Project #:   DS 04a

Project Title: **Co-location Modelling to Inform Old Growth Reserve Selection**

Steering Committee Members: Jody Holmes, Dan Cardinal, Glenn Dunsworth/Sally Leigh Spencer/Martin Buchanan, Steve Gordon/Buck Tanner/Todd Manning

1.0 FUNDING
Of the $125,000 approved to fund this project by the LRF WG, $83 155 was spent.

2.0 PURPOSE
Careful design of old growth reserves can help to satisfy multiple ecological conservation and forestry economic objectives simultaneously. The purpose of this project was to explore how this could most effectively be achieved in the Central and North Coast LRMP planning areas and to use the results to develop information relevant to First Nations Detailed Strategic Planning Processes and the implementation of the initial suite of EBM land use objectives. This project piloted the use of spatial modeling tools (Marxan and SELES). The results presented are experimental and strategic in nature and are in no way intended to be construed as ready to implement de facto reserve maps.

3.0 EXTENT TO WHICH PROJECT OBJECTIVES WERE ACHIEVED

This project was completed in conjunction with the EI 02c Focal Species Analysis project. Each of the three phases of the EI 02c project informed this project, which in turn, informed the next phase of the EI 02c project. In the EI 02c project, domain experts used best available base information and ecological knowledge to recommend map inputs and scenarios to be tested using MARXAN. The outputs of MARXAN runs were evaluated by the domain experts and the feedback from this evaluation informed the next round of MARXAN scenarios. The eventual outcome of this iterative effort was intended to provide an automated approach for strategically locating potential areas for old growth retention in a manner that meets conservation objectives while minimizing impacts to timber supply.

With approval from the EBM WG, project Steering Committee (SC) members agreed to expand the project scope several times over the life of the project to accommodate the following factors:
1. Delays in available focal species habitat inventory and modeling information from the Ministry of Environment that were required to undertake Marxan scenarios;
    a. This led to running Marxan scenarios for the South Central Coast two times (Phase 1): the first time with available focal species datasets and the second time with updated focal species datasets
2. Approval to implement Phase 2 of the project – full scale-up to run Marxan scenarios for the Mid Coast and North Coast.
    a. While the SC approved Phase 2 of this project ((running Marxan scenarios for the Mid Coast and North Coast) in the Winter of 2008, lack of available focal species data for the North Coast delayed the running of Marxan scenarios in the North Coast and, as a result, missed the limited opportunity to have North Coast results analyzed and reviewed by focal species domain experts engaged in the EI 02c project;
    b. Mid Coast Marxan runs were analyzed and reviewed by species experts under the EI 02c project;
    c. A SC request to run Marxan scenarios in the North Coast using Site Series Range of Natural Variation (RONV) also delayed the completion of Marxan results for the North Coast. This SC request was not undertaken because SS RONV numbers are not currently available.

The Approval to Fund[1] for this project was updated several times during the life of the project to address the first two factors listed above. Each time the project scope expanded the timeline to complete the remaining objectives was pushed back. The evaluation of project objectives shown in the table below was populated based on the project Approval to Fund.

Objective	Description	Evaluation (Text)	Summary*
1	Confirm project objectives, tasks and deliverables with SC	Developed workplan with SC input in January 2008	Fully Met
2	Meet with the Steering Committee and confirm the most appropriate modeling approach	Met with the SC on January 21st and confirmed most appropriate modelling approaches	Fully Met
3	Assemble relevant data layers	As relevant information became available it was added as an additional data layer	Fully Met
4	Develop "mappable "cost" function	Section 2.5 of the final report describes the cost function layer which incorporated both an area based cost as well as a surrogate for timber values	Fully Met
5	Develop Marxan scenario outputs, using existing focal species datasets in the South Central Coast Pilot, and circulate results to SC	Results were circulated to the SC after the first EI 02c focal species project workshop in June 2008	Fully Met
6	Develop SELES outputs using existing focal species datasets in the South Central Coast Pilot, and circulate results to SC	Due to the limited availability of complete focal species datasets, the SC dismissed this objective on the grounds that it was impossible to meet within the project timeline and project funding	Not Met
7	Develop Marxan scenario outputs using **updated** focal species datasets in the South Central Coast Pilot, and circulate results to SC	Results were circulated to the SC and species domain experts in November, 2008	Fully Met
8	Develop SELES results using updated focal species datasets in the South Central Coast Pilot and circulate results to SC	Due to the limited availability of complete focal species datasets, the SC dismissed this objective on the grounds that it was impossible to meet within the project timeline	Not Met
9	Using Marxan and SELES outputs and available inventory data, air photos and field reconnaissance, prepare recommended OGMAs for selected landscape units in the North Coast	This objective was met in the DS 04b: Landscape Level Reserve project	Not Met
10	Decide whether to undertake Phase 2 (running Marxan scenarios for the Mid Coast and North Coast) of the project	The SC decided to undertake Phase 2 of this project in the winter of 2008.	Fully met

[1] Approval to Fund (ATF) documents were drafted by ILMB support staff. In most cases information in a project's detailed project description was used to populate the ATF (including project objectives, milestones, and deliverables). The total amount of EBM sub-trust funds required to undertake a project was also identified. Before the ATF was given to the EBM WG co-chairs for funding approval, the ATF was reviewed and approved by all of the project steering committee members.

Objective	Description	Evaluation (Text)	Summary*
11	If Phase 2 (running Marxan scenarios for the Mid Coast and North Coast) is undertaken, run full scale-up approach	The full scale-up approach - running scenarios for the Central and North Coast - was undertaken in the Spring of 2009 for the Central Coast and the fall of 2009 for the North Coast.	Fully met
12	Ensure the final report, which summarizes Phase 1 and 2 results, has been reviewed by peer reviewers and the SC and comments incorporated	EI 02c project report #2 summarizes the methodology and results of DS 04a Phase 1 (Marxan results for the South Central Coast). This report was reviewed by the SC and peer reviewed by domain experts engaged in the EI 02c project. The same domain experts reviewed and provided recommendations on Marxan scenarios (including low risk, best habitat, and co-located solutions) in the South Central Coast and Mid Coast in the EI 02c project report #1. The DS 04a draft final report was reviewed by members of the LRF Technical Liaison Committee	Substantially Met
13	In addition to but separate from the, 1716 Environmental Consulting contract, ensure the project results and draft report are peer reviewed	The draft final report for this project was not peer reviewed.	Not Met

* Use: Fully met (100%), Substantially met (>75%), Partially met (25-75%), Marginally met (0-25%), Not met (0%)

4.0 MAJOR TASKS COMPLETED

Task	Description	Date
1	Confirm project objectives, tasks and deliverables with project steering committee	January, 2008
2	Meet with the Steering Committee and confirm the most appropriate model,	January, 2008
3	Assemble relevant Data layers,	January, 2008-March, 2009
4	Identify phased approach for priority planning processes	February, 2008
5	Develop "mappable "cost" function	March, 2008
6	Attribute data to common analysis unit framework	March, 2008
7	Confirm project methodology with PSC and peer reviewers	June, 2008
8	Run first phase and circulate results to PSC	June, 2008
8	Run first phase and circulate results to PSC	June, 2008
9	Based on first phase results, and availability of focal species data, determine whether to run second phase (full scale-up of CC and NC areas)	March, 2008
10	Map and assemble results and make available for presentation and use in other DSP processes and activities and in the EBM WG at the	March-December, 2009

TSA or other administrative unit.

5. KEY PRODUCTS

Item #	Description	Completion Date	Location
1	Project workplan	January, 2008	ILMB project document files
2	Participation in meeting to identify appropriate modelling approach	January, 2008	N/A
3	List of data layers that will be applied in the project	March, 2008	Posted on the EBM Data Centre FTP site
4	Document explaining the factors used in the "cost function"	March , 2008	To be posted on EBM WG website
5	Marxan scenario outputs for the South Central Coast Pilot based on existing focal species data	June, 2008	ILMB project document files
6	Marxan scenario outputs for the South Central Coast Pilot based on updated focal species data	November, 2008	Posted on the EBM Data Centre FTP site.
7	Contractor participation in the meeting to determine if Phase 2 (running Marxan scenarios for the Mid Coast and North Coast) should be undertaken based on available time and resources	March, 2008	N/A
8	Marxan modelling outputs for the remainder of the Mid Coast based on available focal species data	March, 2009	Posted on the EBM Date Centre FTP site.
8	Marxan modelling outputs for the North Coast based on available focal species data	December, 2009	Posted on the EBM WG FTP site.
9	Final report, which summarizes Phase 1 and 2 results incorporating peer review and SC comments.	January, 2010	To be posted on the EBM WG website.

6.0 PEER REVIEW

As described above the focal species domain experts engaged in the EI 02c focal species analysis project, served as peer reviewers to refine focal species data used as inputs into Marxan, and review and provide recommendations to improve Marxan scenarios. These "domain experts" included 18 biologists with expertise in the ecology and management of habitats for each of the focal species. This peer review was undertaken in three phases:

Phase 1: Preparation for strategic co-location scenarios: In Phase 1,. This information from the Knowledge Base for Focal Species and their Habitats in Coastal B.C. (Part 3 of the Focal Species Project report series)**,** was used to prepare a proof of concept of a 'Co-location Tool' using MARXAN conservation planning software to strategically co-locate areas of old growth retention with habitats for focal species. The proof of concept was tested for the South Coast planning sub-region.

Phase 2: Testing of strategic co-location scenarios: In Phase 2, domain experts reviewed outputs of various scenarios using MARXAN to test and assess the sensitivity of the scenarios to changes in targets for old growth retention. Scenarios were run for the South Coast planning sub-region. Domain experts met in December, 2008 to review the

scenarios and develop recommendations for improving habitat mapping and to refine inputs into MARXAN. These inputs informed scenario runs in Phase 3.

Phase 3: Synthesizing results: In Phase 3, domain experts reviewed a final set of scenarios that represented low risk, best habitats and co-located solutions. Scenarios were run for the Mid and South Coast sub-regions. They used this review to develop strategic recommendations for management of focal species within and outside of old growth retention areas under Ecosystem-Based Management. The review and recommendations are summarized in *Management recommendations for focal and fine filter species under Ecosystem-Based Management* (Part 1 of the Focal Species Project report series).

A parallel Landscape Level Reserve Project (DS 04b) served as an additional peer review process for Marxan results in four landscape units throughout the three coastal sub-regions. In this project Terry Lewis and Laurie Kremsater compared the strategic Marxan solutions to reserves designed at the landscape scale using a more hands-on approach. The 'landscape unit design' process applied in this project used the output of Marxan scenarios based on different levels of habitat retention to guide the more detailed co-location of habitats within OGRAs and the final project report provided an analysis for the use of Marxan software in future reserve design planning.

Given that co-location runs had not yet been completed for the North Coast as of March 31, 2009 and EBM WG trust funds were no longer available after this date, the DS 04a: co-location project final report was not peer reviewed. As such, only Marxan results for the North Coast, run in December 2009, were not reviewed by focal species domain experts.

7.0   MAJOR FINDINGS/CONCLUSIONS

7.1 Results
7.1.1 Focal Species Marxan Inputs
A full accounting of the focal species habitat layers used as inputs is found in Appendix 1, while the specific GIS sources for each of the following focal species is described in Appendix 2 of the final report.

7.1.2 Primary Scenarios
In the final phase of the DS04 project three primary scenarios became the focus of co-location experiments. All three scenarios used the same landscape unit objectives to define old growth retention goals for site series surrogates. For focal species representation goals, each scenario was based on, or involved a variation of, the "Low Risk" goal definition (see Table 2.10.1.1 in the final report for habitat information that was locked into each scenario).

- Scenario 1: *Low Risk* -- In this scenario, focal species goals were applied as described in table 2.10.1.1
- Scenario 2: *Best Habitats* -- For the "Best Habitats" scenario, Domain Experts were asks to define a subset of habitat attributes within the available species model that they considered "best." For example, instead of collocating with both "High" and "Moderate" probability habitats, the representation target might only apply to "High." The hope was to create a more focused co-location scenario that pushed co-location into optimum areas for species overlap and for overlap to be centered on the most valuable of habitats.
- Scenario 3: *Co-Located Landscape Unit Objectives (LUO)* – This scenario was created for the purpose of modeling how successful co-location might be given the limitations of the existing legal orders. In this case, "Best Habitat"[2] goals were still applied to focal species target, but a cost threshold was set within Marxan. That threshold was based on the total cost associated with meeting only the LUO goals for SSS old growth retention and Grizzly Bear critical habitat—a number calculated in a separate Marxan run with only those LUO features included. The resulting threshold or "budget" then acted as a cap in a second Marxan run that included both

---

[2] In the case of South Coast "Low Risk" Goals were used for the Budgeted LUO scenario, but based on subsequent domain expert input, "Best Habitat" Goals made more intuitive sense and were thus used in Mid Coast and North Coast scenarios

SSS and Focal Species habitat. Using the Species Penalty Factor, Marxan was programmed to meet all of the SSS goals, but only represent focal species habitat up to the point that the cost budget would not be exceeded.

A detailed description of these representation goals as applied to each focal species, including rationale for their use, is presented in Appendix 1 of the final report.

7.1.3 Spatial Outputs
One of the most important products that emerge from the Marxan driven co-location exercise are the spatial outputs that can be created in a GIS environment using what are called Marxan 'Best' and 'Summed' solutions.   A detailed description of the application of "Best Solutions "and "Summed Solutions" is found in Section 3.1.1: Spatial Outputs, of the final report.

7.1.4 Packaging of Results
Results from the DS04 package are described both spatially, in the form of GIS layers, and quantitatively, largely through tables and figures. In the final report sections 3.2, 3.3, and 3.4 describe overall sub-regional results. A full breakdown of both sub-regional and landscape results is made available in the DS04 'Results Package' through the use of pivot tables which allow the user to select combinations of species, landscape units, and other data to survey results in closer detail and at finer scales.

7.1.5 Existing Protection
Existing reserves of the South Central Coast are sporadic covering 18.7% of the forested area[3] of the sub-region while just over 50% of the forested landbase for the Mid Coast lies within current protected areas including sizeable new Conservancies, and approximately 28% of the North Coast has park, Conservancy or BMTA status. In the South Central Coast and Mid Coast there is a notable overlap between Marbled Murrelet class 1 habitat and grizzly bear Critical Habitat while Ungulate Winter Range captures only around 10% of suitable goat habitat.. In the Mid Coast there is also a substantial contribution made by newly designated Conservancies and Biodiversity Areas towards habitat protection. In the North Coast Grizzly bear class 1, goat, Marbled Murrelet class 1, and Northern Goshawk foraging class 1 habitats are particularly well represented (>40% representation) by the existing reserve system.

7.1.6 Scenario Footprint
In all three sub-regions the Low Risk scenario occupied the most THLB and NTHLB and incurred the highest cost compared to the other two scenarios. In the South Central Coast the Low Risk scenario occupied well over half of the sub-region THLB, NTHLB and total available cost while the Best Habitat scenario required less than half the THLB to meet goals, and reduced costs by over 60%. In the Mid Coast and North Coast there was a very small difference in footprint and cost between the "Best Habitat" and "Low Risk" scenarios.

As expected, the Co-Located LUO scenario had the smallest footprint overall in all three of the sub-regions. Moving from the Low Risk scenario to the Co-location scenario there were significant reductions in cost, (~45% in the South, ~35% in the Mid, and ~20% in the North) and area of THLB (~50% in the South, ~66% in the Mid, and ~35% in the North). In co-location scenarios in both the South and Mid Coast there was a ~20% reduction in area of NTHLB between Low Risk and Co-location scenarios while these scenarios filled out approximately the same non-THLB area in the North Coast.

7.1.7 Habitat Results
South Central Coast
Probably the most apparent pattern to be observed for the South Central Coast is the relatively low degree of existing protection for species habitat and the high degree of overlap between habitat and THLB. These conditions make cost limited co-location a challenging prospect and indeed, differences between proposed low risk goals and Co-Located LUO scenario results are the norm as opposed to the exception.

---

[3] "Forested" for the analysis in this project includes any forest cover polygon for which a full Site Series Surrogate has been defined.

The LUO scenario captures: 60% of high value deer habitat, > 50% of high value goat habitat, ~100% of Grizzly bear class 1 and < 55% of class 2 habitat, ~75% of Marbled Murrelet class 1, 53% of class 2 and 45% of class 3, 38% of Tailed frog class 1 and 42% of class 2 habitat, 52% of Northern Goshawk foraging class 1 and 42% of class 2, and 55% Northern Goshawk nesting class 1 and 45% class 2.

Mid Coast

For the Mid Coast, the Low Risk and Co-Located scenarios still constituted the high and low representation thresholds respectively. However, in the Mid Coast, the Best Habitat result was barely distinguishable from the Low Risk scenario. In general, the Mid Coast results reflected a much higher degree of existing protection for habitat as compared to the South central Coast and suggested that more opportunities existed for co-locating habitat with old growth objectives—particularly within the non-THLB.

The Co-location LUO scenario captures the following focal species habitat: 68% of high value deer habitat, 76% of suitable Goat habitat, 100% of Grizzly bear class 1 and ~70% of class 2 habitat. It also captures ~85% of Marbled murrelet class 1, >70% of class 2, and ~65% of class 3 habitat, between 60-65% of all moderate and high value nesting and foraging Northern goshawk habitat, and >70% of Tailed frog habitat classes 1-4.

North Coast

In the North Coast, a much reduced logging history, and higher proportion of non-THLB allowed for greater co-location opportunities than those found in the South Coast. In many cases the differences between proposed low risk representation targets and Co-Located LUO scenario results were bridged with habitat found in the non-THLB. Further, despite the lack of a riparian/floodplain reserve layer, there still was a high degree of overlap between habitat and existing/de facto reserves in the North Coast.

Focal species habitat represented in the Co-located LUO scenario includes: > 85% of suitable goat habitat, 100% of Grizzly bear class 1 and >70% of class 2 habitat, > 80% of class 1 Marbled murrelet habitat, 100% of class 2, and > 60% of class 3 habitat, between 68-75% of all Northern goshawk moderate and high value nesting and foraging habitat, and ~60% of Tailed frog habitat classes 1-4.

7.2 Limitations

7.2.1 Interpreting Results

The outputs known as "Best Solutions" emerging from any Marxan scenario in DS04 should not be interpreted or taken as de facto reserves. Instead, these areas should be used for ongoing strategic analysis with regard to how multiple land use objectives can be accommodated. Summed solutions emerging from DS04 Marxan scenario should provide useful guidance for identifying areas with a high probability of meeting multiple land use objectives. This guidance is best used by reserve design experts, and people knowledgeable about the landscape unit in question.

7.2.2 Issues with Data and Focal Species Models

A full accounting of the limitations of habitat models used for this project can be found in *Methods for Strategic Co-Location of Habitats in Coastal B.C* (EI 02c report #2). However, it is important to note that ungulate models, grizzly bear polygons, and the Northern Goshawk model are all under review and/or have been modified since these analyses have been conducted.   In particular, the ungulate models used in this study have since been deemed, inappropriate for further planning efforts until such time that necessary improvement can be made.

7.3 Recommendations

7.3.1 Data and Modeling improvements

Several important modifications to data are recommended (in Section 5.1 of the final report) before further landscape design work proceeds, including. In the process of spatializing reserves in the plan area a number of key methodological issues are identified including:

- Based on Domain Expert feedback, a hierarchy of habitat types is required in order to better fine tune the goals used for species habitats in the Co-location scenario.

- Allowable impacts to THLB and non-THLB should be clearly articulated i.e. how much THLB can be included in a reserve design to satisfy co-location requirements that may go above and beyond area required to meet old growth objectives.
- A high risk threshold for focal species habitat representation should be defined.
- A new Co-Located scenario for all sub-regions should be run based on the above mentioned updates and clarifications.

Recommendations for applying DSO4 and EI02 results have been incorporated into the. DS04 (b) report *Design concepts for Landscape-Level Reserves: a comparison of Methods*, (Lewis and Kremsater, 2009) under Section 4.0 *A recommended landscape-level planning methodology.*

8.0 LRF TECHNICAL LIAISON COMMITTEE RECOMMENDATIONS

The key findings and recommendations resulting from this project should be considered as information to support strategic landscape reserve planning in the Central Coast and North Coast.

9.0 RELEVANCE/SIGNIFICANCE FOR EBM IMPLEMENTATION

This project provides information that can be used in strategic landscape reserve design planning in the Central and North Coasts. This information includes: 1) the development of co-location methodology; 2) the development and refinement of three Marxan scenarios (Low Risk, Best habitats, and Co-located Landscape Unite Objectives), that meet old growth SSS targets and involve a variation of the proposed "Low Risk goal definition"; and 3) the spatial GIS shape files and quantitative results package for each scenario in each sub-region; and 4) an analysis of the quantitative results.