Model Overviews

The first step in understanding the connections between the models and the score card and portal applications was to understand what each of the ESA Project models was developed to accomplish. The modellers provided the following descriptions (summarized by the authors).

Biodiversity

The Biodiversity model measures how individual 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 versus reference abundance is calculated for hundreds of individual species, 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, farms) compared with what would be there in the absence of a human footprint. All of the data inputs are informed by 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 very 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).

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. The model is entirely integrated in the sense that they are in the same model. This model simulates forest growth and links it to timber production processes and carbon budgeting 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.

Pollination

The pollination model focuses on native pollinators and their links to crop yields. The model focuses on canola, which is a widespread cash crop in Alberta that benefits from insect pollination. Canola can typically be self-pollinated, 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 kilometer 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.

Rangeland Forage and Carbon

The Rangeland Forage and Carbon model includes forage production and carbon storage. After reviewing a number of models, a widely-used grassland-process-based model of ecosystem dynamics called the CENTURY model was selected. This model has a number of sub-models including plant production[1]. CENTURY is a complex model where biological processes are represented using mathematical equations, and there are numerous outputs. In essence, anything that affects carbon cycling is included as an input or intermediary variable, and the user can access any of variables. For the Rangeland Forage and Carbon model, forage production will likely be offtake from cattle (annual accumulation of offtake) and total carbon storage in the system (including both above- and below-ground vegetation, carbon in litter (above and below) and soil carbon). The CENTURY model outputs everything. The model uses soil information and climate information although there are other parameters that have been estimated for similar systems that can be used for the Rangeland Forage and Carbon model. The CENTURY model is point based, but the i-CENTURY platform was developed to run multiple sites at a time. The point-based sites link back to a map enabling it to make a spatially explicit model. The Rangeland Forage and Carbon model uses the AGRASID soils data set (based on expert opinions of polygons of any size with consistent soil properties) and climate WNA (downscaled and extrapolated to 4km) for climate data. The soil polygons have an average size of 10km^2. The Rangeland Forage and Carbon model will be run for various scenarios looking at how land use scenarios affect changes in the provision of ecosystem services.

Water Purification

The water model has been designed to capture the ES provision or supply of water purification services, in particular how precipitation, topography and landscape components affect overland flow and stream flow. Overland flow is then connected to water quality variables (N, P and sediment) to look at how these three pollutants are routed through the hydrological system: where the pollutants came from, how they are moving through the system and where they end up.

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[1] CENTURY also has a Soil Organic Matter sub-model.

The model simulates the physical conditions necessary to support future assessments of this ecosystem service. The model captures the provision of the ES but not the ES itself. It does not look at demand but how a given landscape generates a level of water purification and how changes in landscape/land cover might impact it.

Synthesis of Modeller Feedback

As this is an interim report with the intent of conveying the feedback gathered thus far, these summary comments should be considered as *observations*, rather than *conclusions*. This section informally identifies some trends that appeared in the gathering of the information, some apparent associations, and instances where multiple comments collectively suggest a potential path forward.

The next steps of the *ES Score Card* and *ESA Web Portal* work will be directly informed by this raw information. It is therefore logical to identify some of the potential avenues for applying this information to those tasks. As noted previously, the most important synthesis will be reflected in the conceptual frameworks for the *ES Score Card* and the *ESA Web Portal*.

Integration with Other Models

- Although integration or coordination of the models has been considered at different points by the different modellers, there was general agreement that there was no pre-conceived mechanisms for integrating the five models.
  - There was also general agreement that integration of some type, even at a generic level, was desirable
- Challenges to integrating the models included:
  - Different spatial foci (e.g., Forest Timber and Carbon focused in the 'Green Area'; pollination and Rangeland Forage and Carbon focused in the 'White Area')
  - Different modelling platforms (four use NetLogo, one uses CENTURY)
  - Lack of integrated data sets
  - Deficient computing power to simultaneously run multiple models
  - There is a range across the models of the types and numbers of outputs produced
- Suggestions for potential links focused more on bilateral options (i.e., between two models) than on collective (i.e., all five models)
  - Suggestions for most likely integration opportunities included:
    - Pollination and Rangeland Forage and Carbon
    - Forest Timber and Carbon and Water Purification
    - Rangeland Forage and Carbon and Water Purification
  - Water purification was most referenced as a potential integration partner
- Integration options often referenced *linear* relationships, wherein outputs of one model were seen as potential inputs for another model
- Potential for integration was seen:

    - At the input level (e.g., common land cover data, similar spatial extents, etc.)
    - In creating standardized modelling contexts, common but tailored to each model (e.g., common scenarios, linked spatial extents, common land use change parameters, management practice suites)
    - In juxtaposing (rather than synthesizing) multiple outputs to create a collective illustration
- Limited potential for integration was seen in:
    - Synchronized model runs for synthesized outputs
    - Mechanically synthesizing the various model outputs after the fact
- Concern was expressed that the models required individualized development and testing before integration could be considered

Data Inputs and Access

- Potential for user-directed data uploads varied, although no model had this conceptually included at this time; some models have limited potential but would require careful structuring to accommodate
- Opportunities for unsupervised user-directed manipulation of existing model parameters (i.e., "levers" that can be pulled) varied considerably with some models having no potential
- User defined opportunities
    - *NB: "user" means unsupervised user, that is, someone who is using the model without the hands-on assistance of the modeller*
    - Input data sets – input data sets are generally set, but there are some opportunities for updating those data
    - Model equations – the equations that define the relationships between the data are set
    - Scenarios – there are some options for users to create/test scenarios
- Confidence in input data (and thus outputs) is a recognized issue by all modellers; in general, variations in confidence are not represented to users
    - Potential strategies for addressing/representing confidence/uncertainty issues included using allowing users to move 'sliders' to manually account for known variations in confidence, including manipulating variations over time, running multiple analyses with min/max values of key inputs/parameters to establish bounds of confidence, validation exercises to compare outputs to field measurements, and reliance on credibility of modelling platforms to indicate robustness

Measurement and Valuation

- In general, the models had a clear conception of the separation of the ecosystem function and ecosystem service, though the ability to explicitly tease out the 'service' measure varied considerably between the models

- The models varied in their supply and demand calculations for ecosystem services in that some allowed for that calculation to happen within the model, while others required a third-party assessment of outputs
- Most models were at least geared toward measuring a market or exchange value (as opposed to comparative or monetized values), though some indicated they currently use a comparative or monetization approach
- The dollar-based valuation methods variously used market methods, production approach, and replacement cost, though some indicated the capacity/intent to expand to others

Interactivity

- Most models included parameters which a user could manipulate, mostly based on cost variables and management practices
  - Forest Timber and Carbon – input costs, wood product prices, carbon prices
  - Pollination – canola price, landscape/bee abundance
  - Rangeland Forage and Carbon – grazing intensity, land use
  - Water Purification – P, N, and sediment; land use change
- Most, but not all, models accommodated scenario testing
  - Fewer were able to accommodate scenarios which tested trade-offs
  - None indicated a native or intrinsic way to identify and monitor thresholds

Web Interface and Delivery

- The development or translation of all models into a NetLogo platform was seen as route to relatively straightforward web delivery
- Challenges identified included:
  - Incorporating data at appropriate resolutions (for both accuracy and web delivery)
  - The need for pre-processing (inability to generate model runs on the fly)
  - Uncertainties in the translation of all models to NetLogo
- Map products were seen as the primary outputs for web delivery
- No significant issues with data access were identified
- Conceptually, there were no issues seen with web-delivering scenario testing, trade-offs, and threshold setting, though that is likely subject to the above-stated limitations in those functionalities
- Tiling of outputs was recognized as important in general as well as for web delivery of model outputs, and there are various efforts at different stages already to accomplish this

Spatial and Temporal Scale

- The models are all operable at a variety of spatial scales, however they are optimized mostly at the local and regional level:
  - Biodiversity – local or regional
  - Forest Timber and Carbon – regional
  - Pollination – parcel-specific or local

  - Rangeland Forage and Carbon – local
  - Water Purification – regional
- Currency of input data was not seen to be a significant issue
- The models vary considerably in how they address temporal resolution with some recognizing they are a snapshot in time, some data sets unaffected, some reliant on the quality of projections in the input data, and some indicating it is a vexing issue.

Scoring and Web Delivery Functionality

- Several models suggested aspects that lend themselves well to being scored in an ES score card
  - Biodiversity – suggested having an overall intactness score and then the ability to pull out different species for different audiences or regions
  - Forest Timber and Carbon – suggested scoring the timber production value (in merchantable volume or dollar values; spatial location captures transport cost), and carbon stock where the standing stock of carbon is measured/scored
  - Pollination – suggested link between pollinator supply and pollinator value; ES score card could be used to explore pollinator value under different management/pollinator scenarios, showing room for improvement in terms of environmental management and bottom line
  - Rangeland Forage and Carbon – site specific exploration of various outputs
  - Water Purification – suggested rating biophysical functions based on different scenarios, then showing percent change, increase/decrease, range of values, ten point scale, etc. (*NB*: need to have scenarios outlined in order to capture how things change, and a score/rating for the baseline and alternative scenarios)
- The modellers generally did not make a strong distinction between the characteristics they would like to see scored in a score card versus those they would like to see web delivered, suggesting they see the primary role of the *ESA Web Portal* to animate or provide functionality to the *ES Score Card*
- The suggestions around web delivery of the models indicated a strong expectation the *ESA Web Portal* would deliver model outputs (versus, or example, access to data sets, on-the-fly model operation, pre-packaged scenarios, reports, etc.)
- When suggesting characteristics of their model they would like to see reflected in a web-delivered format, modellers indicated the following:
  - Biodiversity – explore land use change impacts on ten species, and perhaps checklists of groups of species
  - Forest Timber and Carbon – outputs are map values at an interesting resolution that can easily stack on top of the other outputs to produce score card-related information
  - Pollination – advanced model functionality such as being able to choose the rotation year/how long a rotation is being used (*NB*: would require some additional work on the model).
  - Rangeland Forage and Carbon – model outputs

- Water Purification – integration with the other model outputs; could link with other models and their outputs in creating an overlay to create a score card which could look at how each parcel of land is providing different services

Lessons Learned

Though the interviews and reviews of materials were focused on the development of the ESA Project's Score Card and Web Portal, there are a number of lessons learned that could inform other similar efforts to develop scoring and web-delivered ecosystem service tools, especially ones that seek to integrate multiple models and their outputs.

Lack of clarity on intended use leads to lack of clarity on intended users

Many people consulted in the first round who had been identified as potential users of the ES project applications responded with questions regarding what were the potential uses conceived at the outset. The more defined the potential application (even in a theoretical form), the easier it is for potential users to be identified, and for those users to identify how they might use a score card or a portal.

Variations in valuation methods can confound model integration

Models that seek to value ES variously use comparative, monetized, or commoditized valuation methods. The first lends itself well to assessing different land use or management scenarios, while the last lends itself well to informing market-based trading. The level of detail required in market transactions tends to be at the parcel level, while the comparative (and to a lesser degree, the monetized) tends to be at the large landscape scale. For applied uses (such as scoring and map-based tools), integrating models that use different valuation philosophies can confound their ability to be credibly synthesized.

Users should be consulted prior to selecting ES models

Especially in the case of models intended to be applied in a resource management or land use context, it is ideal to consult those envisioned as ultimate users prior to selection of the ecosystem services and the associated modelling platforms. Those individuals/organizations/agencies can then be involved in the framing of the decision context, and the chosen ES / models can be directed at identified needs from the outset.

Spatial resolution of integrated models should be common

Scoring or porting model outputs for applied uses can be confounded by significant variations in the spatial resolution for which the models are optimized. For example, ES valuations for programmatic applications (especially those associated with payment programs) require a fine resolution to be able to identify who specifically is benefitting from or providing the service. ES valuations used to support arguments for/against land conversion require much coarser-scale information. Scoring those varied-scale valuations together can stretch the credibility of the resultant numbers.

Web-based interactivity of models is constrained when running multiple models

ES models are typically complex, and individual runs may take hours. To web deliver these models, simplifications are required to ensure the results can be provided in a timely manner. This challenge (and the resultant simplification) increases exponentially as multiple models are added.

Generalized user definitions work with coarse-scale applications

In cases where users are not, or cannot be, identified in advance, generalized definitions of users can be used with coarser-scale applications. Generalized user descriptions include "landowners", "government agencies", "ranchers", "municipalities", and "conservation groups." Broad-scale associations and hypotheses can be made between coarse-scale user groups and coarse-scale landscapes (watersheds, planning regions, land use types). Expectations of specific land management, policy, or market changes requires a more explicit understanding of who the user is and what their motivations for changes in behaviour might be, and thus a more explicit understanding of the character of their specific land base.

Map-based outputs are most desired

Map-based outputs provide a simplified and visual representation of ES valuation, relative scoring, and/or varied model results. As such, they tend to be the output of choice for ES valuation, scoring and portal delivery. However, caution should be taken that it is much harder to control the misconceptions that arise in that integrated output form. Challenges include representing to the user variances in confidence of outputs, gaps in input data, and misperceived alignment with physical boundaries.

Score cards are points in time, while models are generally projections

Scoring model outputs has a fundamental challenge in that score cards are created (or perceived) as points in time; a single measure at a single moment. However, models are (generally) designed to project into the future. When combining multiple models, it is inescapable to have scenarios where one ES is being scored based on its perceived future contribution, while another is being scored based on its current contribution (with the expectation it will remain constant into the future).

Scoring systems need a clear goal to guide them

Generic scoring of ecosystem services is fraught with challenges based on the dynamic nature of ecosystem services and the intended simplifications in the underlying models. A given ecosystem service (e.g., recreational value) has multiple facets, not all of which may be of interest to a given group at a given time and place. The underlying valuation measures are based on a myriad of modelling assumptions, data limitations, and management response assumptions. A clear goal regarding the need for a scoring system clarifies the process, allowing the score card developer and the intended user to agree on which assumptions are of key interest and importance, and which can be ignored in that specific instance.

Implications for Score Card and Portal Design

Though there are significant challenges in integrating the form and outputs of the five ecosystem service models, the *ESA Project* modellers have provided great feedback to inform the design of the *ES Score Card* and *ESA Web Portal*.

The identified challenges, however, constitute a 'workplan' more than 'barriers' – issues to be worked through, rather than mortal frailties. Integration of model outputs into a workable, useful score card appears to be achievable, as does the delivery of model outputs in a web-based form. Collaboration with the *ESA Project* modellers will continue in order to realize this outcome.

Going forward there are a number of key considerations to be infused in the *ES Score Card* and *ESA Web Portal* design:

- Although the specifics of how the models could be integrated is as yet uncertain, owing largely to the stage of model development, there is clearly genuine interest in doing so.
- In general, the models have a robust capacity to support a variety of functionalities usable in both the *ES Score Card* and the *ESA Web Portal*, and the modellers themselves are very engaged in understanding how to mobilize those functions.
- For both the score card and the web portal, the critical challenges – as well as managing for five different ecosystem services – revolve around the need to manage the differences in platforms, stage of development, valuation methods, perceived utility, and desired interactivity.
- Score card and web portal structure will have to accommodate a need for functionality to evolve as not all models are at the same point in defining (both conceptually and technically) how their outputs would translate into a decision making or resource management context.
- For web delivery, modelling on-the-fly is likely not an option, so scoring and web delivery will likely (but not certainly) be focused on modelling outputs, creating a need to prescribe scenarios and pre-process data.
- The models' optimal scale is local/regional vs. parcel-specific or provincial (though individual models may have some capability across those realms). Utility for both scoring and web delivery will likely have to be at that spatial scale.
- With regard to the *ES Score Card* and *ESA Web Portal*, they are generally not perceived by the modellers as separate entities. Most of the responses indicated an intuitive sense that there would need to be 'something' in between the model outputs and their use in a resource management context. The *ES Score Card* tended to be referenced in a default way as playing that role.
- Modellers faced an underlying challenge in answering the questions in the *ESA Modeller Needs Assessment* as they were unclear what was the intended vision of the *ES Score Card* and the *ESA Web Portal*. This was most likely based on a lack of defined target end

user/use to inform such a vision, and led to modellers providing several excellent tactical suggestions for score card and web portal features which very quickly outstripped the capabilities of a score card. This issue will continue to be a challenge that will need on-going active management.

- The *ESA Web Portal* may have to be developed separately owing to the need to work through web-delivery of the models as individual entities before integrating them in a web–based environment.

Next Steps

The information summarized in this report will be used to create the ES Score Card and ESA Web Portal by directly informing the following tasks:

- Identification of the opportunities for pre-processing of modelling outputs for the score card and portal;
- Identification for each model of which outputs are scoreable;
- Identification of workable interactivity options (incorporation of scenarios, user-defined choices, sliders, etc.);
- Determination of how scoring can be integrated across models (given variations in valuation philosophy, variations in optimal scale, etc.);
- Development of mechanism for delivering scores and map-based outputs at a common spatial resolution;
- Creation of beta structure for portal/score card that accommodates future expansion/evolution of the ESA models (future single modelling platform, additional ES models); and
- Determination of how to integrate the web portal and the score card into a single tool which maintains desired functions of both, but draws on the identified synergies.