DESIGN CONCEPTS FOR LANDSCAPE-LEVEL RESERVES: A COMPARISON OF METHODS

Project No. DS04 (b)

Prepared by

Terence Lewis PhD, PAg., PGeo.

&

Laurie Kremsater MSc, RPF., RPBio.

for the Ecosystem-based Management Working Group

March, 2009

Disclaimer

This report was commissioned by the Ecosystem-Based Management Working Group (EBM WG) to provide information to support full implementation of EBM. The conclusions and recommendations in this report are exclusively the authors', and may not reflect the values and opinions of EBM WG members.

CONTENTS

1.0 Introduction

This pilot project explores several approaches for designing landscape-level reserves for landscape units in the south, central and north coast of BC. The project includes a comparison of reserve design when representation is based on site series surrogates (SSS) versus terrestrial ecosystem mapping (TEM). It also compares reserves drawn with and without the benefit of output from Marxan software (Co-location Project DS04(a)). We use our reserve design efforts to determine the consequences of using SSS versus TEM, and to assess the extent to which Marxan can assist and expedite landscape-level reserve planning.

The intent of this project is to explore methods of designing landscape reserves, not to actually provide draft reserve plans. Several important steps that would normally be undertaken when planning reserves are missing, namely;

- First Nations have neither been contacted nor involved to incorporate their concerns, to recognize their role in management, including the identification and consideration for protection of significant cultural areas;
- Operational forestry and engineering personnel have not been contacted to consider their management concerns; and
- Focal species experts have not had an opportunity to comment on the strengths or weaknesses of the reserve designs for their particular species of interest.

In addition, the design approaches were not taken to completion but terminated once the pros and cons of a particular approach became clear. That is, each of the designs could be improved upon in detail, but this would not be productive in the absence of a planning process involving input from First Nations, operational and focal species representatives.

Four landscape units (LUs) spanning the south, central and north coast were chosen by the project steering committee: the Roderick, Stafford, Gribbell, and Thurlow LUs. These choices were made to include: a range of ecosections, biogeoclimatic subzones and variants, and the resulting ecosystem patterns; a range of focal species needs; a variety of timber harvesting history; and, to include LUs that allow the TEM versus SSS comparison. The planning scale is 1:20,000 (cf. the operational or site-level scale of 1:5,000).

Largely because of the timely availability of data, four different approaches were taken for the Stafford LU. Initially, reserves were designed independently by each of the authors, one using TEM and the other using SSS (i.e. without TEM) as the basis for meeting representation targets and achieving low-risk focal species targets. Then a so-called ‘Co-located30’ design was compiled that restricted representation to the 30% of total that aimed to best achieve the low risk focal species targets. None of these three designs had the benefit of Marxan output (as specified in the original work plan). When Marxan output became available, a fourth Stafford design approach reworked the Co-located30 concept incorporating consideration of the Marxan model outputs.

The Roderick LU reserve design approach focused on meeting the legislated targets of the Legal Order as of November 2008, utilized TEM and elucidated the nature of reserve design for the hypermaritime Hecate Lowland landscape.

Gribbell, which also represents the hypermaritime Hecate Lowland, was planned as far as possible but the design has been hampered by the lack of some focal species data. The original work plan called for two design approaches, with and without the benefit of Marxan output. The Marxan assisted design was not feasible since Marxan output is not yet available for the North Coast. As a result, the work plan was altered, with the approval of the project steering committee, to do that comparison in the Stafford LU where other comparisons were already available and the comparison would be most informative.

The Thurlow concept reserves were developed with Marxan as an aid at the outset of the design process.

Targets for representation and for focal species were provided by the EBM Working Group. Initially, for Roderick, Stafford, and Gribbell, we met representation targets at 30% of total Old seral. Once the revised Legal Order was available, we used the revised Legal Order targets for Thurlow and Gribbell LUs. Data on focal species came from the focal species teams (Project EI02c). We used their low risk targets, except for designs where we were explicitly trying to achieve representation targets and only meet focal species habitat as far as possible within that representation. In some cases, habitat layers from focal species models were not available in a timely manner and only became available later; hence not all design concepts used the focal species information now available. Part way through our work on Stafford, habitat layers were updated and we updated some but not all of our designs to reflect the new information.

Updating all of the design scenarios would have been too time consuming for the time and budget available and since this project is not intended as an actual reserve planning process, was not necessary where the design process had already provided sufficient insight into methodology. In the Appendix (see section 5.0) that describes the various LU landscape-level reserve concepts, we provide detail on the data that was available at the time the reserves were designed.

We offer our suggestions on a useful reserve planning process in section 4.

2.0 Approach to Rational Reserve Design

At the outset of reserve design, we first assemble all available GIS data layers encompassing the known values present in the LU that will contribute to reserve design. This typically includes:

- protected areas (Parks, Ecological Reserves, Conservancies etc.)
- legally established reserves including ungulate winter ranges (UWR) for deer and mountain goat, and wildlife habitat areas (WHA) for focal species including marbled murrelet (MAMU), northern goshawk (NOGO) nests and tailed frog
- red- and blue-listed ecosystems
- habitat inventories for focal species, notably for grizzly bear and MAMU
- modeled focal species habitat: MAMU, NOGO, Tailed frog, grizzly, mountain goat and deer
- riparian features, including mapped active fluvial sites
- archaeological and culturally significant sites
- site series where TEM is available
- site series surrogates where TEM is unavailable
- predictive ecosystem mapping (PEM) units where available
- seral stage map (derived from forest cover or vegetation resource inventory (VRI)

At this time, we also assemble available GIS data regarding the operational cost of placing areas in reserve, including operability, timber harvesting land base (THLB) and non-THLB, and indirectly where Marxan output is utilized, an ‘opportunity cost’ layer. We used operability layers to indicate where harvesting is least attractive and used terrain classification to identify unstable slopes. In some LUs, we also obtained a logging history map, and maps of currently active, recently completed, already engineered and projected cutblocks. More revision to the all of the reserve designs remains to be done, but this is best accomplished during the operational review phase during a reserve planning process.

All of the above is of course in addition to such base information as TRIM features (streams, lakes, contours etc.), land ownership and a Spot 5 satellite image. The importance of a high quality, recent satellite image cannot be overstated in providing an overall landscape perspective during the design of landscape reserves.

Our approach to rational reserve design (i.e. as opposed to an automated or software-assisted reserve design) is directed by the following considerations:

1. List values to be conserved and rank them, considering not only the nature of the value but also the quality/confidence of the data. Modeled habitats/values should always be ranked lower than inventory data.

2. Focus on values first and representation later; i.e., fill in representation gaps after important values have been dealt with. Where possible add to core reserves (e.g., grizzly class 1, UWR, WHA) when filling gaps; this increases reserve sizes.

3. First design reserves where there are exceptional concentrations of values; these will usually be valley-bottom reserves, e.g. the Stafford fluvial complex above the lake.

4. Use small reserves only for places/values that are truly special. Otherwise design larger reserves and favor shapes that minimize edge and maximize forest interior conditions; i.e. avoid highly irregular boundaries, narrow peninsulas etc. (note the minimum perimeter/area shape is a circle). Ultimately we aim for a range of reserve sizes, including many large enough to provide old growth with interior forest conditions. Where suitable we cluster reserves to increase forest interior and place reserves to improve connectivity.

5. Except for representation, design reserves primarily on the basis of ecological value, and second on the basis of seral stage. If old seral is available, then it should be used prior to earlier seral stages. When looking for recruitment areas we looked for oldest first, but tempered that by trying to build a reserve system that over the long term has a good geographic distribution of representation and habitat. In some instances that means not taking the oldest as recruitment, but allowing younger areas to grow to eventually become useful components of the reserve network.

6. Use inoperable in preference to operable wherever possible, providing ecological values are not compromised. Keep in mind that 'operable' and 'inoperable' (thlb/non-thlb) categorizations are not firm. Use local knowledge and confirm/discuss with operational personnel as appropriate (in this pilot project, we have not had discussion with operational personnel).

7. As much as possible use boundaries that 'fit the landscape'; i.e. boundaries that follow natural breaks (e.g. ridge-lines, basin boundaries [tailed frog], edge of floodplains or the back of terraces, active portion of fans). Existing seral stage boundaries make sense for some values (e.g. MAMU habitat).

3.0 Broad Findings

3.1 SSS vs. TEM

Reserves based on SSS and those based on TEM capture similar areas when biodiversity values are concentrated, as for example where focal species habitats and red- and blue-listed ecosystems coincide or occur in close proximity. In this situation, the co-location of several values can often be readily accomplished. Reserves based on SSS and those based on TEM diverge most where the reserve focus is on representation targets in the absence of or with a dearth of other values. The extent of these two extreme situations depends very much on the ecosystem pattern within individual landscape units. For LU's that encompass broad glacial valleys that penetrate the Coast Mountains and that span submontane to alpine elevations (the Stafford archetype - see Lewis, 2007), many values can be captured in a valley bottom reserve that extends from an estuary upstream to encompass a complex of fluvial ecosystems and associated values including active fluvial sites, red- and blue-listed ecosystems, forested swamps and habitats for grizzly, MAMU and NOGO. For LU's that encompass the extensive subdued terrain of the coastal lowlands (Hecate Lowland) and Fiordland that do not have large river systems, there are relatively few concentrations of biodiversity (i.e. anchors for reserves). As a consequence reserves based on SSS tend to be quite different than those based on TEM.

The lack of congruence of TEM-based and SSS-based reserves when reserves are focused on representation, largely results from the relatively poor correlation between TEM and SSS map units. This can readily be seen by intersecting TEM and SSS layers in ArcView/ArcGIS. This has also been documented by Green (2008). Although an intersect reveals a broad correlation, it only becomes relatively strong when there are particularly strong forest cover to site series relationships. For example, the correlation between good and medium Sitka spruce-leading types (SSS analysis units 10 and 11) and fluvial ecosystems (e.g. CWHvm1 /09) is quite good. Even so, the distinction between good and medium sites is questionable since this difference can largely be determined by stand history. For a generalist species such as hemlock, the correlation between good and medium hemlock-leading types and site series is poor. On many circum-mesic sites, the site quality rating can be as much a function of stand history as inherent site or ecosystem differences.

Using SSS often results in small, scattered polygons identified only to meet representation targets (i.e. no overlap with any focal species habitats; see comparisons for Stafford LU, section 5.2.4). Reserves based on TEM representation tend to create fewer fragments. In either case, it is important to assess whether any such small units have special ecological significance. For example, in the Stafford LU, if indeed there were an area with an old seral, Douglas-fir-leading stand, it would deserve consideration since this is an area with very little Douglas-fir (a consequence of climate and fire history. In fact, the only Douglas-fir leading stands are plantations following logging in the Apple watershed).

SSS sometimes identify polygons that aren't real on the ground; however, these are readily apparent only when clearly contrasting, as for example where a forested SSS is mapped in the alpine. This suggests there are very likely more subtle errors (a common complaint of those involved in field layout) that are not apparent and which could only be revealed by fieldwork. Where identified, such inventory artefacts should not be included in the reserve system.

For both SSS and particularly for TEM units, we recommend some ecologically sensitive grouping of units to avoid an excessively fragmented reserve system. The root cause of excessive fragmentation is a large number of subdivisions. Although 13 site series surrogates may well be reasonable at lower, submontane elevations; with increasing elevation, the number of surrogates (subdivisions) should be progressively reduced in montane, subalpine and alpine subzones/variants. No subdivision is warranted in the alpine tundra or mountain hemlock parkland (mapped 'stands' in these areas are often erroneous). In the montane and forested mountain hemlock variants, four groupings (hemlock-leading poor, hemlock-leading medium and good; redcedar/cypress-leading poor, and redcedar/cypress-leading medium and good) would reduce excessive fragmentation with littlie impact on the ecological value of the groupings. Unusual stands that do not fit these four could be placed in an 'other' grouping and examined more carefully to identify truly different situations.

Only clearly special situations (ecosystems or stands, based on TEM or based on SSS) should be considered for small, isolated reserves (see recommendation for reserve planning in section 4.0 below). The smallest of these (generally areas of <2 ha) are best managed at the site level.

3.2 Using Marxan

Marxan was extremely helpful to identify reserves in areas where there are few clear anchors and reserves are intended to satisfy representation goals. Where there are few requirements for focal species, or where there are few red- or blue-listed ecosystems or riparian systems to provide a reserve backbone, the Marxan model provides a great tool for meeting representation goals while co-locating on scattered polygons of habitat. The model appears to handle the representation tangle well and if we use areas that are repeatedly included in the model's solution set, it reduces the iterations of checking what we have in reserves compared against the targets for multiple site series or surrogates. For an area in which meeting representation targets is one of the highest ecological goals, it makes sense to look at the model outputs at the outset of reserve design.

In areas where overlapping values are high and decision on reserves are constrained by other legal reserves (UWR, WHA) or meeting certain goals (e.g., meeting low risk targets), there is less flexibility and options for locating reserves are constrained. In those cases, Marxan outputs are not critical because the placement of reserves is already constrained. However, even in areas where values are concentrated and core reserves are 'obvious' (e.g. the Stafford LU), Marxan output efficiently identifies and highlights such core areas. As well, even in those more constrained situations there are usually areas of the watershed (such as high elevations) where meeting representation is the main driver and there are numerous possibilities for reserve locations and Marxan output helps identify useful reserves and linkages.

Marxan 'reserves' tend to be far more fragmented than those we design, with many widely scattered, small reserves. This pattern does not satisfy needs for forest interior conditions and could well threaten the long-term integrity of such reserves. However, clusters of Marxan polygons can be readily incorporated into larger reserves with more cohesion and more interior, and with lower risk to integrity. As well, Marxan can identify useful areas to use as connections between concentrations of biodiversity values.

In areas with extensive logging history (e.g. Thurlow LU) Marxan selects many small fragments because the old growth that remains is so fragmented. Unlike the Marxan software that seeks old seral, we were not so dogmatic in our pursuit of old forest but rather tended to encompass areas of old along with areas of recruitment (even if old exists elsewhere) in larger reserves to attain more forest interior over time. We are more focused on the long term ecological value of the reserve system rather than its age today.

If targets for focal species or representation are unclear, then Marxan should be used to evaluate the consequences of various targets. Marxan can efficiently explore numerous scenarios. It is inefficient and costly to explore various target scenarios by the rational design process.

In summary, efficient reserve design is invariably facilitated by Marxan. In particular, the most recent version of the 'Best-30' scenario and the 'summed' output is the most efficient starting point for a rational reserve design.

3.3 'Hard' Reserves, 'Soft' Reserves and Seral Stage Management

In cases where targets are clear and habitat needs to be set aside, then hard reserves fixed over the long term appear most appropriate. In cases where targets are less certain, habitat information is less reliable, or in areas where disturbance is common (rare in coastal B.C.) then a proportion of a reserve system that can be moved over time, or even short-term aspatial reserves may be appropriate.

Hard reserves are most appropriate where ground or air checking has been done on habitat that is accepted as critical for a species of concern. Examples of areas most appropriate for hard reserves include, among others, goat winter ranges that have been field checked, Marbled Murrelet nesting habitat has been confirmed in the field, and Grizzly class 1 and 2 habitat that has been confirmed in the field. We are less confident in reserves that are built when only modeled habitat is available. In this pilot project, situations arose that tested our confidence in some habitat model results. For example:

- The deer model did not select already designated UWR's, or even areas nearby.
- The tailed frog model identifies basins without any vegetation whatsoever and model results have not yet been checked for the actual presence of frogs.

Of course, not all conservation goals need to be met by reserves. The active, purposeful management of seral stage distribution in both space and time is an additional tool to meet some goals. We believe that this is the best approach to supplying foraging habitat for northern goshawks and that the current low-risk target can be met through time by such an approach. Hard reserves for goshawks should focus first on existing nest sites, including buffer; plus ensuring additional reserved potential nesting habitat based on the model habitat rating plus additional consideration of nest spacing and distribution (e.g. for linear valleys like the Stafford, ensure potential nesting areas en echelon along the valley at lower elevations spaced +/-7 km apart). Other focal species that are best served by the integration of reserves and active management of seral stages include deer, black bear and grizzly bear.

The proportions of hard reserves to softer reserves or to management in the matrix depends in part on the target level of conservation. However, regardless of target levels or relative risk, consideration should always be given to supplementing hard reserves with soft reserves and/or matrix management in achieving conservation objectives. The appropriate mix can then be tailored to specific landscape situations.

3.4 Reserves at Multiple Scales

A key concept of conservation biology is to integrate conservation of values across multiple scales. Landscape-level reserves lie within a continuum of reserves; between larger parks/protected areas and smaller site-level reserves. Some objectives are best handled at the site level; and, not all so-called hard reserves can be considered landscape level reserves.

Reserves mandated by the Legal Orders that are defined based on 1-2 tree-heights, usually with some flexibility of application on the ground, should be considered as site-level reserves. These are too narrow to be considered as landscape level. This includes, for example, buffers against active fluvial sites and forested swamps, as well as other riparian based reserves.

Some low-risk focal species targets (Project EI02c) can also be managed at the site level. For example, the majority of tailed frog stream reaches identified by the tailed frog habitat model are S5 streams. These are commonly used for cutblock boundaries or incorporated within in-block retention and can also be customized on-site with tailed frog needs in mind. At the landscape level, it is the tailed frog basins rather than stream reaches that need to be considered as a component of landscape-level reserves.

3.5 Other observations

Comments on the use of raster-based models:

Raster-based models produce a myriad of very small (<1 ha) polygons that are meaningless for landscape-level planning, unless they are in some way clustered. To utilize such a model, consider applying a lower area limit based on the ecology of the species in question (e.g. we suggest that: for mountain goats with high fidelity to range, use 5 ha; for murrelet, use 5 or 10 ha? (Ian McDougall pers. comm.); for northern goshawk, use 10 ha. For deer, use 20 ha, or group polygons of more than 2 ha into at least 40 ha areas (Brunt-Dec. workshop). Because of the myriad of small units, strictly applying percentage targets is ecologically inappropriate. Habitats less than 2 ha really are stand level features that would best be captured in retention or wildlife tree patches. The following table illustrates this problem; it summarizes area distribution of several habitat model layers for the Stafford LU.

HABITAT	TOTAL AREA (ha)	# of POLYGONS	MEAN POLYGON SIZE (ha)
Goat 1	4,345	5,851	0.7
Goat 1 >5 ha	2,305	199	11.6
Goat 2	1,709	4,783	0.4
Goat 2 >5 ha	315	35	9.0
Deer 1	105	1,232	0.1
Deer 1 >20 ha	0	0	-
Deer 2	225	2,731	0.1
Deer 2 >20 ha	225	2,731	0.1

HABITAT	TOTAL AREA (ha)	# of POLYGONS	MEAN POLYGON SIZE (ha)
Goshawk forage 1	5,612	7,352	0.8
Goshawk 1 >10 ha	2,091	99	21.1
Goshawk forage 2	8,214	5,641	1.5
Goshawk 2 >10 ha	5,596	139	40.3

The table summaries show that raw model output in isolation is not suitable for setting targets. When an area cut-off is applied (size depending on species), the total area often becomes meaningful (goat and goshawk forage), but even then is not necessarily meaningful because an area cut-off may exclude many small polygons that are in one general area and could clump up into a useful polygon (e.g., deer). Because the summaries don't account for clustering, the appropriate total area for setting targets probably lies somewhere between. Just where will depend on the species in question and the actual habitat pattern, and suggests that considerable judgement needs to be applied in designing reserves rather than attaining some arbitrary target.

Before using model output in design, it should be checked against our current understanding of ecology, habitats and local knowledge. For example, the deer model does not appear to fit the Stafford LU very well in that established winter ranges that appear to be 'logically' based do not rank high (or medium), and the largest area ranked 1-2 in the model, although on a south-facing mid-elevation slope, is not associated with openings or rocky openings. However, we do understand the models are in various stages of refinement, and anticipate upcoming improvements to address some of these shortcomings.

Comments on TEM and BEC lines

Subzone/variant boundaries derived from TEM at 1:20 000 scale commonly do not match BEC boundaries mapped at much smaller scales. This is not merely a matter of scale, but results from purposeful boundary shifts that derive from improved on-the-ground data. This is indeed the case in the Stafford and Roderick LU's (Lewis, 1997, 2005) and in the Thurlow LU (Blackwell & Assoc., 1999, 2000, 2006). As a result, the analysis of representation can be confounded, and in order to preserve internal consistence, SSS representation must be evaluated in relation to small-scale BEC and TEM representation must be evaluated in relation to larger scale TEM subzone/variant boundaries.

3.6 Planning for revisions

No matter how good is the quality of data used in reserve design, there will always be better data available in the future. Consequently, an approach to revising reserves (i.e. continuous improvement analogous to the approach of many certification schemes) should be explicitly recognized and attached to any reserve plan. In addition, there needs to be some operational flexibility allowed when managing around reserves (e.g. cutblock boundary layout, road location). Modifying reserves up to 5-10% (area basis) should be routinely allowed providing the principle of replacing any removals with areas of "equivalent value" is applied and approved by an appropriately qualified professional (e.g. professional forester, with/without consultation with a professional biologist as appropriate). This type of flexibility is currently provided for OGMA reserves (MacDougall, pers. comm.).

4.0 A recommended landscape-level planning methodology

This project's main purpose was to explore different approaches to landscape reserve design. This included a comparison of rational design approaches to design using model outputs (i.e. Marxan software), as well as comparing the effects of using TEM versus using SSS to attain representation targets. In this pilot project, we did not involve First Nations, operational personnel or focal species experts in the development of actual reserve plans. We did however recently undertake the planning of a landscape-level reserve system for Tree-farm Licence 6 (Lewis and Kremsater, 2008) that provided additional insight into the broader planning aspects of establishing reserves, which did include considerable and meaningful consultation with First Nations and various stakeholders.

Note that we use the term ***'design'*** in the context of defining reserves (perhaps more properly thought of as reserve precursors) in the absence of consultation (i.e. as an academic or technical task) and we use the term ***'planning'*** where the reserves are reviewed, vetted and contributed to by various stakeholders in a much more inclusive process.

Based on our various comparisons as well as on past experience, we recommend an efficient and effective approach to landscape-level reserve design but embed that design methodology into a much broader planning process. We do not believe that design in the absence of an inclusive planning process is appropriate and that such an approach risks the alienation of parties that have a profound interest in a coast-wide system of landscape-level reserves.

4.1 Suggested planning approach

We recommend the following approach to planning landscape-level reserves. Although the following presentation is arranged in linear fashion, recognize that there are potentially a number of feedback loops:

1. *Involve First Nations and affected and interested parties (subsequently referred to as stakeholders) at various stages throughout the planning process:*
   - Advise First Nations and stakeholders with an early initial contact as the planning process gets underway.

   - Involve First Nations and stakeholders in a review of the reserve design as it begins to take shape (an early working draft) and solicit input at that time. Suggested alterations and inclusions are especially useful in influencing the reserve system at this early stage when changes are anticipated and are welcomed.
     - First Nations should be consulted and involved to ensure their interests are considered.
     - Operational and planning foresters in the affected tenures should be consulted about their areas of interest, priorities and constraints and areas of possible trade-offs.
     - Focal species experts should be tasked to consider the draft reserves and assess the relative strengths and weakness of the cumulative reserve network in relation

to their species of interest.

2. *Compile a comprehensive list of biodiversity/ecological, cultural and other values to be conserved:*
    - Start with and revise the template in 2.0 as appropriate.
    - Solicit input from stakeholders in compiling this list.

3. *Clarify targets:*
    - Define what targets are to be used for representation and for focal species. If targets are based on habitat models, evaluate them and adjust targets as necessary to allow for the contributions of stand-level reserves and 'unreal' artifacts of the models. Targets based on actual inventories are likely more realistic.

    - Identify if several options need to be explored; if so, use modeling software (Marxan or similar).

    - Decide if some portion of the targets should be satisfied by soft reserves or aspatially, and whether this is a short- or long-term strategy.

    - Decide on all targets prior to continuing with rational reserve design.

4. *Develop Marxan outputs:*
    - Complete Marxan runs and evaluate changes between scenarios as needed. Most of such scenarios will be available from Co-location Project DS04(a).

    - Where various options are explored, consider the "summed runs" that show which polygons are chosen most frequently for various solutions.

5. *Build reserve systems based on concentrations of values and Marxan outputs*
    - Build reserves using the approach outlined in Section 2 and in view of the findings presented in section 3. We repeat the main points as follows:
        - Focus on values first and representation later. First design reserves where there are exceptional concentrations of values. Where possible add to such core reserves (anchors) when filling gaps for representation.

        - Use small reserves for places/values that are truly special. Otherwise, design larger reserves and favor shapes that minimize edge and maximize forest interior conditions. Where suitable, cluster reserves to increase forest interior and place reserves to improve connectivity.

        - When looking for recruitment areas, look for oldest first, but temper that by trying to build a reserve system that over the long term has a good geographic distribution of representation and habitat. In some instances that means not taking the oldest as recruitment, but allowing younger areas to grow to become useful components of the reserve network.

        - Use inoperable in preference to operable wherever possible, providing ecological values are not compromised. Keep in mind that 'operable' and 'inoperable' (thlb/non-thlb) categorizations are not firm. Use local knowledge and confirm/discuss with operational personnel as appropriate.

- As much as possible use boundaries that ‘fit the landscape’; i.e. boundaries that follow natural breaks (e.g. ridge-lines, basin boundaries [tailed frog], edge of floodplains or the back of terraces, the active portion of fans). Existing seral stage boundaries make sense for some values (e.g. marbled murrelet habitat).

- When using TEM, also check how reserves fit SSS targets and see if any rare stand types are missed by using TEM and add those to the reserve system. Do not include areas that are apparently misclassified.

- Use Marxan’s ‘representation target run (Best-30)’ and ‘summed run’ to identify core areas as a starting point for design. Amalgamate small reserves identified by Marxan into larger units as much as possible if appropriate.

6. *Solicit comments from stakeholders on the draft reserve system. Provide not only the reserve design and an evaluations of the reserve in relation to targets, but also provide some evaluation of socio-economic implications (e.g. Patchworks or SELES output):*
   - First Nations
   - Operational/planning foresters/engineers
   - Local communities
   - Focal species experts
   - Other stakeholders

7. *Revise based on comments and circulate for further review until an effective consensus is reached.*

8. *Define a process for future revision.*

Reserve design and planning is best undertaken by (or assisted by) personnel with some local knowledge of the LU.

4.2 Time and Effort Considerations

Based on a landscape unit modal size in the order of 40,000 hectares, we anticipate developing a reserve plan suitable for public review would take 16 person-days per LU. The time break-down is as follows:

ACTIVITY	PERSON-DAYS
Notification of interested parties	1
Data acquisition (incl. Marxan outputs)/compilation (assuming data package is available)	1
Initial reserve design	4
Consultation	6
Revise/finalize	4

Consultation will take longer if there are many interested parties, several First Nations and/or complex tenures with multiple licencees in the LU, or if a contentious issue delays or stalls the planning process.

5.0 Appendices. Sample Landscape Unit Reserves: approaches and draft designs

To explore different approaches to formulating landscape-level reserves, we designed reserves for four LU's using a number of different methodologies: Roderick, Stafford, Thurlow and Gribbell. For each LU in the following sections, we describe the nature of the landscape unit, the data available for reserve design, our approach to design, a brief characterization of the individual reserves, a quantitative evaluation of the reserve designs in relation to targets and findings relevant to design methodology.

5.1 Roderick Landscape Unit

The Roderick LU lies entirely in the hypermaritime coastal environment with the CWHvh2 variant at lower elevations and the MHwh at higher elevations. Most of the LU lies within the inner part of the Hecate Lowland Ecosection; hence, poorly drained sites are extensive and include substantial units of blanket bog, but blanket bogs do not dominate the landscape as they do in the outer Hecate Lowland. The two southern unnamed islands do have extensive blanket bog and represent the outer Hecate Lowland quite well.

Apart from some early hand-logging and A-frame logging along the shoreline, most logging has been since the mid 1990's following the Forest Practices Code and FRPA regime. Consequently, the pattern of logging is characterized by scattered cutblocks of less than 40 ha.

5.1.1 Available Data

TEM mapping is available for most of the LU, namely for Roderick and Pooley Islands (Lewis and Inselberg, 2005). It is not available for Susan Island and the two unnamed islands to the south of Susan. Grizzly habitat is mapped on a seasonal basis for the entire LU. Otherwise, there is very little focal species habitat data available. The data gaps (as of early Dec., 2008, when this design was undertaken) include:

- no NOGO WHA's (nest sites) or habitat model
- no MAMU WHA's or habitat model (including the Hobbes MAMU model)
- No UWR's, neither deer nor mountain goat
- No black bear habitat model, other than a small-scale black bear pdf file that shows some habitat in Roderick (not a shape file)
- A number of potential tailed frog stream reaches have been identified based on morphology, but there is no systematic inventory. During site-level assessment work, tailed frogs have not been found on any offshore islands with the exception of King Island (Broekhuizen, pers. comm.; 2009). This appears to be confirmed by tailed frog WHA's received in Feb-09 that do not include any areas in the Roderick LU.

Good quality Spot 5 satellite imagery is available coast-wide.

5.1.2 Approach to Reserve Design

The Roderick LU was the first of the four LU's to be designed. The approach taken to design reserves for Roderick was to first incorporate various legally mandated areas, including existing protected areas and ecosystems to be reserved pursuant to the recent Ministerial Order: active fluvial sites, forested swamps, 70% of blue-listed plant communities, 100% of class 1 grizzly habitat and 50% of class 2 grizzly habitat.

Although the actual use of class 1 and 2 grizzly habitat by grizzly bears in the Roderick LU is unclear, we included all the class 1 and 2 habitat since these habitats also appear to be valuable to black bears (including the white phase); and also since there is considerable overlap with blue-listed skunk cabbage plant communities. During TEM fieldwork in the CWHvh2, it became clear that very few site series are capable of growing redcedars of a size suitable for denning and that most potential den trees are found at the interface between skunk cabbage ecosystems and somewhat better drained upland sites (mostly 04). Including the class 1 and 2 grizzly habitat is likely to include many of these potential denning sites.

In the absence of a MAMU habitat inventory or model, we applied our understanding of habitat (stand types) to select likely sites based on the satellite imagery.

Since TEM mapping is available for most of the Roderick LU, it was used as the basis for representation. We used 30% of total old seral as the target for representation, which is slightly higher than the TEM-based target (29% = 30% of RONV) that was subsequently established in the Revised Legal Order of January, 2009.

5.1.3 Description of Proposed Reserves

The proposed landscape-level reserves in the accompanying shape file are numbered sequentially and briefly described as follows:

- #1 Pooley: Protected Area plus: Used conservancy as the base, then added class 1 grizzly habitat (mostly summer range). Also added active fluvial, estuary and salt marsh red- and blue-listed, and stability. Included areas between terrain and blue, etc, but mostly those are inoperable. Rounded off to heights of ridges. Added representation of H3.
- #2 Pooley: Grizzly, blue-listed, stability.
- #3 Pooley: Blue-listed ecosystems around lake, tailed frog modelled stream, stability, grizzly. Also added wetlands along east edge of lake.
- #4 Pooley: Tailed frog base plus blue-listed plus some wetland complex.
- #5 Roderick: Blue-listed, grizzly, terrain, tailed frog; Goat Harbour existing conservancy, then merged with tailed frog stream and unstable slope; then added sloping bog.
- #6 Roderick: Stability, grizzly, cross-island connection coast to coast.
- #7 Pooley: stability, grizzly (a few areas), blue, and lots of forest in between, though not great productivity forest. Used harvested areas as boundary.
- #8 Pooley: Blue-listed, grizzly, terrain then added wetland with meandering creek.
- #9 Pooley: Stability, blue-listed and wetland complex.
- #10 Roderick: Grizzly, terrain, tailed frog, and representation of cedar-leading stands (main reason) also some blue-listed.
- #11 Roderick: Stability, blue-listed, and tailed frog; also representation of cedar-leading H4, grizzly.
- #12 Roderick: Terrain, pocket of blue-listed,

#13 Roderick: Terrain, operability, some blue, tailed frog stream and also H4 representation. Loops around a large lake.
#14 Roderick: Stability, representation of poorer, cedar-leading and representation of H4 & H3.
#15 Roderick: Operability, representation of poorer cedar leading; tailed frog; grizzly. This is a larger reserve. Also added to representation of H4.
#16 Roderick: Blue, inoperable, representation.
#17 Roderick: Stability and H4 representation.
#18 Pooley: Stability ; inoperable and H4 representation.
#19 Roderick: Stability, H4 combination; includes minor blue-listed.
#20 Roderick: Representation of H3 and H4, blue-listed plus shoreline, likely raptor nests, visuals; stability.
#21 Roderick: Grizzly mainly, minor blue-listed added.
#22 Roderick: Blue-listed (some operable), wetlands.
#23 Roderick: Two grizzly areas, blue-listed, representation of H11.
#24 Susan: Conservancy (Rescue Bay), wetlands, shoreline, likely H3, H11, maybe some blue-listed.
#25 Susan: Representation, probably of H1, H11, H3, H4, geographic spread.
#26 Susan: Grizzly and representation of H1, H11, H3, H4, shoreline.
#27 Susan: Representation of H1, H11, H3, H4, shoreline.
#28 Unnamed island 1: Representation of more rugged part of the island, some grizzly
#29 Unnamed island 1: Reserve represents subdued blanket bog terrain of outer Hecate Lowlands.
#30 Unnamed Island 2: Reserved in its entirety; extensive subdued blanket bogs; added to make up to 30% in reserves on both unnamed islands. Will also have ecosystems associated with salt spray and beach sand. Very exposed south and west shorelines.
#31 31 includes a number of smaller polygons of grizzly habitat.

5.1.4 Roderick LU Findings

The extent of representation and impact on operability of the draft Roderick LU reserves is summarized in the following table.

Ecosystem[1]	I[2]	Oc	Oh	Ohe	Reserve Total	LU Total	% in Reserve	Comments
A	271	5	9		286	327	87%	
H1	2770	189	247	42	3249	10400	31%	
H11	932	69	16	1	1019	2891	35%	
H12	8				8	8	100%	locally rare bog woodland
H13	157	161	11	0	328	471	70%	blue-listed
H2	246	0	0	0	247	299	82%	
H3	293	15	12	6	327	873	38%	
H32	624	29	2	0	656	1233	53%	bog
H33	68	4	1		72	86	84%	fen
H4	3340	532	241	10	4123	13734	30%	
H6	362	37	30	1	430	1030	42%	
H7	106	73	7		187	194	96%	blue-listed

Ecosystem[1]	I[2]	Oc	Oh	Ohe	Reserve Total	LU Total	% in Reserve	Comments
H8	38	9	1		48	48	99%	red-listed
HMH1	1479	3	27	18	1527	2271	67%	
HP	1479	0	3	1	1483	1884	79%	
LAKE	1	0		0	1			
NV	233	1	0		234	251	94%	
OUT	1711	74	6	1	1791	4934	36%	Susan & 2 unnamed islands
PARK	1885		0		1885	1885	100%	
RIVER	1	0			1			
Grand Total	16005	1201	616	81	17902	42819	42%	
% Operable	89%	7%	3%	<1%				

1. Ecosystem units: H1 to Hn = CWHvh2 /01 to /n site series; HMH1 = MHwh/01; HP = MHwh parkland; A = snow avalanche communities; NV = non-vegetated.

2. Operability: I = inoperable; Oc = operable, conventional; Oh = operable, heli-logging; Ohe = operable, heli-logging with economic constraints.

All representation targets are achieved and in many cases exceeded. This includes 99% of the red-listed H8 and at least 70% of the blue-listed H7(devil's club) and H13 (skunk cabbage). Wetlands are well represented, including all of the locally rare, bog woodlands (H12) and 84% of the relatively rare fens (H33).

Overall, 89% of the reserves are currently considered inoperable. It should be noted, however, that WFP personnel have strong reservations with respect to the reliability of this information (some areas labelled inoperable are likely operable, Janzen, pers. comm.; 2008), an issue that would be addressed in consultation during subsequent reserve planning. The relatively productive H4 just meets the 30% target, but does include over 500 ha of conventional operable (Oc). This could probably be reduced, by shifting towards unstable areas of H4, as the reserve is further refined. The blue-listed targets for H7 and H13 also require inclusion of conventional operable (234 ha); but this is unlikely to be found outside of the operable land base.

Overall, it appears that representation targets for landscape level reserves for the Roderick LU can be achieved very largely by co-location with other constraints mandated by the North Central Coast Legal Order, including grizzly habitat, active fluvial sites and forested swamps, as well as existing protected areas. In the absence of additional focal species data (inventory or models), the 'coarse filter' representation approach should theoretically satisfy the habitat needs of MAMU and NOGO. This situation is likely to be replicated in the majority of LU's that are largely located within the Hecate Lowland Ecosection.

This reserve design cannot yet be compared to Marxan output (not available as of March, 2009).

5.2 Stafford Landscape Unit

The Stafford LU consists of two large glaciated valleys of the Stafford and the Apple rivers, which penetrate well into the Coast Mountains of mainland B.C. As such, it is representative of many coastal mainland landscape units. The Stafford LU lies at the driest end of the very wet maritime (CWHvm 1 & 2). The Apple Valley was logged extensively in the 1960's and the layouts of that time left almost no old seral in the valley bottom or on lower valley slopes. The lower Stafford Valley was similarly logged in the 1930's and 1960's; but the latest stage of logging since the mid 1990's has been pursuant to the Forest Practices Code and FRPA, and is characterized by smaller, scattered cutblocks largely in the upper valley above Stafford Lake.

5.2.1 Available Data

At the initiation of reserve design in early December, 2008 we had the following information for the Stafford LU:

- Legal conservancies
- Grizzly bear habitat as defined in schedule 6 of the South Central Coast Legal Order
- Grizzly habitat mapping (classes 1 and 2)
- Marbled murrelet nesting habitat inventory
- TEM mapping (Lewis and Inselberg, 1995)
- SSS
- UWR's for deer and goat
- Riparian information (Forested swamps, active fluvial, active fans)
- Red-listed ecosystems and blue-listed ecosystems, based on TEM
- Seral stage mapping

In February of 2009, we received shape files for deer and mountain goat habitat models, for northern goshawk nesting (no known nest sites) and foraging, and for tailed frog stream reaches and basins. Marxan model output also became available at this time.

The lack of some data at the outset of design did not allow all designs to be based on the same inputs. This means some designs would require further work if they were to proceed to a planning process. However, the ***data limitations did not greatly hamper the main objective of this project, namely to explore a range of approaches to reserve design (not to actually produce a draft reserve plan)***.

5.2.2 Approaches to Reserve Design

In the Stafford LU, as always, we initiated design by identifying all of the existing legislated reserves. Many of these "base legal reserves" become anchors on which to build a more inclusive reserve system. These include existing protected areas and ecosystems to be reserved pursuant to the South Central Coast Legal Order: active fluvial sites, forested swamps, red-listed plant communities, 70% of blue-listed plant communities, and schedule 6 grizzly habitat. All reserve designs include these base legal reserves.

Pursuant to the original work plan, the intent for Stafford was to compare reserve design by using TEM vs. using SSS to achieve representation targets. This comparison was perhaps confounded somewhat since we undertook these two designs independently – i.e. Lewis used TEM for representation; Kremsater used SSS, hence there may be some individual bias. Both aimed to meet low risk goals for all focal species, but this was not feasible because of data limitations (see 5.1.1, above).

The original work plan was modified to answer additional questions and to respond to the data limitations that surfaced. Ultimately, four main Stafford reserve designs were created, as follows:

1. Lewis designed a reserve system to meet representation targets by TEM and to meet low risk focal species targets. This design is available in stages (TL3, TL5 & TL6), in part reflecting the late availability of some data.
2. Kremsater (LK) designed a reserve system to meet representation targets by SSS and to meet low risk focal species targets, but only for data available in December, 2008.
3. We jointly designed a reserve system that accomplished 30% representation by TEM while encompassing as much focal species habitat within that as possible (Co-located30). Representation was allowed to exceed 30% only if clearly within the inoperable land base.
4. We jointly designed a second version of Co-located30 using Marxan outputs that became available (Co-located30 using Marxan outputs).

For each version we added to the base legal reserves based on areas of the most ecological value and tried to create geographic distribution of reserves across main watersheds, including some connections from Stafford to neighbouring LUs and connections across the different valleys within the LU. Approaches specific to each version are noted in the sections below.

5.2.3 Description of Proposed Reserves

Design TL5:

This version of the reserve system in Stafford was designed to meet low risk targets for grizzly bear and marbled murrelets and 30% representation of TEM Site Series. The details that follow should provide some insight into the reserve design approach.

#1

- This is the Stafford fluvial complex above the Lake
- It focuses on by far the greatest concentration of diversity and values in the Stafford LU
- Includes important/sensitive grizzly habitat, active fluvial sites (both floodplains and fans), red-listed plant communities, blue-listed plant communities, wetlands (fens, forested swamps, minor bog), class 1-2 MAMU habitat and spawning and rearing reaches in this important fisheries watershed
- Most of these values are protected pursuant to the South Coast Legal Order

#2

- This reserve focuses on a cross-valley connection and representation of ecosystems from submontane to alpine (the full elevational range)
- It includes a mountain goat winter range, some class 1-2 MAMU habitat and a few active fans in the East Stafford
- It includes considerable unstable terrain and is largely inoperable

#3

- This reserve also focuses on the cross-valley connection and representation of ecosystems from submontane to alpine (the full elevational range)
- It includes important grizzly habitat (lower elevations of tributary) and a strip of class 1-2 MAMU habitat that flanks the fluvial reserve, #1
- It includes considerable unstable terrain and is largely inoperable, but does include operable at lower elevations that is needed to meet the MAMU low risk target

#4

- This reserve encompasses the upper East Stafford valley
- It focuses on grizzly habitat along the lower slopes and valley floor (avalanche tracks and forest patches/strips), as well as south facing goat winter range
- It represents sites ranging from montane to alpine
- It is very largely inoperable, apart from one potential conventional area at the western end and a number of scattered potential heli-blocks

#5

- This is the Stafford headwaters reserve encompassing the uppermost Stafford valley above the incised bedrock canyon
- It also includes a large goat winter range between the canyon and the East Stafford
- The upper valley floor and lower slopes include grizzly habitat on extensive complexes of snow avalanche tracks (including lush runout areas on fans) and strips and patches of montane and mountain hemlock forest
- It is very largely inoperable, apart from scattered heli-blocks in the westernmost portion

#6

- This diverse reserve focuses on the lower Apple River fluvial complex, extended westwards to encompass the exceptional Apple River estuary and salt marsh complex, and an existing conservancy that includes the smaller Stafford estuary and salt marsh, the lower Stafford River flanks and shoreline sites at the head of the Inlet
- The lower Apple valley floor encompasses important grizzly habitat, active fluvial sites, forested swamps, red/blue-listed plant communities as well as some class 1-3 MAMU habitat where older forest remains (lower Apple was logged in the 1960’s)
- It also flanks important fisheries habitats of the lower Apple River

#7

- This reserve focuses on lower elevation valley-floor grizzly habitat, and merges several fragmented schedule 6 units
- It includes red-listed fluvial plant communities and active fluvial sites

#8

- Reserve #8 encompasses grizzly class 1, goat winter range, some MAMU habitat and represents site series from montane to alpine.
- It also includes some relatively rare higher-elevation active fans, with unusual willow-dominated plant communities that include some subalpine fir

#9

- This reserve takes in much of the Boulder Creek tributary valley
- It includes a large proportion of unstable terrain, much of which is coincident with MAMU habitat (classes 1-3)
- The reserve is extended to the west to take in additional MAMU habitat in order to attain the low risk target
- The side valley is largely inoperable but the western extension is operable

#10

- #10 encompasses very largely inoperable (including unstable) sites representing a complete elevational sequence from submontane to alpine

- It also includes some class 1 grizzly habitat and a band of class 3 MAMU habitat at lower, submontane elevations

#11
- This is almost entirely goat winter range, spanning from submontane (minor area) to alpine

#12
- This reserve takes in two winter ranges (goat & deer) and is extended to provide submontane to mountain hemlock parkland representation
- It includes one substantial area of unstable terrain, the source of major rockfalls in the past (some with deposits into the estuary and salt marshes)
- It is designed to avoid a stable bench area that includes some recent heli-blocks
- It contributes some class 3 MAMU habitat and thereby contributes to the low risk target for MAMU
- It also includes representation of the drier ST13 colluvial sites in complexes with rocky ST2 sites.

#13
- This smaller reserve is based on class 1 MAMU habitat

#14
- #14 includes class 1 grizzly habitat (2 schedule 6 units), additional snow avalanche complexes and class 3 MAMU habitat
- It contains some operable

#15
- This reserve focuses on class 1 grizzly habitat and is extended to take in additional snow avalanche complexes
- It is all inoperable

#16
- #16 includes some class 1 grizzly habitat, adjacent swamp and blue-listed communities, some class 1 MAMU habitat, as well as needed representation of submontane ST1 sites

17
- This focuses on grizzly habitat (avalanche/forest complexes) in three small valleys
- It is extended to the ridgeline to take in representation for montane and mountain hemlock ecosystems, and includes a minor amount of MAMU habitat

#18
- This reserve focuses on class 1-3 MAMU habitat; it includes unstable slopes and contributes to representation targets
- It is about 2/3 inoperable; the operable portion is needed to attain the MAMU low risk target

#19
- This reserve focuses on class 1-3 MAMU habitat and contributes to representation targets
- It is about half inoperable; the operable portion/half is needed to attain the MAMU low risk target

#20

- This reserve focuses on class 1-3 MAMU habitat; it includes unstable slopes and contributes to representation targets
- It is about 90% inoperable; the operable portion is needed to attain the MAMU low risk target

#21

- The focus here is on unstable terrain, MAMU habitat (class 3) and submontane representation
- It is almost entirely inoperable

#22

- This reserve focuses on MAMU habitat and unstable terrain
- It is largely inoperable, but does include some operable, needed to attain the low risk MAMU target

#23

- The focus here is unstable terrain and associated old forest with class 3 MAMU habitat
- It is almost entirely inoperable

#24

- As in #23, the focus is unstable terrain and associated old forest with class 3 MAMU habitat
- It is almost entirely inoperable
- Could be excess to needs for MAMU3

#25

- #25 is focused on class 1-3 MAMU habitat, needed to attain the low risk target
- Much of this reserve is operable, but unavoidable to attain the MAMU target

#26

- #26 is also focused on MAMU habitat, but only class 3 here
- It takes in unstable terrain and a narrow strip of operable along the eastern Stafford Lake shoreline

#27

- This small reserve is about half unstable with MAMU class 3 habitat
- Could be excess to needs for MAMU3

#28

- #28 focuses on MAMU habitat, including some class 1 and a greater proportion of class 3
- It includes steep, rocky slopes and represents ST2
- It is largely inoperable except for the class 1 MAMU habitat needed to attain the low risk target.

#29

- #29 also focuses on MAMU habitat, including some class 1 and a greater proportion of class 3

- It is largely inoperable except for the class 1 MAMU habitat needed to attain the low risk target.
- It is adjacent to #7

#30 (former 37)
- This reserve includes wetland and poorly drained site on the low divide to Knight Inlet
- It includes some class 2 grizzly habitat (not schedule 6)
- It could facilitate cross-watershed tailed frog dispersal
- Recovery is needed in the forested fringes of the reserve (not Old)

#31
- #31 focuses on class 1 grizzly habitat that is extended to the ridge-line for representation
- At lower elevations it is extended north to take in class 1-2 MAMU and to the south to take in class 3 MAMU

#32
- This reserve is essentially all grizzly habitat, encompassing avalanche-forest complexes on lower slopes and in the valley bottom
- It is very largely inoperable

#33
- The focus here is deer winter range, augmented by similar plant communities
- It contributes to representation of ST1 (zonal) and ST2 (dry, rocky) submontane ecosystems
- It is about half inoperable/half operable

#34
- This is fen-swamp wetland complex
- It includes some grizzly habitat (class 2;not schedule 6) and class 3 MAMU habitat

#35
- This reserve is to augment representation of submontane zonal (ST10, rocky (ST2) and ST15 sites

#36
- This reserve includes a small red-listed fluvial plant community, and augments representation of submontane rocky (ST2) and zonal (ST1) sites
- It includes the undisturbed portion of a class 2 grizzly habitat unit (the non-vegetated, disturbed portion is excluded)

Design TL3:

TL3 was the third iteration in the process to design TL5. It is included as a stand-alone design since to that point, relatively little operable land base was included in the design. At this point TL3 met the 30% representation target by TEM site series, the low risk target for grizzly bear and a higher risk for marbled murrelet (higher risk a), namely 62% of MAMU habitat classes 1-3 inclusive.

Design LK:

This version of the reserve system in Stafford was designed to meet low risk targets for grizzly bear and marbled murrelet and 30% representation based on site series surrogates. The core areas of the reserves include the main Stafford Valley (reserve 101), the side reserves along the upper and east Stafford, reserves around the estuary and reserves along main Apple Valley (including grizzly and goat areas along the valley sides). After developing acceptable elevational and geographic distribution of reserves that captured low risk focal species targets, I needed to add many more reserve polygons to meet representation targets. In the list below, these reserves added for representation are noted as "added for representation of…".

For many SSS, old seral is not available; so the best area to recruit was based not necessarily on age but mostly on location and potential to create useful reserve areas over time. Some areas that have (or will have) high biodiversity values are now young (e.g., in the lower Apple River valley) and if we used a rigid recruitment rule (using the next oldest first), such areas would be missed.

The core areas of the Stafford reserves system are almost a given based on the location of many overlapping values and hard reserves. More options for locating reserves occur at high elevations where representation is the main driving factor. I chose locations of higher elevation reserves based mostly on geographic representation and tried to create connections across valleys and into adjacent LU's.

After this reserve design was complete, we received new information on deer, mountain goat, northern goshawk and tailed frog habitats. The time available did not allow further adjustment of the reserve design. It appears likely that slight adjustments of areas included for higher elevation ecosystem representation (which were the most flexible areas anyway) would incorporate deer, goat and tailed frog habitats without any impact on the operable land base. In contrast, achieving the low risk targets for goshawks (nesting and foraging) would add a considerable area of operable.

Most reserves are numbered (i.e. here and in the ArcView attribute table using numbers starting from 100), but some small polygons of grizzly habitat from the base legal reserves layer are not numbered nor described below. To calculate areas and compare against targets, several reserves were merged (dissolved) to ensure no overlapping areas (i.e. no double counting). Some detail in the descriptions below was perhaps lost as a result (merging polygons sometimes lost the tabular descriptions).

#100

- This reserve includes the upper Stafford at the very back end of the LU
- It includes the upper valley floor and lower slopes include grizzly habitat on extensive complexes of snow avalanche tracks and strips and patches of CWH vm2 and MH forest
- It includes a cross-valley connection and representation of ecosystems from submontane to alpine (the full elevational range)
- It is very largely inoperable, apart from scattered heli-blocks in the westernmost portion
- It includes a large goat winter range near the main Stafford

#101

- This is merged from several smaller reserves.
- This is perhaps the most important reserve in the LU containing multiple overlapping values in the Stafford fluvial complex above the lake.
- It includes important/sensitive grizzly habitat in the lower elevations, active fluvial sites (both floodplains and fans), red-listed plant communities, blue-listed plant communities, wetlands (fens, forested swamps, minor bogs), class 1-2 MAMU habitat (usually flanking the fluvial area) and spawning and rearing reaches in this important fisheries watershed.

- Most of these values are protected under 'hard' base legal reserves under the South Central Coast Legal Order.
- Because of the merging of reserves it also includes a large goat winter range between the canyon and the East Stafford

#102

- This reserve was merged from several reserves. It encompasses the upper East Stafford valley and a cross-valley connection from East Stafford to Upper Stafford
- It has representation of ecosystems from submontane to alpine (the full elevational range).
- It includes a mountain goat winter range, some class 1-2 MAMU habitat, and a few active fans in the East Stafford.
- It includes considerable unstable terrain and is largely inoperable (there may be some heli blocks to discuss).
- It focuses on grizzly habitat along the lower slopes and valley floor (avalanche tracks and forest patches/strips), as well as south-facing goat winter range.

#103 added for representation of CWH vm1 SAU6.

#104

- This reserve is an inoperable cross valley linkage added to join the valley reserves of 101 and 103 and 166, to upper valley reserves of 105 and 106

#105

- This reserve builds representation of AT SAU6 off the grizzly polygon.
- It links to 104 and 106 to create a cross valley connection west from the main Stafford

#106

- This reserve was added for geographic representation and to complete the cross valley connection, no impact on operable

#107 added for geographic representation no impact on operable

#108 added for representation of CWHvm1 SAU4

#109 added for representation of CWHvm1 SAU4

#110, 111 and 112

- These polygons should be merged
- The focus is Grizzly habitat (110) and representation of CWH vm1 SAU 6 (111 and 112)

#113

- This reserve captures MAMU class1 habitat – we need all of it

#114 added for representation of CWH vm1 SAU7. It's operable
#115 added for representation of CWH vm1 SAU4
#116 added for representation of CWH vm1 SAU6
#117 added for representation of CWH vm1 SAU2
#118 added for representation of CWH vm1 SAU7

#119

- focuses MAMU and grizzly habitat

#*120* added for representation of CWH vm1 SAU 6
#*121* added for representation of CWH vm1 SAU 6
#*122* added for representation of CWH vm1 SAU 6
#*123* added for representation of AT SAU9
#*124* added for representation of AT SAU?

#*125*

- This reserve adds representation of MHmm1 SAU5 built off riparian features near lakes/ponds

#*125* added for representation for CWH vm1 SAU7

#*126*

- Base grizzly polygon

#*127*

- Added to UWR polygon for representation of CWH vm1 SAU7.
- These aren't old forest

#*128* added for representation of CWH vm1 SAU7, operable and not old

#*129*

- Near a wetland but placed there to get representation if CWH vm1 SAU 7 again not old

#*130* added for representation of CWH vm1 SAU7

#*131*

- Grizzly polygon
- Added areas for representation of CWH vm1 SAU6 and high elevation representation and grizzly polygons.
- Also geographic representation to get this extreme west side of LU.
- A connection carries down to the estuary through reserves 133 and 132.

#*132* added for representation of CWH vm1 SAU 7, operable and not old

#*133*

- The reserve is a riparian system that links high elevation in the west of LU with the estuary.
- It includes representation of CWH vm1 SAU6
- It includes hard reserve around estuary, and an existing conservancy that includes the smaller Stafford estuary and salt marsh and the lower Stafford River flanks.
- It could be merged with 134 and 135 below which were added for representation

#*134* added for representation of CWH vm1 SAU4
#*135* added for representation of CWH vm1 SAU7

#*136*

- This reserve expands on hard reserves up the Apple River valley linking valley bottom ecosystem and grizzly habitat to goat winter range and adding for representation of CWH vm1 SAU 6 and up to Alpine tundra. Many polygons were merged here and so we may have lost some reasons for the reserve. It includes important valley bottom habitat in the Apple which was heavily harvested.

- It includes the lower Apple River fluvial complex, extended westwards to encompass the exceptional Apple River estuary and salt marsh complex. The lower Apple valley floor encompasses important grizzly habitat, active fluvial sites, forested swamps, red/blue-listed plant communities as well as some class 1-3 MAMU habitat where older forest remains (lower Apple was logged in the 1960's)
- It also encompasses important fisheries habitats of the lower Apple River
- Mid slope operable areas were avoided as far as possible

#*137* added for representation of AT SAU 9 (but looks unlikely). Quite unstable
#*138* added for representation of MHmm1 SAU 9

- 137 and 138 provide geographic distribution of reserves into first valley off Apple.
- The areas include quite unstable terrain
- There is some MAMU habitat included

#139

- This reserve focuses on lower elevation valley-floor grizzly habitat, and includes riparian habitat in between
- It includes red-listed fluvial plant communities and active fluvial sites

#140

- This reserve is mostly focused on goat winter ranges
- Then linked to grizzly hard reserves
- Then added for high elevation representation
- Some information was lost in merges. There were some specific SSS I was after here as well as linkage into East Stafford.
- This reserve abuts 123 and 124 which join into East Stafford 102

#141

- This reserve includes grizzly and valley bottom fluvial up into high elevation representation.
- In the merging of polygons the exact SSS I needed to represent has been lost.
- The valley bottom portion is hard reserve

#142

- Reserve focused on MAMU class1

#143

- Reserve focused on MAMU class 1

#144

- Reserve includes a forested swamp

#145

- Grizzly hard reserve

#146 added for representation of CWH vm1 SAU 1 (a 3 ha portion!)
#147 added for CWH vm1 SAU 1 again
#148 added for representation of CWH vm2 SAU3
#149 added for representation of CWH vm2 SAU7

#150

- Focuses on a bit of grizzly habitat and then added to for representation of high elevation ecosystems including AT SAU 6.
- This is at the far end of the Apple and connects to a low pass into the Phillips. Not quite sure what would use that connection, but it appealed for geographic distribution of high elevation reserve

#151

- This reserve includes a grizzly polygon but was extended to include representation of some SSS whose information has been lost

#152

- Focused on a hard grizzly reserve then extended for representation of AT SAU6
- 151 and 152 provide some geographic distribution of reserves in the upper end of the apple/

#153

- Added for representation of CWH vm1 sau6 in estuary areas near base reserve

#154

- Reserve include MAMU habitat in estuary areas.

#155 added for representation of CWH vm1 SAU 7 (up a tributary by the lake)
#156 by lake, added for representation of CWH vm1 SAU 7
#157 added for representation of CWH vm2 SAU 7 (up a tributary by the lake)

#158

- Focused on MAMU habitat in the Apple

#159

- Focused on grizzly habitat up a side drainage of the Apple (hard reserve)

#160

- Includes MAMU class 1 up tributary by lake

#161

- Based on UWR legal hard reserve. Abuts to 127 for representation of CWH vm1 SAU7

#162 added for representation of AT SAU 5
#163 added for representation of CWH vm2 SAU4
#164 added for representation of CWH vm1 SAU 13
#165 added for representation of CWH vm1 SAU4 (recruitment)
#166 added to major riparian valley bottom reserve for CWH vm1 SAU5
#167 added for representation of CWHvm2 SAU7

Design TL6:

TL6 includes amendments to TL5 to satisfy additional and/or revised focal species data (received in late January) – notably with respect to mountain goat, tailed frog and deer.

Amendments for mountain goat:

- Additional 475 ha of type 1 and 63 ha of type 2 habitat are required to meet the 70% of

1/60% of class 2 target

- Because of fidelity concerns, first added in areas not well represented (gaps) - #38-#45 inclusive.
- Second, added incrementally to TL5 reserves, by adding goat habitat while deleting similar areas of A & AT (since no need to add further to this representation) – involves #2, 3, 5, 8, 11, 12, 14, 15, 17, 18, 24 & 32; - should be minimal cumulative change to total reserve area.
- Amendments in TL6 should not materially change thlb impact or representation.

Amendments for deer:

- Minor amendments (additions) on south-facing slopes in lower East Stafford.
- Deer rank 1 totals 105 ha in 1232 polygons; avg. = 0.08 ha; max. = 8 ha; polygons >5 ha = 1; polygons >2 ha =7. The model misses established winter ranges, which appear to be appropriately located. Conclusion: this model does not form a useful basis for landscape-level reserves in the Stafford LU

Amendments for Grizzly:

- None required; use of schedule 6 covers grizzly habitat; at 99% of class 1 & 92% of class 2
- The minor % shortfalls are largely due to recent developments – roads, cutblocks & spoil piles (habitat mapping somewhat out-of-date)

Amendments for Tailed Frog:

- Inoperable includes >80% of classes 1-4 inclusive! Well above targets.
- Reserves increased in size for tailed frog, based on using basin boundaries – include #3, 8, 10, 17, 20, 40, 41 & 43; #17 is in a relatively low pass (few available) – potentially good for frog dispersal towards Knight Inlet.
- Basin boundaries are often used as they provide a better boundary rationale, especially in higher elevation areas where inoperable, AT & A can be readily reconfigured
- Tailed Frog stream reaches in TL6 = 36% of the 50% target; however, since such stream reaches (S5's) would normally be excluded from layouts, site-level reserves would readily achieve the target

- Reserve #24 was dropped from TL6– contained only minor MAMU 3 excess to target.

Amendments for Goshawk:

- Only incidentally part of TL6 version; revisions for goshawk will form the basis for TL7 (not undertaken)
- There are no known nest locations
- Note M foraging polygons are identical to M nesting polygons; some M foraging polygons are also H foraging??
- Targets are of 30% of H & 60% of M+H (i.e. of 100 ha of M&H foraging or nesting habitat, 60 ha should be retained in the solution for a low risk to goshawks. Of this 60 ha, at least 1/2 (30+ ha) should be of high value. If an LU cannot meet this high target, more needs to be in M class with all H captured in the solution).
- Re nesting, for habitat that is apparently rare, that 13,650 ha of 59,879 ha is habitat seems counter-intuitive? - i.e.23% of the LU total area; on a forested basis (21,130 ha), this amounts to 65% of the forested area!
- For nesting habitat polygons >20 ha, area = 5,935 ha; TL5 approaches (99%) this target at 5,868 ha

Stafford Co-located30 Design:

As with all designs, the starting point is the base legal reserves. We then added to reserves to meet the 30% representation for each site series while including as much focal species habitat as possible within that 30%. We added to the base legal reserves using areas of the most ecological value and tried to create geographic distribution of reserves across main watersheds, including some connections from Stafford to neighbouring LUs and connections across the different valleys within the LU.

We saved "Co-located30 untrimmed" because it was our best initial reserve design, then checked to see how close to 30% we were and how much was operable versus inoperable. In most cases, our first iteration was over the 30% target and so we reduced the included operable where possible. To check our impact on operable we looked at only the operable included in the reserves that were *incremental* to the base legal reserves. The hard reserves themselves overlap considerably with operable area (overlaps are with red-listed and grizzly habitat in particular)

Most of our overlaps with operable were in ST13, ST3, ST2 and MT1.

- To avoid operable areas of ST13 we had to pull back from class 2 Marbled Murrelet habitat and shrink some reserves in the valley bottom. This created a much more fragmented valley connection than originally drawn. Most of the areas we pulled back from are indeed areas that would be attractive for harvesting.
- In ST3 we also pulled back to avoid operable. This also caused some fragmentation of our reserve design. However, most operable areas of ST3 included in the reserve are simply small overlaps included because of the coarse nature of our mapping. They could be avoided when final lines are drawn if this reserve design goes any further.
- For ST2 most of the overlaps are small along reserve edges and easily avoided if the design is refined any further.
- For MT1 in Apple we left boulder Creek MT1 operable in reserve since it seems so unstable and hence inoperable. This needs to be checked with operational staff. We took out MT1 from a reserve that linked Grizzly and MAMU habitat to a legal goat UWR in the Apple to avoid operable and allow some opportunity for heli-logging of that area. The pull back reduced connection somewhat, but connections are maintained around the edge of the reserve. (Connections are a useful design principle for locating habitat, but not of solid enough to insist on in most places. Most organisms do not need entire intact stands to be able to move through habitat. Connections for organisms needing forests can also be achieved by stand-level retention). In the east fork of the Stafford, we pulled back from operable MT1 which reduced our large block and reduced valley bottom reserve, losing a large amount of MAMU habitat (class 1 and 2). That would be an area for discussion with operations and with MAMU biologists. Pull backs out of operable in ST 13 and MT1 have large implications for amount of MAMU habitat in reserve.
- Apparent overlaps (150 ha in total) in MH1 do not appear to be actual operable ground, so we didn't reduce MH1; this would be checked with operational staff if this design continues into the planning stage.

Reserve design is commonly an iterative process. The various ‘pull backs’ noted above impacted the amount of reserves in other ecosystem types. We inadvertently reduced our inoperable in ST13 and lost about 130 hectares of ST1 -- each iteration changes the numbers for other ecosystems too, so several iterations would be required to come up with a final reserve design. We went back to fix ST13, ST1,and ST 15 which went into deficit due to our changes. This added some small reserve fragments just to get back to targets (because we tried not to include anything extra that would be necessary to make nicer shapes). In fixing the deficit in ST 1 we took back the riparian area in Apple that is operable, but also makes sense ecologically to be in reserve. If we try for only inoperable ST1, there isn’t enough and what there is will be in bits and pieces scattered here and there. After one iteration of ‘fixes’ we went below targets in MT1, then ended up finding an area of inoperable MT1 in Apple that we didn’t originally identify and augmenting that with some pieces near the UWR on the south aspect of the east fork of Stafford; and traded operable for inoperable in the back end of Stafford.

If this was to be the process to actually determine a landscape reserve design, then the next steps would be more iterations to reduce operable as much as possible and to find inoperable to replace it. However, this should be done with operational people so that only operable that is truly operable is removed from the reserve system. Many of the overlaps do not appear to actually be operable areas although they are mapped as such. Similarly, we didn’t add in overly much inoperable because in reality that is not all firmly inoperable either. There are various areas where we could have increased patch sizes, reduced edge and maximised interior by adding inoperable, but it would have taken us above the 30% even more so. This would be a reasonable approach however, and is what we generally do when designing and planning reserves.

Co-located30 using Marxan inputs:

Fundamental questions to be considered include: Can Marxan help us improve our reserve system; and, how would Marxan change our approach to design if we started with Marxan at the outset? Would starting with Marxan have directed us to a system much different than what we otherwise create?

This design is based on a reconsideration of the Co-located30 design based on the recently available Marxan outputs. We first compared our Co-located30 to several Marxan outputs, and then redesigned the Co-located30 using the guidance provided by Marxan (“Co-located30_trimmed_mw.shp”). Marxan step 3 output essentially uses the same philosophy as our Co-located30 design. Both are trying to get representation to 30% total while overlapping with as many important habitats for focal species as possible while having the least impact on timber supply. Marxan however bases representation on site series surrogates while we base representation on TEM, although we do cross check for representation based on SSS. Our TEM version also met the SSS targets quite well except for good cedar (CWHvm1 SAU4); so we adjusted our reserves based on where Marxan included good cedar.

We compared our Co-located30 scenario to Marxan’s step 3 by looking at the LU sub-drainage by sub-drainage. As a check we also looked at the layer from Marxan that shows how often polygons are selected (“summed runs”) in solutions for meeting representation and low risk focal species targets to see if we could incorporate the most used polygons. We also checked on the tailed frog, deer and goat layers that we did not have when we built the Co-located30 scenario – if that habitat could be included without impact on operable we adjusted our reserves to include that habitat. We did not go into operable to fully meet low risk targets for focal species as that was not the intent of this scenario. Impacts on operable are only accepted to attain representation targets.

Upper Stafford

- Marxan reserves a polygon of medium cedar at high elevation, but in fact that polygon is snow and ice, so we did not adjust our reserve system to incorporate it.
- We expanded our reserves slightly up the inoperable valley to include areas Marxan caught but we didn't. It's a very slight increase in reserves up the valley.
- Marxan reserves also suggested a nice link towards east Stafford, also in inoperable, so we drew a reserves around several Marxan polygons to make them into a broad valley reserve that also encompasses tailed frog reaches and basins, and includes some goat habitat. (We didn't have tailed frog or goat information when we did the Co-located30 version or we would likely have caught these drainages before. As it was, our choice of high elevation representation was not informed by tailed frog or goat models.)
- Marxan and some of our other plans identified reserve areas going from Upper Stafford towards Knight Inlet Divide. We didn't initially have this in our Co-located30 version, but now have adjusted it to include a link up that divide. This is a good area to include.
- We also adjusted the reserves on the west side of the Divide area to include areas identified by Marxan's step 3 and to catch goat habitat inoperable. The adjustment is only affects inoperable.
- We adjusted a small area in inoperable to include a polygon that Marxan caught during most of its runs to meet low risk focal species targets.
- We didn't bother including all the streams and basins for tailed from if they were above tree line.

In summary, aside from the link into the Divide any changes in Upper Stafford were minor but useful and don't impact the operable land base.

East Stafford

- Because it is using SSS, Marxan reserves a polygon of poor hemlock at high elevation at the end of the valley, but in fact that polygon is snow, so we didn't adjust our reserve for it.
- We extended our reserves up the inoperable valley to include goat habitat and areas Marxan identified for representation. It is a small extension in inoperable.
- Expanded the reserve on the south east side of valley to include areas Marxan identified for representation and overlapped polygons Marxan used many times in it solutions. We also capture goat and frog habitat. All adjustments were in inoperable.
- Expanded goat winter range at beginning of drainage into inoperable to capture areas Marxan used often and also identified in its step 3 run. That reserve now links across the valley of the East Stafford.
- Extended reserve into a valley off the southeast side if east Stafford to capture goat and frog in inoperable and some areas Marxan used frequently in solution sets.

In summary, East Stafford changes added some areas to upper elevation inoperable to catch goat and frog mostly, and to cover some areas identified for Marxan in its step 3 run. None of the changes affect operable land.

Main Stafford to west and along to south end of lake

- We added some areas Marxan identified for representation to the north and west side of the Lake. We didn't go into the operable because we know we have met TEM targets with that operable and don't have any holes in the SSS in those types either. In this case, had we used Marxan to start with we would have created more reserve in the valley bottom, which may be better for MAMU and Goshawk but has operable impact.
- We expanded winter ranges to west and south end of lake to include some more goat habitat.
- We added operable polygon of cWHvm1SAU4 (good cedar), because we were low in that SSS (recall we met TEM but missed a few SSS) and it is used in Marxan.

In summary, only small changes. Some impact on operable for the good cedar site.

Main Stafford to east below fork with east Stafford and down to south end of lake

- In some of the valleys draining into the main Stafford, we added goat and frog habitat in inoperable.
- We did not adjust our reserves for representation of some misidentified SSS (e.g., medium hemlock in alpine that really isn't anywhere close to medium)
- About 3 km north of the lake we extended a unit into a steep slope between the flood plain and the logged bench above. Marxan includes the area in its Step 3; we had avoided it because its operable. But it may not really be operable and is good MAMU and likely good NOGO habitat. If it's really operable we could exclude it because we don't need area for representation in our version. Often the slope above the river will be good for grizzly too.
- We did not adjust for the large CWHmm1 SAU9 representation polygon captured by Marxan but not in our reserve. We already have enough.
- Extended a reserve to surround two small lakes (but extended it from Marxan step 3). and extended that even more to protect tailed frog habitat in inoperable between lakes.

In summary, some fairly large areas added, mostly for goat, some for frogs, and all in inoperable except that valley piece which should be check with operational engineers (we think it's not really operable)

Apple

- We extended reserves in upper apple to catch more goat habitat
- If we had started with Marxan we may have used north side of east apple for a reserve rather than the south side. We just wanted a connection to Philips, it wasn't that it was special habitat. And it not like the connection is going to change whether it's reserved or not, so it doesn't matter if it's in reserve or not. Makes no impact on operable either way.
- In Apple, below the confluence of upper Apple and east Apple, we didn't add some large polygons that Marxan included for medium and poor cedar in vm2 because we have it elsewhere and there is some operable area involved.
- Added inoperable goat habitat in side drainages to east of main Apple.
- And added low elevation inoperable goat habitat to west of main Apple.

- Again, we did not adjust for the large CWHmm1 SAU9 representation polygon captured by Marxan but not in our reserve. We already have enough. Seems to be some flexibility in where to get that SSS without impacting operable.
- On northwest side of main Apple we picked up an areas of CWHvm2 SAU5 (poor cedar) that was inoperable and we don't have overly much of.
- On southeast side we also picked up some CWHvm1 SAU4 (good cedar) that we don't have very much of. Says it's an operable polygon, but may not actually be very operable.

Meadow Creek area (from south of lake to estuary and to the west)

- We extended reserves to catch more goat habitat
- Could readily get more tailed frog basins in this area that are totally inoperable. That wouldn't help the frog because nobody is going there anyway, but could easily meet targets if that is important for some reason. Actually, we are sure we have already met targets.

5.2.4 Findings from Stafford Reserve Designs

It is not efficient for people designing reserves to look at many different possibilities/scenarios. Looking at implications of different targets is best done using a model. Then, designing reserves based on desired targets can be done efficiently (2-4 person-days per LU).

We used 4 approaches to reserve design for the Stafford LU:

1) 30% of total based on representation by TEM site series, meeting low risk focal species targets (TL3,TL5,TL6);
2) 30% of total based on representation by SSS, meeting low risk focal species targets (LK);
3) 30% of total based on representation by TEM site series, including in that (i.e. co-locate) as much focal species habitat as possible, and as much as possible avoiding the THLB (Co-located30); and
4) as 3 above, but using Marxan output to assist in locating reserves (Co-located30_mx).

These designs are subsequently referred to as TL (variants TL3, TL5 and TL6), LK, Co-located30 and Co-located30-Marxan. The following table summarizes the extent to which targets were attained by each of the designs, total reserve area and the area of operable (Oc) in the design. Further detail is available in accompanying spreadsheets (see 6.0).

DESIGNS	TL3	TL5	TL6	LK	Co-located30	Co-located30-Marxan
Focal Spp.:						
Grizzly – low risk	YES	YES	YES	YES	YES	YES

DESIGNS	TL3	TL5	TL6	LK	Co-located30	Co-located30-Marxan
Mamu – low risk [1](62% of all habitat, starting with class 1and 2 and adding class 3 as necessary),	NO	YES	YES	NO	NO	NO
Mamu – higher risk (i.e. 62% of 1-3 incl.)	YES	YES	YES	YES	NO	NO
Goat – low risk	N/A	N/A	YES	N/A	N/A	YES
Deer – low risk	N/A	N/A	YES[3]	N/A	N/A	NO[4]
Tailed frog basins – low risk	N/A	N/A	YES	N/A	N/A	YES
Northern goshawk – nests & nest sites	N/A	N/A	YES[2]	N/A	N/A	YES[3]
Northern goshawk – low risk for nesting/foraging	N/A	N/A	NO	N/A	N/A	NO
Representation:						
by TEM	YES[2]	YES[2]	YES[2]	NO	YES	YES
by SSS	NO	NO	NO	YES	NO[5]	YES
Hectares of Operable Reserved	1855	2209	2265	2462	1907	2051
Total Hectares in Reserve	19740	21847	24632	21621	20836	25463

YES = target met; NO = target not met; N/A = data not available at time of design.

1. To reach the MAMU low risk target of 62% class 1, 2 and 3, the solution included 100% of all class 1 and class 2 and some of class 3
2. TEM representation is met if circum-mesic site series are grouped.
3. There are no known nest sites, but reserve distribution and included/nearby habitat appears adequate for goshawks.
4. Deer model is poor for Stafford LU; winter ranges are included plus additional.
5. Only minor shortfalls for good C sites.

Key points arising from the above summary table are:

- Not surprisingly, attaining representation targets with co-location of habitat impacts less operable than attaining both representation and low risk targets;
- Attaining low risk MAMU cf. higher risk (62% of 1-3 inclusive) requires 350 ha of additional operable;
- Attaining low risk targets for goat, deer and tailed frog has negligible incremental impact on operable once MAMU targets are achieved;
- Using Marxan output to guide design allows both TEM and SSS targets to be achieved with only an additional 50 ha of operable; and
- Accommodating goshawk nest sites can be achieved by reserve designs that adequately account for a reasonable distribution of reserves along major valleys (i.e. even where N/A is indicated, these designs would accommodate goshawk nesting).

The South Central Coast Ministerial Order (Sec. 14(1)), states "…retain an amount of old forest equal to or greater than that specified for each site series surrogate listed in schedule 3…". We commonly exceed targets to achieve a more cohesive reserve design (larger reserves with more forest interior and less edge) where there is little or no impact on the THLB., for example, >30% of non-forested ecosystems, or >30% of clearly inoperable high elevation forests (see accompanying spreadsheets for details). We restrict our efforts to just meeting representation targets only to avoid unnecessary impact on the THLB.

With Marxan output, and as with the independent LK and TL rational designs, we located reserves in different higher elevation locations. Such differences are probably not ecologically meaningful, as one higher elevation area is not very different from another; but the Marxan cost layer likely makes the Marxan choice better than our choices which were based solely on operability. Essentially, where there was considerable choice to attain representation, Marxan directed us and helped us choose. Where values were high and overlapping, or where choices for representation very constrained, similar areas were reserved with or without Marxan.

The strength of using Marxan is that it allows us to efficiently build a reserve system from reserve pre-cursors (Marxan's candidates) by adding logical connections and by reducing edge and increasing interior. The Marxan model could be adjusted to increase aggregation (C. Rumsey, pers. comm.), but this would be a mechanical approach rather than our more flexible, rational/intuitive approach that includes many landscape considerations. This additional effort/modification of the Marxan outputs is not likely to greatly increase the utility of the Marxan output.

A limitation of many models is that they capture good habitat no matter how small. Unless some arbitrary minimum value is imposed (this can vary to suit the various species), many small polygons (hundreds) are identified and contribute to the total area of habitat apparently available. Unless such small components of habitat clump up to a realistic, useful size, they should not be used to create landscape-level reserves (some may be useful at the stand level), **nor** should they contribute to firm numerical targets.

Even when we do not attain all low risk species targets, it is important to recognize that the reserve system is more than the sum of the reserves for individual species. The combined reserve system will increase the protection for most species beyond the levels specifically reserved just for them. It may be that the combined reserve system is likely still close to low risk for most species, (although this is just our sense and not confirmed). A useful approach during reserve planning would be to ask focal species experts what they think of the overall reserve system for their species of interest. Where are the weaknesses? What areas of important habitat are omitted? This is different from simply checking how much of a species' high value habitat is captured in the reserve. Rather, it requires that not only amount but also the pattern of all reserved habitat be assessed, and that consideration be given to what the reserve system will provide over time as some habitats mature. We believe that when an overall reserve system is planned, the importance of meeting strict numerical targets is decreased.

Where mountain goat and tailed frog habitat is not included in reserves, in many cases it will remain unharvested. Needing to meet the full target of 90% of goat habitat in reserves is likely a very low risk scenario as much of the areas not included are inoperable.

There is no substitute for knowing the area well: forest, terrain, and general harvest history (as for Roderick and Stafford). Local knowledge makes creating reserves much easier and results are far more reliable. This supports our strong preference for ***planning*** as opposed to ***design***.

This version of our "Co-located30 using Marxan outputs" is a good start to planning a reserve system for Stafford. It impacts operable only for representation and includes focal species habitat in inoperable to make connections. More focal species targets could be added to this version if desired, but first a review by focal species experts would allow them to assess if/where there are real risks to their species in this design. We consider this version to be the most useful reserve design for Stafford, suitable to go forward to a consultative planning process.

5.3 Thurlow Landscape Unit

The Thurlow LU consists of four main islands – East Thurlow, West Thurlow, Sonora and Hardwicke, and a number of small islets. It lies within the Outer Fiordland Ecosection, an area of relatively subdued terrain at low to moderate elevations without any alpine. It straddles a strong climatic moisture gradient ranging from the CWHxm through the CWHdm and CWHmm to the CWHvm subzone, and includes two additional montane variants (CWHmm2 and CWHvm2). There are few physical constraints to operability and as a result there has been an extensive logging history. Apart from the CWHvm, the landscape is dominated by mid and young seral stages. Especially in the CWHxm, old seral consists of numerous small, scattered patches mostly associated with poorer, rocky sites.

The Thurlow LU includes a considerable area of private (fee simple) land that is not available for reserve design (i.e. 5,421 ha private; 14.4% of the gross area).

5.3.1 Available Data

At the outset of design in February, 2009, we had the following information for the Thurlow LU:

- Legal conservancies – Parks and Ecological Reserves
- TEM mapping (Blackwell & Assoc., 1999, 2000, 2006),
- SSS
- Seral stage mapping
- Marbled murrelet nesting habitat model
- Deer habitat model

- Northern goshawk foraging and nesting habitat models; and known nest sites
- Red-listed ecosystems, blue-listed ecosystems and wetlands, based on TEM

Some focal species are not present in Thurlow, namely mountain goat, grizzly and tailed frog. There are no established UWR's for deer or WHA's. In addition, there are no large fluvial systems; hence active fluvial and active fans would at most be site-level features. We did not have an operability layer available to work with and assumed operability is essentially not physically constrained in this LU. Slope stability information is incomplete (Timberwest only), but was augmented by Lewis's past on-ground experience. With one notable exception, stability issues are constraints to road location rather than to harvesting.

Marxan model output became available soon after we initiated the Thurlow design work (note, this output incorporates consideration of a cost layer).

5.3.2 Approaches to Reserve Design

Two approaches were taken to reserve design in the Thurlow LU:

- Design using TEM to attain representation targets, subsequently modified by Marxan (Reserves1); and
- Design using TEM to attain representation targets using Marxan right from the outset of design (Reserves2).

The core legal reserves are common to both designs and include existing parks (Thurston Bay Marine Provincial Park on Sonora Island) and ecological reserves (some offshore islets). We also added the standard 800-metre radius buffer to three known northern goshawk nest sites.

As always, our next step in building a reserve system was to assess the ecological values in the LU to decide what the main building blocks would be. For both Thurlow designs, these included:

- small areas of deer winter habitat, suitability classes 1 and 2;
- limited marbled murrelet habitat classes 2 and 3 (no class 1 suitability);
- one polygon of clearly unstable, gullied terrain on West Thurlow I.; and
- representation of a relatively large variety of site series and site series surrogates because of the multiple subzones/variants present.

The relatively small amount of marbled murrelet and deer habitat largely reflects the small amount of remaining old forest. Since the models are based habitat suitability rather than on capability, areas of younger forest have low habitat ratings. We reserved the currently suitable habitats in reserves and augmented them with adjacent potential habitat when we selected younger recruitment areas. We limited deer polygons included in the reserve system to those greater than 2 ha since smaller areas can be captured at the stand level (either in-block retention or Wildlife Tree Patches (WTP's). We limited polygons of marbled murrelet habitat to those greater than 5 ha so that at least they would have some interior habitat based on an edge influence of 100 m. Only class 3 polygons exceeded 5 ha (class 2 MAMU amounts to 8 ha in 21 polygons).

Although existing goshawk nest sites plus buffers will be core to the reserve system, both modelled nesting and foraging habitat is quite extensive and does not easily help identify core reserve areas. Therefore, instead of planning the reserve around the modelled goshawk nesting and foraging habitat, we undertook a post-design check to ensure we have suitably distributed goshawk nesting habitat, and adjusted the reserve system where necessary. (We consider goshawk nesting habitat to be higher priority than foraging habitat). Although the focal species group suggests that foraging habitat should be caught in reserves to attain a low risk, we feel that this habitat can be created and maintained by management over time (i.e. as aspatial targets rather than hard reserves) by using a dynamic model (e.g. Patchworks or SELES) to check and adjust so that active management creates and maintains a sufficient supply of habitat over time.

Because only a small amount of the LU is designated as habitat needed by focal species and there are few other ecological anchors at a landscape scale (e.g. active fluvial, forested swamps), attaining ecosystem representation targets is the dominant priority for Thurlow. These targets are attained differently in the two versions of the Thurlow reserve design, one by site series based on TEM modified by Marxan; the other, also based on TEM but using Marxan from the outset.

Design Approach based on TEM Representation modified by Marxan (Reserves1):

The Thurlow LU includes six variants of the CWH; and fortunately site series have recently been mapped using TEM methodology at our 1:20,000 planning scale (Blackwell & Assoc., 1999, 2000, 2006). The TEM mapping is supplemented by mapping of site series surrogates and seral stages. Representation targets have recently been revised in an amendment to the South Central Coast Ministerial Order, based on a percentage by site series, in some cases plus additional hectares (a top-up provision). Since there are no major river systems and therefore no fluvial site series, the representation targets are essentially to encompass circum-mesic, upland sites plus localized small wetlands. Because of the lack of habitat anchors in the Thurlow LU, the site series layer and the pattern of site series drives the design of reserves. Consequently, reserve design attempted to capture different site series patterns and often took the form of elevational transects across two or three variants, also with consideration of geographic distribution. We initially designed the reserves from TEM, and then modified the reserves based on reconsideration in the light of Marxan output. As the design proceeded, we increasingly relied on Marxan output.

Design Approach based on TEM Representation using Marxan at the outset (Reserves2):

A strength of Marxan is its ability to identify site series surrogates that best overlap with focal species habitat needs. Because representation is the largest priority on Thurlow, we used Marxan to guide the best places to include that representation while including as much focal species habitat as possible. This is the first LU design for which we used Marxan outputs at the outset of the reserve design process.

We used four Marxan outputs: referred to as steps 1, 2 and 3, and the “summed run”:

- Step 3 includes just what is needed to meet representation targets, while co-locating as much focal species habitat as possible.
- Step 2 adds MAMU classes 1 and 2 habitat (note, no MAMU class 1 in Thurlow), and Deer classes 1 and 2. In the Thurlow LU, there is little change (5 to 10% more) to the area under reserve from step 3 to step 2.

- Step 1 attains all of the low-risk focal species targets. As a result, the reserve area increases substantially, largely to satisfy the NOGO targets.
- The summed run showed polygons most often selected in the solutions of the various runs.

Although we did not purposefully include deer polygons of <2 ha or murrelet polygons of <5 ha, by incorporating Marxan output into this design, such smaller habitat polygons would still influence the design, hence this information is not completely lost by this approach. We then designed reserves to meet representation targets by site series for the various subzones and using Marxan guidance to co-locate that representation on important habitats for species.

In the Roderick and Stafford LU's, we rarely used site series or SSS as a primary design tool; rather, we designed reserves around other priorities and only subsequently checked how well we met representation targets after the basic reserve system was compiled. We then adjusted as necessary for any misses or overshoots in representation. In contrast, for Thurlow, aside from the few areas of focal species habitat and legal reserves, we focused on representation layer as a dominant tool to help us draw reserve boundaries and used Marxan to guide the choices.

After we had completed the Reserves 2 design, it was pointed out to us that we had misinterpreted the legal orders, and that the targets were to be applied to each site series, not to the circum-mesic site series as a group. At this point, we had insufficient time and funds to further modify the design.

5.3.3 Description of Proposed Reserves

Design based on Representation by TEM modified by Marxan – Reserves 1:

In the first iteration of the design (Reserves1), we aimed for representation of all site series, but were not rigid about meeting the 27% of old (30% of RONV) for each site series. Rather we aimed for a reasonable geographic distribution of site series, including old seral where available but including considerable mid and early seral for recruitment, in larger reserves that ultimately will have a predominance of forest interior and relatively low amount of edge.

Sonora Island

Sonora Island includes CWhxm2 and CWH mm1. It is dominated by site series 03, particularly in the CWHmm1, with much smaller components of other site series. The brief reserve descriptions that follow should provide a sense of our design rationale.

1. The polygon has at its core deer habitat class 1 and 2. To that we added potentially unstable areas to extended the reserve into lichen sites and into site series 20 (fern bluffs). We also dropped the polygon to the west into the richer SS12 (skunk cabbage) area and into moist rich sites in the valley bottom. This is nice range of representation from dry to wet and from and from CWH xm2 to CWHmm1.
2. Deer habitat extended into SS11, and SS20, but mostly focused on rocky bluffs. Area is potentially unstable (class 4). Has CWHxm2 to mm1 representation.
3. Shoreline reserve that will be useful for visuals as well as ecological values. It included some drier sites (02 lichen sites) and some moister sites at shoreline.

4. Another shoreline point, focused on deer habitat (which occurs in small polygons) and extended to include complex shoreline adjacent to shallow near-shore habitats. Excludes areas of private land that wrap around the point (an interesting area for marine life). Extended substantially for representation in CWHxm2.
5. Park, but extend to include some mesic and drier CWHxm2 representation, lake shoreline (and wet area near lake) and deer
6. Park (Thurston Bay Marine Park)
7. Park (Thurston Bay Marine Park)
8. CWH dry rocky
9. Deer winter range
10. Tip of Island to include mature forest and deer habitat. Moister, more productive area than some other reserves on this island. Extended to also catch potential future Mamu habitat on north slope CWHxm and mm.
11. West edge of island for representation (no deer, Mamu). At the moment it includes recent cutblocks with retention. We'll see if we need them for representation or can find better areas.
12. CWHmm to capture interior of island by lakes (geographic spread of reserves).

These 12 areas were intended to encompass the most important areas of the Island. We subsequently looked at the Marxan output to see where our reserves encompass similar areas and where they do not overlap, to make the following amendments:

- Added to the north of reserve for representation of SAU1 of CWHxm2 (zonal site)
- Extended reserve 5 to include areas identified by Marxan as always selected for representation
- Added to reserve 11 for more representation to the west point of the island
- Linked reserve 1 to 3 through areas that would be needed for representation
- Added reserve 13

13. Along to the south shore. Area of older trees around a younger patch. For representation in xm. Extended again for representation.

East Thurlow Island

East Thurlow Island includes CWhxm2 and CWHmm1, with a greater mix of site series than Sonora. There are very few fragments of habitat for focal species, and very few areas that are clearly ecologically superior, so we used Marxan outputs to help select areas for representation. We relied on polygons that Marxan frequently used in its solution sets.

14. CWHxm to mm representation added to NOGO nest polygon. Component of poorly drained areas and wetlands. Fattened out considerably to the west just because we are nowhere near 30% of RONV yet.
15. Lower slopes of CWHxm and poorly drained
16. CWHxm drier rocky sites and deer winter range
17. CWHxm representation zonal to lichen and drier salal sites in the east. Some CWH mm representation in the higher areas. Representation of hardhack fens, lakes

and wetlands complex in CWHxm2 to the west. Then extended to capture more shoreline once we looked at Marxan polygons that were used many times.

18. Representation from CWHmm through xm representation

19. Area of decent Mamu habitat as focus and extended to include more potential MAMU habitat and representation through various CWHxm2 site series.

20. Deer winter range habitat and CWH xm2 representation. North shore of a lake.

21. East side of Island. CWHxm representation and areas suitable for deer winter range

22. CWHxm representation, both of dry southerly and moister northerly aspect draw.

23. Point to the west for representation in CWH xm2. Fattened for representation of CWHxm to get a large sized reserve.

24. Point of drier CWHxm. Also good for visuals

25. Island to south west.

West Thurlow Island

West Thurlow Island includes CWHxm2 and CWH mm1. Considerable harvest history on this island There are very few bits of habitat for focal species, and very few areas that jump out as ecologically interesting than other spots, so we used Marxan outputs to help select areas for representation. We looked at polygons that Marxan frequently used in its solution sets.

26. Focused on many deer polygons, merged to a larger winter range unit. Wrapped an area around easterly point. Then added a large area up the easterly coast and inland which includes some mesic and moist riparian and gully areas. Ought to have future value for murrelets.

27. An unmapped, unstable area on northeast an extended that along the shoreline that is over the break and not reachable for harvest.

28. Representation of CWHxm through CWHmm, northerly shoreline, widened for representation.

29. All CWHmm1, poor sites (salal), but the only mm without much logging

30. Wetlands in CWHxm2, skunk cabbage, between logged blocks in northeast part of Island

31. Unharvested area around lake and extending across the island almost shore to shore. For representation of CWH xm2.

32. Western shoreline and point. CWH xm2 drier, rocky sites. Likely has value for visuals too.

33. Mesic CWHxm2 with component of wetlands and wetter sites; extends into CWHmm as well.

34. Representation of mesic CWHxm alongside of private land block

35. Representation if CWHxm – dry, mesic and moist.

Hardwicke Island

The Island includes CWHdm, and CWHvm1 and vm2. Past logging is concentrated on the east side of the Island. A couple of goshawk nests provide anchors for reserves but other than that there are very few critical habitats for focal species, and very few areas that are clearly of ecological interest; so we used Marxan outputs to help select areas for representation. We looked at polygons that Marxan frequently used in its solution sets and added to these to provide interior and improve connectivity.

36. Large area to link coast to coast and incorporate a large proportion of CWHdm and into CWH vm1 and vm2. Includes goshawk nest site. We assume roads can be built through the reserve as needed. Extended that area to include shoreline along the north shore of the island
37. Representation of CWH vm1 includes archaeological sites
38. Westerly point also CWHvm1

Design based on Representation by TEM using Marxan at the outset – Reserves 2:

Hardwicke Island

- H1. Drew reserve to encompass deer winter ranges on east side of Island in an area identified by Marxan as used in most runs. Added to that an area close to existing VR blocks for representation in CWHdm. We didn't include an area between blocks that Marxan included because it's fairly clear they would harvest this soon and it would be a high priority for harvest. It includes a coastal bit close to the road and they may want it for harvest in which case we can replace it with another area. Some riparian areas also in this reserve.
- H2. Coastal area for representation in CWHdm. This area includes many polygons identified by Marxan as important areas for representation (step 3) and presumably collocate focal species habitat. Extended along coast to include estuary. We used recent cutblock boundaries to direct the edge of the reserve so the reserve includes some areas close to recent harvesting that we could replace if they want to harvest.
- H3. Riparian area along river to link CWHdm into CWH vm1 and eventually to CWHvm2. Private land interrupts the linkage down to the estuary of reserve H2.
- H4. Reserve around wetland complex (includes a few polygons identified by Marxan)
- H5. Includes goshawk nest site and skirts private land. We assume roads can be built through the reserve as needed. Extended that area to include shoreline and to include some areas Marxan chose for representation in CWHvm1.
- H6. This reserve connects CWHvm1 to CWHdm and includes riparian and rocky areas of deer winter range, plus one of the few areas of MAMU habitat. This area includes almost all of the CWHvm2. If some is desired for harvest, it can be withdrawn from this reserve while still avoiding impact to prime deer and MAMU habitat.
- H7. Reserve surrounds a NOGO nest site and includes riparian habitat and polygons identified by Marxan for representation.
- H8. Reserve that includes much of westerly point (York Point) including archaeological sites; CWHvm1.
- H9. Reserve on northern shoreline for CWHvm1 representation and geographic distribution.

West Thurlow Island

- WT1 Focused on many deer polygons, merged to a larger winter range unit. Wrapped an area around the south-eastern point.

WT2 An area of unmapped unstable slopes on the northeast coast, extended along the shoreline that is over the break and no reachable for harvest.

WT3 Western shoreline and point. CWH xm2 drier, rocky sites. Likely has value for visuals too.

WT4 Representation from south shoreline up towards CWHmm1. Mostly dry rocky areas.

WT5 Unharvested area around lake and extending across the island almost shore to shore. For representation of CWH xm2. Amalgamates Marxan polygons, but doesn't use the largest concentrations of Marxan polygons. We think we are capturing similar representation while getting less operable sites.

WT6 Representation of mesic and drier and some rocky, considerable south aspect for future deer winter range.

WT7 Representation if CWH xm – dry, mesic and moist

WT8 Mesic CWHxm2 with component of wetlands and wetter sites. Touches into CWHmm2 as well .

WT9 Area along eastern shore.

WT10 New polygon to capture old in CWHmm1

East Thurlow Island

ET1. CWHxm2 to mm representation added to NOGO nest polygon. The nest polygon contains some cutover areas. Component of poorly drained areas and wetlands. Fattened out considerably to the west to include polygons identified by Marxan as often used in solution sets.

ET2. Point to the west for representation in CWH xm2. Likely visual values too. Representation of CWHxm2. Rocky sites.

ET3. Area from ocean around lakes up to CWHmm1. We assume the road can stay so access through the reserve is not an issue. May include some Mamu habitat particularly in future. This area identified by Marxan as often used in its solution set. Added to this another coastal area to get more CWHxm2.

ET4. Lower slopes of CWHxm2 and poorly drained. Directed by Marxan and locations of wetter ecosystems. Captures riparian habitat among lakes.

ET5. Representation from CWHxm2 through to mm2. Added to reserve to capture CWHmm1 and catch also future Mamu habitat

ET6. Marxan uses private land and we instead took an area on east side of Island that has representation of dry rocky CWHxm sites and areas suitable for deer winter range.

ET7. Point of drier CWHxm. Also good for visuals.

ET8. Representation of hardhack fens, lakes and wetlands complex in CWHxm2 . Interesting looking complex of ecosystems. Also identified by Marxan.

ET9. CWHxm2 representation of a whole variety of ecosystems: zonal to lichen and drier salal sites in the east. Includes Marxan polygons that were used many times.

ET10. Northern shoreline CWHxm2 that connects to CWH mm representation in the higher areas.

ET11. Added areas of polygons that Marxan identified in its step 3. They are old forest stands near the large lake and include some riparian areas around confluence of stream. We used existing layout as reserve boundary.

Sonora Island

S1. Park (Thurston Bay Marine Park)

S2. Park (Thurston Bay Marine Park)

S3. Tip of Island to include mature forest and deer habitat. Moister more productive area than some other reserves on this island. Extended to also catch potential future MAMU habitat on north slope CWH xm and into CWH mm1.

S4. Some mesic and drier CWHxm2 representation, lake shore line (and wet area near lake) and deer (includes CWHxm2 and mm1)

S5. Area of Marxan highly used polygons in CWH mm1.

S6. Area of Marxan highly used polygons capturing patches of old around lake. About half and half CWHxm2 andmm1.

S7. The polygon has at its core deer habitat class 1 and 2. To that we added potentially unstable areas to extended the reserve into lichen sites and into site series 20 (fern bluffs). We also dropped the polygon to the west into the richer SS12 (skunk cabbage) area and into moist rich sites in the valley bottom. This is nice range of representation from dry to wet and from and is mainly in CWH xm2 but touches into CWHmm1.

S8. Reserve on the south shore. Area of older trees around a younger patch. For representation in xm2. extended to capture three clusters of archaeological sites.

S9. West edge of island for representation (no deer, MAMU). At the moment it includes recent cutblocks with retention. We'll see if we need them for representation or can find better areas

5.3.4 Findings

Because of the nature of the terrain and ecosystem pattern in the Thurlow LU, achieving representation targets severely impacts the operable THLB. Apart from the poorest, rocky sites; all of the proposed reserves involve THLB. The lack of old seral results in reserves that are mostly comprised of younger seral stages (mostly mid and early) for recovery and eventual recruitment of old seral.

The initial approach (Reserves1) placed excessive ha in reserves - 42% overall; and only three site series were within 4% of the 30% target. Representation exceeded 50% for 25 of the 46 site series. We believe that this substantial overshoot largely resulted from the influence of the private lands and several large lakes on these islands, which distorted our perception. It does not reflect negatively on the use of TEM or Marxan (note the Marxan output included the private lands, apparently inadvertently). We considered this initial design to be a failure; so we abandoned this approach and embarked on an approach using Marxan outputs right from the outset of design.

As in other portions of other LU's where there are few anchors for reserves (existing reserves, biodiversity values, critical habitats etc.), we found it difficult to design reserves solely for representation. In essence, one hectare of a particular site series is more or less as suitable as any other. In this situation, the utility of Marxan output becomes abundantly clear.

Our second design for the Thurlow LU relied quite heavily upon Marxan output to build on the rather limited amount of core legal reserves. This design achieved targets on a subzone/variant basis and achieved targets for many but not all individual site series. The elevational and geographic spread we sought would represent most site series quite well, but not all to 30% (see Reserves2 by TEM Resultant.xls). Significant under-representation of 6 of 46 site series requires improvement in this design.

We achieved targets by circum-mesic site series groups and some particular wetland types. This grouping of circum-mesic site series was a result of our misinterpreting the legal order, but provided a reserve system much less fragmented than had we met targets site series by site series. Achieving targets site series by site series would produce a reserve system of many scattered unconnected areas. The degree of fragmentation would likely approach that of the Marxan output, which includes many reserves (reserve pre-cursors?) that have little forest interior and considerable edge. To connect them, considerable additional area would have to be reserved in excess of targets. We believe it valuable to consider grouping site series, particularly circum-mesic site series, into useful ecological units so that scattered small reserves are only used when habitats are truly different and valuable (if site series are not very different from each other, then we consider that providing larger areas and forest interior to be more important than strict representation).

The South Central Coast Order appears to allow for some flexibility with respect to targets by the wording, "to the extent practicable", without elucidating just what that means any further. Furthermore, pursuant to Section 14(6), full targets may not be met if there is:

- information sharing and consultation with First Nations;
- habitat assessment for species at risk and regionally important wildlife;
- old forest is retained to provide sufficient habitat to sustain species at risk or regionally important wildlife;
- old forest is retained to meet the risk-managed target (schedule 4); and
- an adaptive management plan is implemented.

Any such variance from targets would best be considered as part of an inclusive planning process (i.e. our recommended procedure) rather than by design in the absence of consultation. Such a variance may be particularly appropriate for highly modified LU's that are not the norm for the South Central and North Central planning areas (in this regard, the Thurlow LU probably lies at the extreme end of modification and has focused attention on this problem). Ecological considerations that should be brought to such consultation include:

- Evaluating the consequences of a trade-off between strict representation targets and the associated fragmentation, versus more cohesive reserves with more interior and less edge;
- Uncommon ecosystems that typically occur in very small polygons could be managed at the site level rather than at the landscape level (i.e. manage at multiple scales). This includes many small wetlands and poorly drained sites, especially in the summer-dry climates of the CWHxm, dm and mm.
- Basing representation on ecologically meaningful site series groups rather than on individual site series; and
- Recognizing that whereas site series are artificially and conveniently discrete when presented in a table; they are inevitably associated in various complex patterns in real landscapes.

5.4 Gribbell Landscape Unit

The Gribbell Landscape Unit is comprised entirely of Gribbell Island (20,742 ha). As with the Roderick LU, it lies entirely in the hypermaritime coastal environment with the CWHvh2 variant at lower elevations and the MHwh at higher elevations. Most of the LU lies within the inner part of the Hecate Lowland Ecosection. Poorly drained sites are extensive and include some larger units of blanket bog, but blanket bogs do not dominate the landscape as they do in the gentler topography of the outer Hecate Lowland.

Logging history has been limited by the low proportion of operable land base. The largest cutover areas are found in two of the larger valleys. In recent years, helicopter logging and partial cuts have predominated. Steep, southerly-facing slopes appear to be commonly and repeatedly disturbed by windthrow (our independent assessment of RONV is 78% [i.e. pre-logging old seral] cf. the North Central Coast Legal Order's 98% for CWH and 92% for MH).

5.4.1 Available Data

When reserve design was undertaken in mid to late February, 2009, the following GIS data layers were available:

- Existing and proposed WHA's
- MAMU habitat, based on the Hobbes model
- Goat habitat based on the CIT model (the actual presence of goats is unclear)
- forest cover and derived SSS and seral stages
- operability
- PEM site series

A tailed frog presence/absence inventory done on a few watersheds indicated no tailed frog presence on Gribbell. Recently defined WHA's for tailed frogs did not include any areas on Gribbell.

We have generated information on red- and blue-listed plant communities based on the PEM and the Spot 5 satellite image:

- Red-listed includes CWHvh2/08 (note, there is no CWHvh2/09 on Gribbell)
- Blue-listed includes CWH vh2/07 (devil's club) and CWHvh2/13 (skunk cabbage)
- Legal orders require 100% of red-listed and 70% of blue-listed plant communities be reserved.

We have used the satellite image and forest cover ESA attributes to identify unstable terrain (this avoided use of a paper map produced by West Fraser Timber i.e. not in GIS form). We also relied on the satellite image for logging history.

The future application and/or adaptation of the northern Vancouver Island black bear habitat model (Helen Davis) might provide additional insight into areas of critical habitat to reserve for black bears (including the white colour phase).

Marxan output is not yet available for the Gribbell LU.

5.4.2 Approach to Reserve Design

We first established a priorized list of values to be conserved, based on the available information. These included:

- Existing and proposed WHA's
- Red-listed and associated fluvial sites (the /08 site series of high bench, river terraces, not fans), forested swamps and fens
- Blue-listed plant communities – CWHvh2/07 and /13
- Marbled murrelet habitat classes 1-3
- Mountain goat habitat (CIT model) of mostly unstable mid to upper slopes.

Red- and blue-listed plant communities were identified based on the PEM, adjusted as necessary (commonly) to the satellite image. Note that we found these units were usually misplaced (i.e. not well mapped) by the PEM, based on our understanding of hypermaritime ecosystem patterns (including considerable field work on nearby Princess Royal I.). It is generally acknowledged that PEM does a poor job of mapping rare and listed ecosystems, so it was important to carefully consider where such ecosystems might occur in the landscape. Consequently, we reserved some ecosystems not mapped as red-listed and did not reserve some that we believed not to be blue (i.e. adjusted in both directions).

We initially intended to base ecosystem representation on the PEM, but found this to be relatively unreliable. Consequently, after attaining the priorities listed above, we added representation based on ecosystem patterns apparent on the satellite imagery. This included reserves focused on relatively rich, productive ecosystems as well as poorer ecosystems. We often defined connections using goat habitat and unstable terrain; we ensured good geographic distribution of reserves, and often designed reserves to transect the full elevational range and complete range of biogeoclimatic variants.

The Gitga'at-B.C. Strategic Land Use Agreement (2006) establishes three types of stewardship areas on Gribbell:

- Kermode Bear Stewardship Area - includes all of the Gribbell LU;
- Cedar Stewardship Area – a coastal strip along the west and south sides of the Island; and
- Fisheries Stewardship Area – one small watershed on SW Gribbell.

Stewardship in these areas focuses on the management of seral stages over time, including the maintenance of certain proportions of old and mature seral, rather than specifying areas to be reserved (e.g. in the Cedar Stewardship area, "maintain 50% or redcedar- and yellow cedar-leading stands in mature or old seral.") The harvest rate is set to maintain this percentage over time, so this doesn't require a hard reserve.

The Gribbell/Princess Royal Kermode Management Area objectives include several provisions that we considered during the landscape-level reserve design, namely:

- Maintaining critical habitats including "beaches/beach margins, estuaries, rich non-forested fens, forested and non-forested bog edges, herb-dominated patches on avalanche chutes with adjacent forest, herb-dominated subalpine parkland meadows, skunk cabbage swamps, floodplain ecosystems and areas where bears fish for salmon" (not all of these occur on Gribbell).

- Maintaining existing den trees and recruiting trees suitable for dens; and
- Maintaining connectivity of bear habitat.

Reserving blue-listed skunk cabbage ecosystems (CWHvh2/13) should overlap with good quality bear habitat. Fieldwork on nearby islands revealed that the most likely areas for den trees are found in transitions between site series rather than fully within particular site series. The interface between 04 (lanky moss) or 06 (foamflower) and 13 (skunk cabbage) sites are most promising. Many hypermaritime site series – CWHvh2 01, 02, 03, most 04, 05, 11, 12 and most 13, and all of the MHwh – do not have the capability of growing redcedars sufficiently large for bear dens.

We noted considerable overlap between blue-listed plant communities and the minor area of operable area and attempted to minimize this impact as much as possible.

5.4.3 Description of Proposed Reserves

Proposed reserves are numbered as follows, as well as in the GIS attribute table:

#1 Encompasses estuary, red-listed (CWHvh08) levees, toe slopes with skunk cabbage (CWHvh/13), lake shoreline and blanket bog. Estuary is likely important for bears, wolves and waterfowl. 75 ha

#2 Red-listed ecosystem appears to be misidentified, we capture both real red and blue. The mapped red may be more like a forested swamp blue-listed ecosystem (13). Boundaries fit existing cutblocks. 65 ha

#3 Reserve based on goat but links lakeshore to reserve 2 (red-listed based). Includes fan, wetland complex at lake inlet. 180 ha

#4 Captures a red-listed ecosystem that was not mapped. Also includes blue-listed ecosystems (both 07 and a little 13). There is some operable close to lake we could remove. 85 ha

#5 Focused on blue-listed ecosystems. We think what is mapped as 13 is really 7, and we expanded it into areas we think are 13 but not mapped as such. Also extended reserve upslope to catch upper slopes. All area is process connected. Good bear habitat and MAMU class 3. 85 ha

#6 Focused on blue-listed ecosystems (not exactly as mapped) likely 07 and 13. Includes brushy, shrubby communities (good bear habitat). 110 ha

#7 Based on riparian with blue-listed forested swamps. Includes class 1 MAMU habitat. Includes some operable that perhaps could be reduced. 360 ha

#8 Includes blue-listed (07 and 13 not as mapped) and brushy headwater areas. Some operable here, but good trade-off as we believe we will not include extensive blue-listed further down valley. Representation of 04 lanky moss and 32 blanket bog. 438 ha

#9 Goat habitat based. Links reserve 6 to other side of Gribbell (reserve 4). Captures some lakeshore. 230ha

#10 Based on representation of 04, 01 and 13, and shoreline in the eastern portion of reserve. The 04, 13 likely has big cedar for bear dens. Into the west the reserve includes riparian and representation to high elevation (unstable colluvial 06 maybe 07 on lower slopes, some 13). Some shrub area for bears. 400 ha

#11 Goat modelled area. Links reserve 10 to west side of Gribbell. Helps representation of those high rocky slopes (goat habitat). Subsequently added to this reserve to incorporate MAMU habitat to south. 260 ha.

#12 Goat habitat that links to reserve 8; less rocky but higher slopes along east side of Gribbell. 120 ha

#13 More goat habitat that links west side of reserve 8 down to lake. Goat habitat includes steep slopes above lakeshore. 160 ha

#14 Reserve based on goat habitat but pulled back from operable and extended into a hanging basin with lake, and extended down to coastal shoreline to south. 430 ha

#15 Goat habitat pulled back from operable; links to reserve 7. 250 ha

#16 Goat habitat extended to capture MAMU (class 1 and 2) and some class 3. Also forms a nice connection to reserves 8 and 13. 740 ha.

#17 Reserve represents 01, 03 mix, even some 02. The area is better drained than zonal sites. Very stable terrain with Folisol soils. Height class 3 cedar, heavy to cedar cypress, little hemlock or balsam. It’s a westerly exposed shoreline not included elsewhere. Probably culturally important (i.e. useful cultural cedar, if not monumental cedar). Contains a bit of MAMU habitat where there is hemlock. 420 ha, more available if needed.

#18 Focused on MAMU habitat, mostly class 3 but also 1and 2. Could extend to catch more MAMU habitat of needed. Captures most of a small drainage. Extended to represent some of CWHvh/11 (bog forest). Subdued terrain CWH01/11. 220 ha

#19 Reserve captures an entire small drainage on east side of Gribbell. Essentially no operable in it, so a good opportunity to reserve an entire watershed. Represents 04 and 01, but very little of richer sites. 260 ha

#20 Focused on beach ecosystems (probably CWHvh/14 and 15, shoreline ocean spray influenced). Also has 01, 03, 11 and 32 complex on subdued rocky topography. Adjacent to reserve 10 to the south. We could have included the west side of point to capture a portion of cedar special management area, but chose beach ecosystem instead, and the cedar can be managed to maintain mature and old as desired. 120 ha.

5.4.4 Findings

The North Central Coast Legal Order requires the reservation of 50% of RONV for the Gribbell LU, which is 49% and 46% respectively for the CWhvh2 and MHwh subzones/variants. The above reserves encompass 24% of CWHvh2 and 27% of the MHwh, far short of the 50% RONV target. We believe the current reserve design does capture the most ecologically important areas, by virtue of our approach. We always start by reserving the most critical areas, most diverse areas, and areas that support the highest concentrations of biological values then work down to lower priorities. Our approach , however, is contingent on the available data. A more inclusive planning process would undoubtedly reveal additional information to improve the design and take it forward to a proper landscape-level reserve plan.

We believe the same reserve design approach could readily be expanded to attain the 50% target, but that is was not useful for us to try and continue to encompass more area given the lack of good biological data or model output and given targets for Gribbell seem to be still under discussion. We understand that consideration is being given to meeting a portion of the target outside of hard reserves (D. Cardinall, pers. comm.). This proportion would best be decided before proceeding further with reserve design. Furthermore, Marxan output is not yet available for the North Coast (note; Marxan output was anticipated in the original work plan). Consequently, we recommend that the 50% be reached during a proper planning process where as much biological information is brought to the table as possible (much seems to be missing for Gribbell at this point) and targets are decided. We considered that little more would be learned regarding the process of design (the objective of this pilot project) by pursuing further reserves on Gribbell at this time. Considerable insight has already been gained into the use of PEM vs. SSS (see below).

PEM vs. SSS:

Both PEM and SSS are derived from forest cover mapping (partly or entirely) and biogeoclimatic classification (BEC). SSS are derived directly from forest cover data attributes and BEC subzone/variant maps, without any further interpretation. As a result, SSS embody the inherent shortcomings and inaccuracies of the forest cover mapping and BEC boundaries, but do not include any additional uncertainties. SSS do not differentiate non-forested ecosystems.

PEM is derived not only from forest cover and BEC mapping but also from a predictive algorithm (‘expert system’) that may include additional GIS data (e.g. slope and aspect maps). The use of an algorithm to predict and map site series incorporates considerable additional uncertainty. Only if the algorithm perfectly predicted site series would PEM uncertainty be no more than SSS uncertainty.

Based on extensive field experience in the hypermaritime and interpretation of satellite imagery, we found that the available PEM mapping was not very reliable. As a result, we relied more heavily on discernable ecosystem patterns on the satellite imagery to design reserves. To check for adequate representation across the full range of ecosystems, we grouped the PEM units to improve the reliability of the groupings, as follows:

- nv = non-vegetated, includes rock (RO,RS); does not include ocean & lakes
- sa = includes shrub avalanche tracks (SA) and slides (ES)
- vh-c = mostly cedar-leading, poor to moderate productivity sites of CWHvh2; includes 01, 03, 11 & 13; all poorly drained
- vh-h = hemlock-leading, moderate to good productivity sites of CWHvh2; includes 04, 05, 06, 07 & 08; all freely drained (mostly imperfectly drained)
- vh-w = wetlands of CWHvh2, mostly bogs, with some richer wetlands
- wh-c = cedar-leading sites of MHwh1
- wh-h = hemlock leading sites of MHwh1
- wh-x = very poor, semi-open, scrubby sites of MHwh1
- wh-p = all of the mapped MHwhp1

Based on these groupings, the reserve design approach does adequately encompass the range of ecosystems. A check for adequate representation using SSS also indicated the reserve design approach adequately encompassed the forested ecosystems of the Gribbell LU. One apparent deficiency – vh2 SAU7 (good hemlock) – is entirely early seral following logging. Its placement in SAU7 rather than SAU8 is a result of inconsistent site quality classification; which often overstates the productivity of young stands in comparison to old. These sites would very likely have been classified as medium (M) in the old seral condition, as nearby comparable sites are indeed classified.

6.0 Deliverables

Deliverables supplementing and supporting this summary report include the following digital files (organized by folders based on the four LU's) on an accompanying DVD (the list below is the same as in the Readme file on the DVD):

Shape files (i.e. .shp and associated files):

Roderick LU folder:
- Roderick reserves.shp

Stafford LU folder:
- base-legal reserves.shp
- Co-located30.shp
- Co-located30_mx.shp
- lk-reserves.shp
- tl3-reserves.shp
- tl5-reserves.shp
- tl6-reserves.shp

Thurlow LU folder:
- Thurlow reserves1.shp
- Thurlow reserves2.shp

Gribbell LU folder:
- Gribbell reserves.shp

Spreadsheet files:

The spreadsheets all include a data page from which additional pivot tables can be generated.

Roderick LU folder:
- TEM + Op Clip – Mar9-09.xls

Stafford LU folder:
- Plan comparison based on MAMU.xls
- Plan comparison based on SSS.xls
- Plan comparison based on TEM.xls
- Plan comparison for Focal Spp.xls

Thurlow LU folder:
- Reserves1 by SSS Resultant.xls
- Reserves1 by TEM Resultant.xls
- Reserves2 by SSS Resultant.xls
- Reserves2 by TEM Resultant.xls

Gribbell LU folder:

- Reserves1 by PEM Goupings.xls
- Reserves1 by SSS.xls

7.0 Literature Cited

Blackwell, B.A. and Associates, 2006. Terrestrial Ecosystem Mapping of the Strathcona TSA. Contract to Western Forest Products Ltd.

Blackwell, B.A. and Associates, 2000. Terrestrial Ecosystem Mapping of International Forest Product Ltd. Tree Farm License 45. Contract to International Forest Products Ltd.

Blackwell, B.A. and Associates, 1999. Terrestrial Ecosystem Mapping of Timberwest Tree Farm License 47. Contract to Timberwest Forest Corp. Broekhuizen, L., 2009. Personal communication (e-mail).

Cardinall, D. 2009. Personal communication.

Gitga'at First Nation and Province of B.C., 2006.. Strategic Land Use Planning Agreement. 22 pp.

Green, R.N., 2008. Comparison of Site Series Surrogates with TEM-based Site Series in the Central Coast LRMP Area. Unpub. report. 13 pp.

Lewis, T. and A. Inselberg, 1997. Ecosystems of Block 2 of Tree-farm Licence 25 – Stafford and Apple River Watersheds. Unpub. report to Western Forest Products. 42 pp.

Lewis, T. and A. Inselberg, 2005. The Ecosystems of Block 5 of Tree-farm Licence 25, British Columbia. Unpub. report. 116pp.

Lewis, T., 2007. Ecological Comparison of Central Coast Landscape Units. Unpub. report to the Coast Forest Conservation Initiative. 13 pp.

Lewis T. and L. K. Kremsater, 2008. Draft Old-growth Management Areas for Tree-farm Licence 6. Unpub. Report to Western Forest Products. 54 pp.

Rumsey, C. 2009. Personal Communication.