Landscape Level Conservation Priorities in the Invermere TSA: Interim Results for Forest Science Program Project Y071069

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Executive Summary

This is an interim report for the first of a two year Forest Science Program Project (Y071069). The goal for year 1 of the project was to pilot a conservation approach that integrates landscape level objectives on crown and private lands in the Invermere Timber Supply Area (TSA) by applying a landscape level decision support framework to identify efficient strategies to meet area-based targets for biodiversity indicators.

The decision support framework is based on Marxan, a software program that uses an optimization algorithm, to determine the most efficient locations to meet landscape level conservation targets. Marxan has been widely applied to the design of conservation reserve networks in marine and terrestrial systems.

The first year results demonstrate that Marxan can be used as a decision support tool to efficiently meet targets and maximize complementarity (primarily through overlap among objectives), while minimizing economic impacts for biodiversity objectives in the Invermere TSA. Options explored in the study revealed trade-offs: scenario results demonstrated that when alternative indicator based conservation features were considered, more efficient outcomes may occur. Scenario results also demonstrated that by explicitly considering economic objectives, the same targets may be met in a more cost effective manner than if economic objectives are not considered.

Further consideration is needed in determining landscape level targets for Indicator 2 and Indicator 3 conservation features. Participation by project partners is necessary for this to occur. Iterative Marxan runs against different indicator sets would be useful to help determine targets that maximize complementarity among indicator values, and will be undertaken in year two of the project, with project partner input.

Introduction

This is an interim report for the first year of a two year Forest Science Program Project (Y071069). The goal for year 1 of the project was to pilot a conservation approach that integrates landscape level objectives on crown and private lands in the Invermere Timber Supply Area (TSA) by applying a landscape level decision support framework to identify efficient strategies to meet area-based targets for biodiversity indicators.

The specific objectives of the project are to:

1. provide a decision support framework for landscape level planning for biodiversity objectives;
2. integrate multiple landscape level objectives for biodiversity;
3. understand trade-offs among objectives;
4. determine 'responsibility' for objectives among tenure holders.

The biodiversity objectives used in this project are based on those developed by Bunnell et al. (2003), as part of a Criteria and Indicators framework, where the indicators are designed to assess whether biological richness and its associated values will be sustained:

Criterion 1: Biological richness and its associated values are sustained within the Invermere TSA.

I-1 Ecologically distinct ecosystem types are represented in an unmanaged state in the Invermere TSA to sustain lesser-known species and ecological functions.

I-2 The amount, distribution and heterogeneity of habitat elements and landscape structure important to sustain biological richness are maintained.

I-3 Productive populations of selected species or guilds are well-distributed throughout the range of their habitat

Forest licencee partners in this project, British Columbia Timber Sales (BCTS), Canfor Radium Division and Tembec Industries Inc. have committed to meeting biodiversity objectives based on the three indicators developed by Bunnell et al (2003) as a component of their Sustainable Forest Management Plans (SFMP) for their respective operating areas in the Invermere Timber Supply Area (Tembec 2005; Canfor and BCTS 2006).

For the Invermere TSA pilot, objectives were developed for this project based on the first two indicators of Criterion 1 – Indicator 1 (ecosystem representation) and Indicator 2 (habitat types and elements), with the intention of expanding the project to incorporate Indicator 3 (species) objectives in year 2, after discussions with project partners. Private lands in the Invermere TSA were also incorporated into the project. Though there are no formal commitments to applying biodiversity indicators on private lands, project partners active in private land acquisition (The Nature Trust and the Nature Conservancy of Canada) are taking indicators under consideration.

The decision support framework is based on Marxan, a software program that uses an optimization algorithm, to determine the most efficient locations to meet landscape level conservation targets for Criterion 1. Marxan has been widely applied to the design of conservation reserve networks in marine (e.g., Stuart and Possingham 2005) and terrestrial systems (e.g., Chan et al. 2006). In this stage of the project, Marxan was used to meet area based targets developed for Indicators 1 and 2.

A primary component of this project is to develop effective strategies to meet targets developed for Indicator 1 (ecosystem representation). Appendix 1 provides details on the development of area-based targets for ecosystem representation for BCTS, Canfor, Tembec and private lands in the Invermere TSA. Targets are based on a determination of licensee 'responsibility', or proportion of the conservation feature associated with the Indicator. Appendix 2 provides further background and rationale for determining responsibility and developing targets for Indicator 1, and other factors to consider when managing to maintain ecosystem representation.

Area-based targets developed for Indicator 2 (habitat types and elements), are based on existing regulatory objectives for maintaining old growth in the Invermere TSA, or on targets developed for this project for hardwood stands and stands with veteran trees.

Indicator 1 and 2 targets presented here do not represent SFMP commitments by BCTS, Canfor or Tembec. Rather, this project provides a rationale for a set of proposed targets for Indicator 1 and an evaluation of how those targets might be met at the landscape level and efficiently integrated with other Indicator targets in the Invermere TSA.

Study Area

The study area for this project is the Invermere Timber Supply Area (TSA), a 1.2 million hectare management unit in the southern interior Forest Region (Figure 1). The study area includes substantial area in forest tenures, provincial parks and much of Kootenay National Park, and has a significant private land component where large investments have been made in lands for conservation purposes.

Methods

Potential areas to meet conservation targets were spatially identified using Marxan v1.8.2, a software program that uses a simulated annealing optimization algorithm (Ball and Possingham 2000; Possingham et al. 2000). CLUZ v1.6 (Smith 2004) was used as an ArcView GIS (ESRI 1996) interface to Marxan. Marxan attempts to find optimal solutions for user defined targets for a given set of conservation features. In this study, targets are area based, though Marxan also includes some spatial parameters such as minimizing edge (through a 'boundary length modifier' or BLM) or minimizing distance between patches. In this study, the highest BLM parameter that did not increase the total area for individual scenario outcomes was applied to all scenarios.

Conservation feature inputs incorporated into Marxan runs were based on selected Indicator 1 and Indicator 2 targets. Ecosystem representation (Indicator 1) targets used in this study are based on the ecosystem representation analysis undertaken by Wells et al. (2004). Targets are for *additional* timber harvesting land base (THLB) required to meet landscape level targets (e.g., Appendix 1). Targets are also based on an assessment of licensee responsibility, which is detailed in Appendix 1 and in Wells et al (2004).

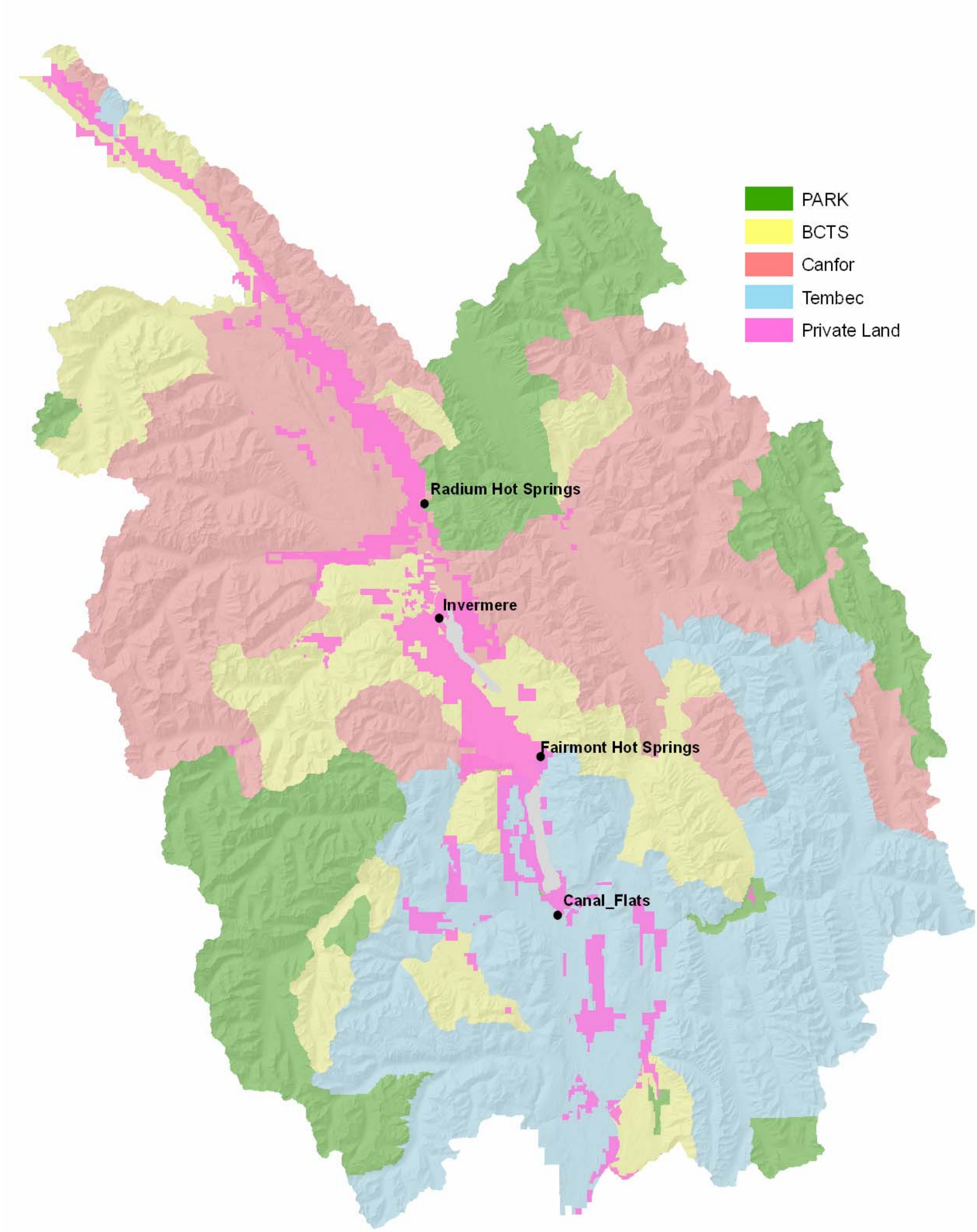

Figure 1. Invermere TSA study area.

Habitat (Indicator 2) targets for ranked Old Growth Management Areas (OGMA), hardwood stands and stands with veteran trees are based on mapping developed by Wells (2005). The spatial distribution of these conservation features associated with the Indicators are found in Appendix 3 (Indicator 1) and Appendix 4 (Indicator 2). Descriptions of data layers sources are found in Appendix 5. OGMA targets[1] were intended to approximate the amount of area (though not spatial requirements) licencees are required to reserve in the timber harvesting landbase (THLB) to meet regulatory obligations.

As a default, Marxan attempts to minimize overall area included in selected sites. This option was applied for all scenarios except a cost scenario. For the cost scenario, Marxan was configured to minimize a merchantability index based on merchantability mapping created for the Invermere TSA (Thomae 2003). This merchantability data was used to generate values for the cost scenario undertaken in this study. An area weighted index of mean merchantability values were generated for each polygon (polygon size range from 2.5 – 34ha).

Results

Three scenarios are evaluated in this study to meet the objectives of integrating landscape level biodiversity objectives and evaluating trade-offs among objectives for forest tenure holders. The first two scenarios focus on comparing different sets of Indicator 2 objectives, while meeting all Indicator 1 targets (detailed in Appendix 1). The third scenario attempts to minimize economic cost based on a merchantability index. Ecosystem representation targets applied in all Marxan scenarios are found in Table 1 (only targets >100ha for all tenure holders were considered; all targets represent additional THLB required to meet a given target). In Scenario 1, Indicator 2 OGMA targets are applied (Table 2) while Scenario 2 splits the OGMA targets with other Indicator 2 features (Table 3). Scenario 3 had the same targets as Scenario 2, but attempted to minimize cost based on the merchantability index instead of overall area. A final scenario, incorporating private land targets (Table 1; Table 2) was combined with scenario 3 results to provide an integrated solution for the full Invermere TSA land base.

For all scenarios, the combined sum of targets for the three forest tenure holders is 19,314ha. In a case where no indicators overlap, this would equal the total required THLB to meet all targets. The optimization algorithm in Marxan ensured all targets were met, finding efficient solutions by identifying area where overlap in objectives occur. Scenario 1 had the was the least efficient outcome, with the largest overall area of the three scenarios (Table 4; Figure 2). Scenario 2 which considered stands with hardwoods and veteran trees in place of some OGMA objectives had better complementarity and a lower net area (Table 4; Figure 3). Marxan was configured to minimize merchantability index instead of area for Scenario 3, and achieved the greatest efficiency for the cost index of the three scenarios (Table 4; Figure 4). With private land targets incorporated, the overall solution was achieved with 10% less area (21, 752ha; Figure 5) than the total of individual targets (24,127ha).

[1] Estimates of current OGMA targets for each licencee for the Invermere TSA were provided by Cam Brown of Forsite Consulting.

Table 1. Ecosystem representation (Indicator 1) targets for all scenarios. EG = ecosystem group (see Appendix 1 for details).

	Target (ha)			
Name	BCTS	Canfor	Tembec	Private
EG One	574	455	937	1099
EG Two	114	0	0	327
EG Three	160	236	423	385
EG Eight	80	0	150	0
EG Ten	282	289	350	0
EG Sixteen	0	0	0	102
EG Twentyfour	0	104	0	0
EG Twentynine	0	158	0	0
Total:	1,210	1,243	1,861	1,913

Table 2. Habitat (Indicator 2) targets for Scenario 1.

	Target (ha)		
Name	BCTS	Canfor	Tembec
OGMA Excellent	1,600	3,000	2,000
OGMA Good	1,900	4,000	2,500
Total:	3,500	7,000	4,500

Table 3. Habitat (Indicator 2) targets for Scenario 2 (forest tenure) and private land.

	Target (ha)			
Name	BCTS	Canfor	Tembec	Private
OGMA Excellent	1,600	3,000	2,000	
OGMA Good	150	500	250	
Veterans	875	1,750	1,125	900
Hardwoods	875	1,750	1,125	2,000
Total:	3,500	7,000	4,500	2,900

Table 4. Scenario outcomes. Area index is relative to sum of individual target areas (19,314ha). Cost index is relative to Scenario 1.

	Area (ha)	Area Index	Cost Index
Total Target	19,314	1.00	NA
Scenario 1	18,449	0.96	1.00
Scenario 2	17,450	0.90	0.96
Scenario 3	17,192	0.89	0.91

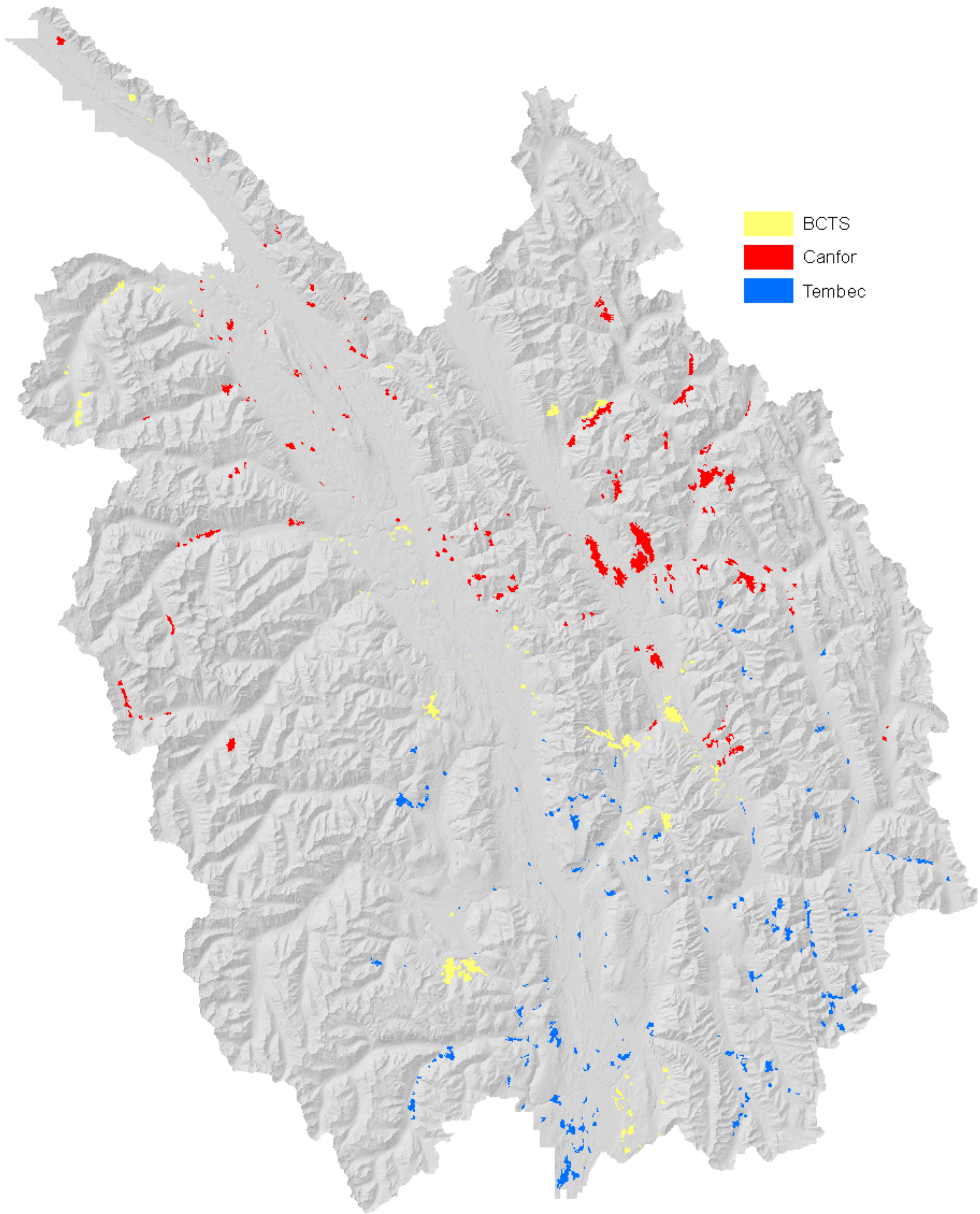

Figure 2. Scenario 1 outcomes.

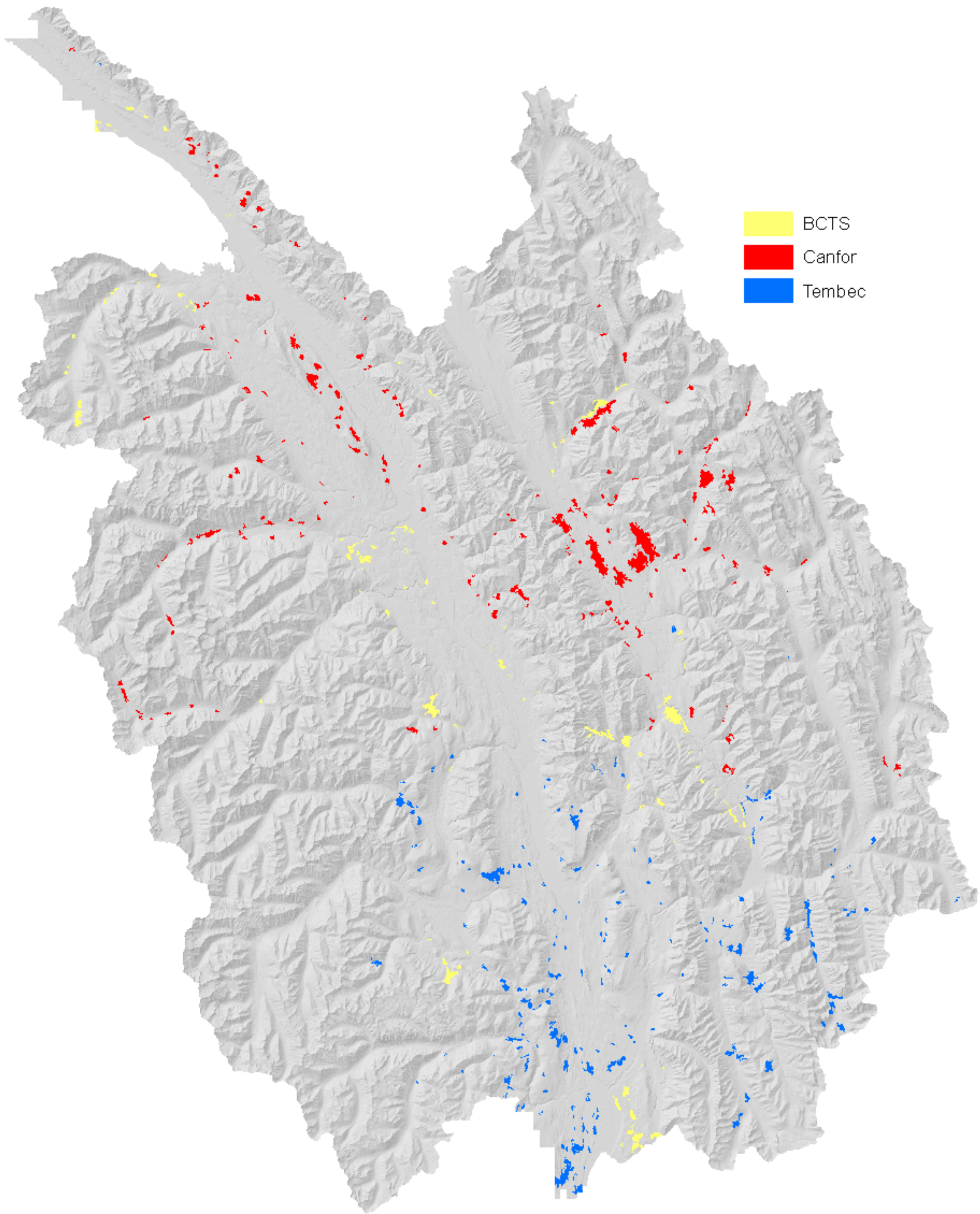

Figure 3. Scenario 2 outcomes.

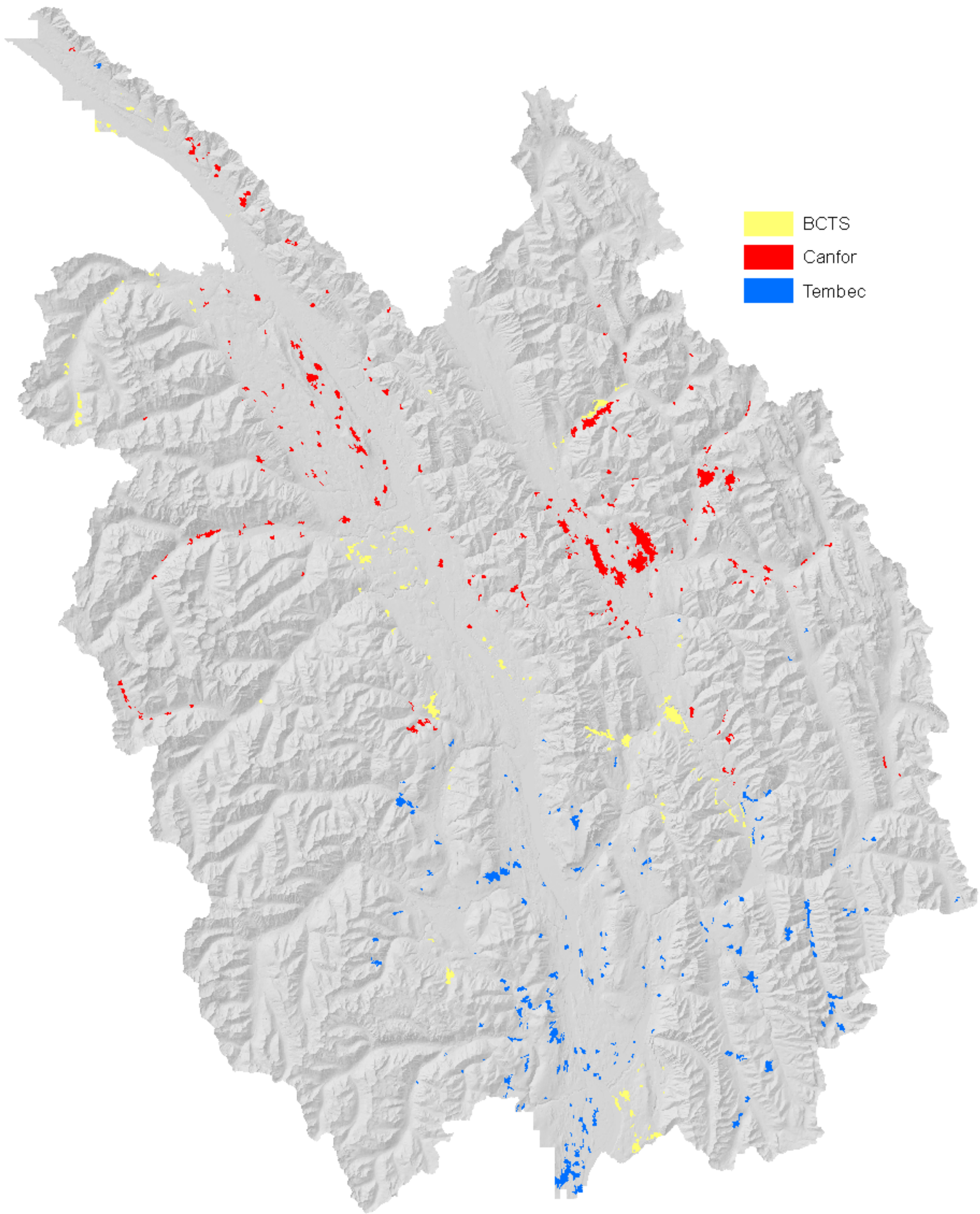

Figure 4. Scenario 3 outcomes.

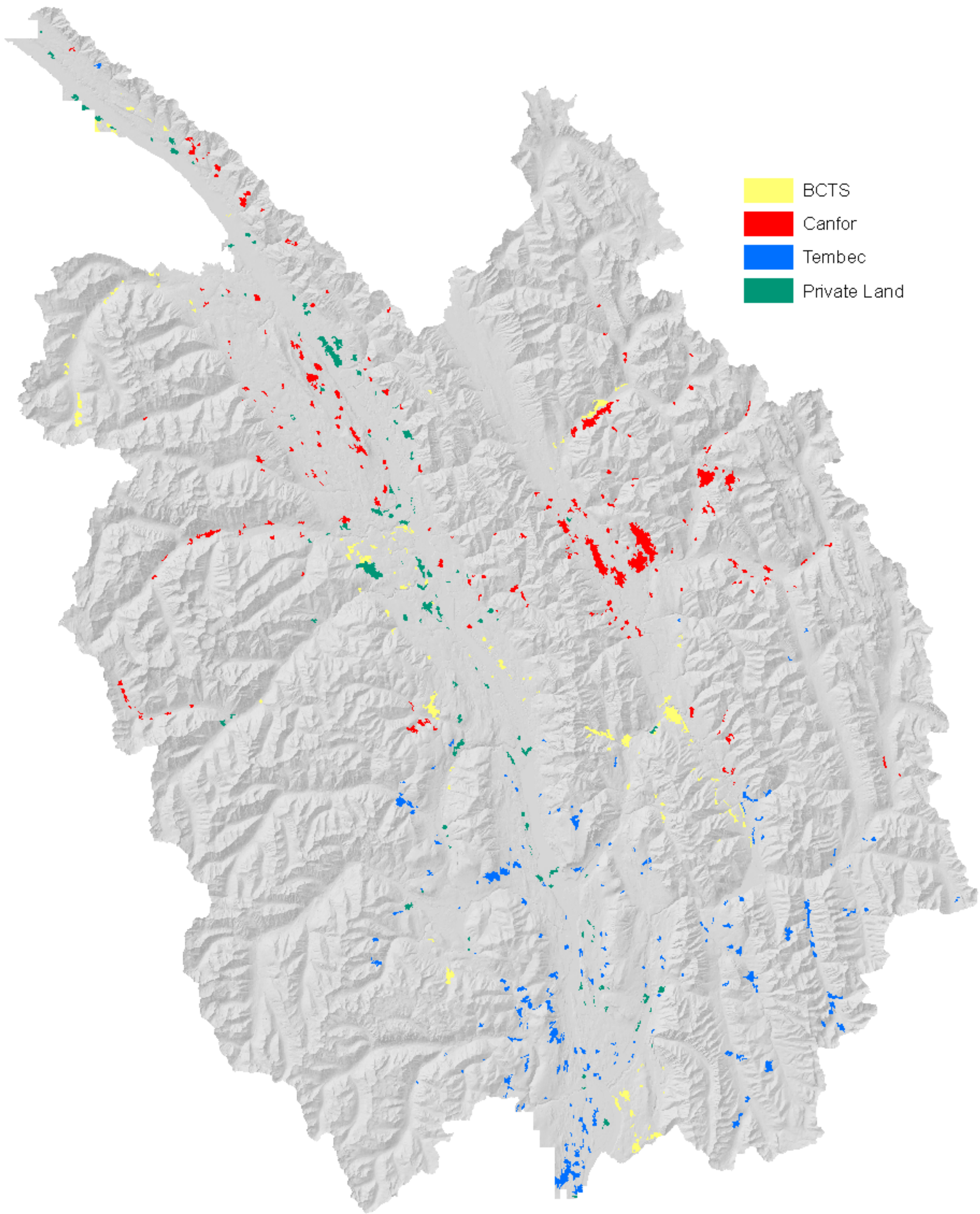

Figure 5. Scenario 3 outcomes with private land included.

Discussion

The scenarios evaluated here provide alternative outcomes that meet ecosystem representation (Indicator 1) and habitat based (Indicator 2) targets for the Invermere TSA. These targets are based on 'responsibility' (proportion) of the conservation feature associated with the indicator for forest tenures and private land (further details about the determination of responsibility and targets for Indicator 1 can be found in Appendix 1).

The first year results demonstrate that Marxan can be used as a decision support tool to efficiently meet targets and maximize complementarity (e.g., Margules and Pressey 2000), primarily through maximizing overlap among objectives, while minimizing economic impacts for biodiversity objectives in the Invermere TSA. Options explored here revealed trade-offs: Scenario 2 demonstrated when a broader range of Indicator 2 values then OGMA alone are considered, more efficient outcomes may occur. Scenario 3 demonstrates that by explicitly considering economic objectives, the same targets may be met in a more cost effective manner than if economic objectives are not considered.

The scenarios presented here represent a subset of Criterion 1 Indicator values that can be managed at the landscape level in the Invermere TSA. For example, other broad habitat based objectives (Indicator 2), such as wetlands or cottonwood stands, or species-based habitat objectives (Indicator 3) for ungulate winter range (UWR), key spawning habitat and wildlife habitat areas (WHA) for identified species in the Invermere TSA (Wells 2005) and could easily be incorporated into future Marxan scenarios. Many of these should complement ecosystem representation (Indicator 1) objectives and the Marxan decision support tool can be expected to find efficient outcomes if applied.

Further consideration is needed in determining landscape level targets for Indicator 2 and Indicator 3 conservation features, particularly where some habitat components may be managed for at both landscape and stand level (e.g. hardwoods). Participation by project partners is necessary for this to occur. Iterative Marxan runs may be useful to help determine targets that maximize complementarity among indicator values. In some cases, where targets represent most or all of an available habitat component (which was the case for some representation ecosystem groups, or OGMA classes in the presented scenarios), it may make sense to treat these as 'reserved' and focus future Marxan scenarios on components where flexibility exits. This approach will maximize the effectiveness of the optimization algorithm.

Finally, the outcomes presented here are dependent on the specific targets applied in the analysis. Some outcomes will change significantly with new indicators and objectives. The results are also dependent on the quality of PEM (Ketcheson et al. 2004), forest cover and merchantability data used to define ecosystem representation and habitat objectives. Any final outcomes would need to be field verified before being implemented.

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This project would not have been possible without Forest Investment Account Forest Science Program funding support. I am also grateful for Forest Investment Account funding provided by BCTS, Canfor and Tembec Industries Inc, and support provided by Parks Canada, the Nature Trust of British Columbia and the Nature Conservancy of Canada. Many people provided helpful direction and support during the project, including Dave Brown, Cam Brown, Bob Forbes, Rob Neil, Al Pollard, Pippa Shepherd, Darren Tamelin and Leanna Warman. GIS and database development support were provided by Arnold Moy.

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Appendix 1: Recommendations for Indicator 1 targets in the Invermere TSA

Maintaining the 'representativeness' of ecosystems in managed landscapes is intended to be precautionary, providing some insurance that species will be sustained in landscapes managed for a range of objectives. Setting targets for ecosystem representation can be challenging since a primary objective is to provide some assurance that species and processes that we know little or nothing about are sustained. Given this objective, it is not possible to know with precision how much area may be sufficient, thus by definition targets must be somewhat arbitrary. Nonetheless, setting management targets for representation is worthwhile, ensuring that some base level of habitat 'insurance' is maintained. Once set, initial management targets may be adjusted based on the results of monitoring or new research.

The recommendations for initial management targets for Indicator 1 provided here are provided for consideration for SFMP objectives but do not represent SFMP commitments by BCTS, Canfor or Tembec. They are based on the results of Wells et al. (2004) for the East Kootenay Compensation Program (EKCP), of which the Invermere TSA is a component. The recommendations for targets are dependent on the relative area of ecosystem groups, based on the principle that if an ecosystem group is less common on the landscape, it potentially is more vulnerable and thus deserves a higher level of protection than a more common ecosystem group.

1. *Rare* Ecosystem Groups (< 2000 ha in the EKCP)

Recommendation: maintain 100% in the non-harvestable landbase (NHLB).
Ecosystem groups <2000 ha in the EKCP are especially vulnerable due to their rareness. For these very rare groups (<0.1% of EKCP area), it is reasonable to consider reserving 100% of the distribution in the Invermere TSA. Percentage targets for the EKCP are provided in Table 1. Ecosystem groups with no net targets are listed to allow for consideration of alternative targets. Estimates of area targets for the TSA (determined by the proportion or 'responsibility' of the ecosystem group found in the TSA) are provided in Table 2 (see Appendix 2 for further description of responsibility). Because current PEM-based mapping for the Invermere TSA (Ketcheson 2004) is likely to be of limited accuracy for site series associated with rare ecosystem groups, a *standard operating procedure* should be established to incorporate these groups into stand level reserves when they are encountered in a proposed cutblock. Site series descriptions of rare ecosystem groups are provided in Table 3.

Table 1. Estimated targets for *rare* ecosystem groups for the EKCP.

Ecosystem Group	Area (ha)	Target	Target (ha)	NHLB	Net Target (ha)
2	949	100%	949	232	717
14	1,645	100%	1,645	480	1,165
16	368	100%	368	130	237
24	1,750	100%	1,750	1,324	426

Table 2. Estimated targets for *rare* ecosystem groups for tenure holders and private land. Net area target is based on the proportion or tenure 'responsibility' for the ecosystem group.

(a) BCTS

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
2	151	15.9%	114
14	47	2.9%	33
16	49	13.5%	32
24	259	14.8%	63

(b) Canfor

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
2	115	12.1%	87
14	0	0.0%	0
16	102	27.6%	66
24	428	24.5%	104

(c) Tembec

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
2	101	10.6%	76
14	114	6.9%	81
16	0	0.0%	0
24	0	0.0%	0

(d) Private Land (40N)

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
2	579	61.0%	437
14	39	2.4%	28
16	208	56.5%	134
24	0	0.0%	0

Table 3. BEC descriptions of *rare* ecosystem groups.

Rare Ecosystem Groups (<2000ha EKCP)

Ecosystem Group	BEC Variant	Site Series	Map Entity	Site Association	Edatopic SMR	CDC[1] List
2	IDFxk	03	DP	Fd - Pinegrass - Stepmoss	mesic - subhygric	*Na*
14	PPdh2	04	CD	Act - Dogwood - Nootka rose	hygric - subhygric	Red
16	IDFxk	05	CD	ActSxw - Red-Osier dogwood	hygric - subhygric	*Na*
24	ESSFdk2	05	FS	Bl - Sedge - Sphagnum	subhygric	*Na*

[1]Conservation Data Centre ecological communities listing

2. *Uncommon* Ecosystem Groups (≥ 2000 ha to <10,000 ha in the EKCP)

Recommendation: maintain a range from 99% to 26% in the non-harvestable landbase (NHLB). For this class of ecosystem group, the target is dependent on area (approx 0.5% - 0.1% of the EKCP), based on a sigmoid relationship (Figure 1). This scale is somewhat arbitrary, but reflects that an ecosystem group becomes potentially more vulnerable with decreasing abundance on the landscape. Percentage targets for the EKCP are provided in Table 4. Ecosystem groups with no net targets are listed to allow for consideration of alternative targets. Estimates of area targets[2] for the TSA (determined by the proportion or 'responsibility' of the ecosystem group found in the TSA) are provided in Table 5. Site series descriptions of rare ecosystem groups are provided in Table 6.

[2] Area targets are estimates, dependent on the accuracy of PEM and the NHLB definition and intended for guidance only. Standard operating procedures should guide operational identification and management of associated site series.

Table 4. Estimated targets for *uncommon* ecosystem groups for the EKCP. .

Ecosystem Group	Area (ha)	Target	Target (ha)	NHLB	Net Target (ha)
8	4,402	89.9%	3,957	732	3,225
10	6,702	50.5%	3,385	2,664	721
12	10,851	27.1%	2,940	3,330	0
17	6,526	53.3%	3,476	3,740	0
18	8,891	31.5%	2,801	4,777	0
19	4,462	89.1%	3,978	4,065	0
29	2,444	99.7%	2,436	1,508	928

Table 5. Estimated targets for *uncommon* ecosystem groups for tenure holders and private land. Net area target is based on the proportion or tenure 'responsibility' for the ecosystem group.

(a) BCTS

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
8	340	7.7%	249
10	1,048	15.6%	113
12	1,434	13.2%	0
17	140	2.1%	0
18	262	2.9%	0
19	47	1.1%	0
29	0	0.0%	0

(b) Canfor

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
8	0	0.0%	0
10	2,689	40.1%	289
12	1,810	16.7%	0
17	137	2.1%	0
18	853	9.6%	0
19	80	1.8%	0
29	417	17.1%	158

(c) Tembec

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
8	552	12.5%	405
10	865	12.9%	93
12	1,124	10.4%	0
17	126	1.9%	0
18	368	4.1%	0
19	18	0.4%	0
29	0	0.0%	0

(d) Private Land (40N)

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
8	107	2.4%	79
10	144	2.2%	16
12	3960	36.5%	0
17	0	0.0%	0
18	78	0.0%	0
19	24	0.5%	0
29	0	0.0%	0

Table 6. BEC descriptions of *uncommon* ecosystem groups.

Ecosystem Group	BEC Variant	Site Series	Map Entity	Site Association	Edatopic SMR	CDC[1] List
8	PPdh2	03	AR	PyAt - Rose - Solomon's-seal	mesic - subhygric	Red
10	ICHmk1	06	SO	Sxw - Oak fern	hygric	
12	IDFdm2	05	SS	SxwAt - Sarsaparilla	hygric - subhygric	Red
12	IDFdm2n	04	SP	FdLw - Spruce - Pinegrass	mesic - subhygric	*Na*
12	IDFdm2n	05	SS	SxwAt - Sarsaparilla	hygric - subhygric	*Na*
12	IDFxk	04	SS	SxwAt - Sarsaparilla	subhygric	
17	ICHmk1	07	SH	Sxw - Horsetail	hygric	
18	MSdk	06	SH	Sxw - Dogwood - Horsetail	hygric	
19	MSdk	07	SB	Sxw - Scrub birch - Sedge	hygric	
29	ESSFwm	05	FQ	Bl - Azalea - Queen's cup	hygric - subhygric	

[1]Conservation Data Centre ecological communities listing

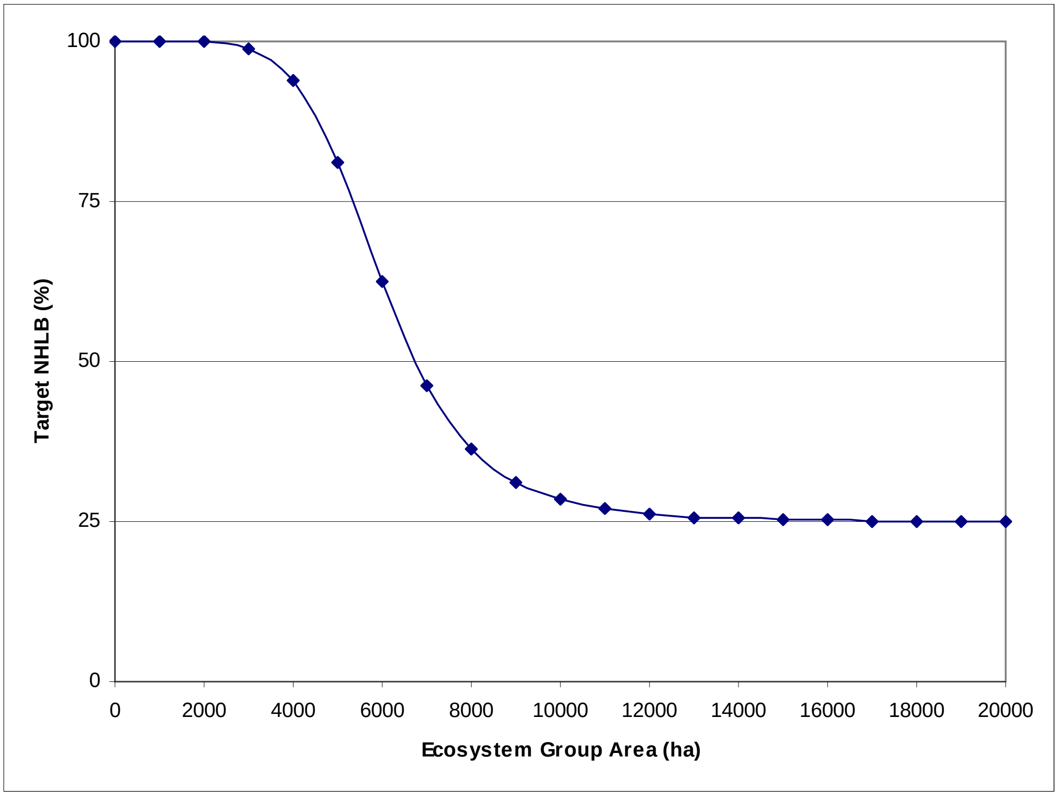

Figure 1. Ecosystem representation targets (%) based on .

3. Common Ecosystem Groups (≥ 10,000 ha in the EKCP).

Recommendation: maintain 25% or more in the non-harvestable landbase (NHLB).
A target of 25% or greater can be considered a conservative starting point, which will be complemented by SFMP objectives for maintaining habitat elements and types (Indicator 2) and species habitat (Indicator 3) in the timber harvesting land base (THLB). While somewhat arbitrary, this target will ensure substantial area of common groups are in an unmanaged state. This target is intended to provide an initial baseline to act as a basis for further analysis and for species-based monitoring programs. Percentage targets for the EKCP are provided in Table 7. Ecosystem groups with no net targets are listed to allow for consideration of alternative targets. Estimates of area targets[3] for the TSA (determined by the proportion or 'responsibility' of the ecosystem group found in the TSA) are provided in Table 8. Site series descriptions of rare ecosystem groups are provided in Table 9.

[3] Area targets are estimates, dependent on the accuracy of PEM and the NHLB definition and intended for guidance only. Standard operating procedures should guide operational identification and management of associated site series.

Table 7. Estimated targets for *common* ecosystem groups for the EKCP.

EKCP

Ecosystem Group	Area (ha)	Target	Target (ha)	NHLB	Net Target (ha)
1	73,765	25%	18,441	10,885	7,557
3	237,685	25%	59,421	55,357	4,065
6	92,710	25%	23,178	29,989	0
7	315,806	25%	78,952	103,435	0

Table 8. Estimated targets for *common* ecosystem groups for tenure holders and private land. Net area target is based on the proportion or tenure 'responsibility' for the ecosystem group.

(a) BCTS

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
1	5,606	7.6%	574
3	9,343	3.9%	160
6	10,963	11.8%	0
7	24,861	7.9%	0

(b) Canfor

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
1	4,439	6.0%	455
3	13,826	5.8%	236
6	18,511	20.0%	0
7	51,018	16.2%	0

(c) Tembec

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
1	9,151	12.4%	937
3	24,750	10.4%	423
6	12,846	13.9%	0
7	46,679	14.8%	0

(d) Private Land (40N)

Ecosystem Group	Area (ha)	Responsibility	Net Target (ha)
1	10728	14.5%	1,099
3	22537	9.5%	385
6	276	0.3%	0
7	5,179	1.6%	0

Table 9. BEC descriptions of *common* ecosystem groups.

Ecosystem Group	BEC Variant	Site Series	Map Entity	Site Association	Edatopic SMR	CDC[1] List
1	IDFdm2	03	DS	Fd - Snowberry - Balsamroot	subxeric - submesic	Red
1	IDFxk	01/02	XJ	Fd - Pature sage bluebunch wheatgrass	mesic	*Na*
1	PPdh2	01	PW	Py - Bluebunch wheatgrass - Junegrass	submesic - mesic	Red
3	IDFdm2	04	SP	FdLw - Spruce - Pinegrass	mesic - subhygric	Red
3	IDFdm2	01	DT	FdPl - Pinegrass - Twinflower	mesic	
3	IDFdm2n	01	DT	FdPl - Pinegrass - Twinflower	mesic	*Na*
6	ICHmk1	04	DA	FdPl - Sitka alder - Pinegrass	submesic	
6	ICHmk1	03	DT	FdPl - Pinegrass - Twinflower	subxeric	
6	ICHmk1	01	RF	CwSxw - Falsebox	mesic	
7	MSdk	01	SG	Sxw - Soopolallie - Grouseberry	mesic	
7	MSdk	04	XL	Pl Oregon -grape pinegrass	submesic - mesic	
7	MSdk	05	XS	Sxw - Soopolallie - Snowberry	submesic - subhygric	

[1]Conservation Data Centre ecological communities listing

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Appendix 2: Description and Rationale for Indicator 1: Ecosystem Representation

Indicator 1: *Ecologically distinct ecosystem types are represented in the non-harvestable land base of the management unit (e.g., Invermere TSA) to maintain lesser known species and ecological functions.*

Maintaining representation of a full range of ecosystem types is a widely accepted strategy to conserve biodiversity in protected areas (e.g., Margules and Pressey 2000) and is suggested for landscapes managed for forestry (e.g., Lindenmayer and Franklin 2002). Indicator 1 is a "coarse-filter" approach to maintaining biological diversity based on the principle of maintaining representation of a full range of ecosystem types. It is not intended as a stand-alone strategy, but rather to complement Indicators 2 and 3. This indicator is 'precautionary', intended to sustain those species for which knowledge is sparse or absent, by ensuring that some portion of each distinct ecosystem type is represented in a relatively unmanaged state. Unmanaged areas also help to sustain poorly understood ecosystem functions and provide an ecological baseline against which the effects of human activities can be compared.

Ecosystem representation may be determined by evaluating the proportion of productive crown forest found in the non-harvested land base (NHLB), including parks and protected areas, but also including areas excluded from harvest for other reasons such as operability constraints (e.g. Huggard 2000; Bunnell et al. 2003).

An ecosystem representation analysis (ERA) can do three things. First, it can identify some types that have minimal representation and could be priorities for locating reserves or special management. Second, results can set the context for Indicator 2. For example, one can choose to emphasize snag management or coarse woody debris objectives in ecosystem types for which representation is poor. Finally, it can provide direction on which ecosystem types to focus effectiveness monitoring efforts (Indicator 3)

Setting Targets and Thresholds

Setting management targets or thresholds for ecosystem representation is challenging. Because the primary intent of ecosystem representation is to sustain poorly understood or unknown species it is not possible to know with precision the level of representation required. Where studies have examined the level of representation required to represent a full range of known ecosystems or species in a study area, there is a consensus that the oft-cited 10-12% target is likely to be insufficient. At this level, some ecosystem types or species were often found to have little or no protection. Some studies found that representation in the range of 40-60% would be required to fully represent the range of ecosystems and species or species assemblages in a study area (e.g., Soule and Sanjayan 1998; Solomon et al. 2003). Other studies also spoke to the need to stratify representation targets among ecosystem and habitat types, to ensure that some types were not missed, which might otherwise occur where overall landscape representation was relatively high (e.g., Groves et al. 2002; Reyer et al. 2002). Howard et al. (1998) found that when targets were stratified across broad geographic groupings, nearly 80% of species spanning a range of taxa could be represented by 20% of the overall area.

Ecosystem representation as discussed here (based on the approach of Bunnell et al. 2003), addresses some of these concerns. Because it is based on explicitly stratifying ecosystem types, it substantially decreases the likelihood that some ecosystem types will be missed. Secondly, an assumption of these studies is that unrepresented areas may not contribute to protecting species or ecosystems, whereas Indicator 1 is only a component of a strategy that includes objectives to maintain habitat elements and species in the THLB.

Despite the challenges associated with setting targets for ecosystem representation, the results of a representation analysis provide clear strategic direction for management. The primary benefit of an ERA is that it allows priorities for management actions to be determined – it can bring management focus to those groups that representation is a problem, and not on those for which representation is very good.

To use an ERA to set management priorities, it is necessary to rank ecosystem groups according their relative risk. There is no exact science in determining relative risk, but to assist this task, some general principles can be applied:

1. Give priority to poorly represented ecosystem groups.

Managers should prioritize ecosystem groups for which representation is low.

The most obvious metric to consider is representation itself (proportion of a given ecosystem group in non-harvested landbase). Because the approach developed by Bunnell et al. (2003) stratifies across ecosystem types, it lessens the concern that some ecosystem diversity may be missed when setting management targets or thresholds without stratification.

2. Give priority to uncommon and rare ecosystem groups.

Groups which are uncommon or rare should be given higher priority than more common groups.

Ecosystem groups typically consist of widespread circum-mesic (upland) groups and less common or rare groups which are typically found on hygric (riparian) or xeric (dry) sites. These uncommon groups deserve consideration because of their ecological uniqueness, and relative uncommonness. In many cases, these ecosystem groups are quite rare relative to the common types (i.e., <1000ha in a 100,000ha management unit). It is not unreasonable to consider fully reserving the most uncommon of these types. When considering rareness, it is important to ensure that the type is truly uncommon, and not just uncommon in the management unit, but common elsewhere.

3. Evaluate management unit *responsibility* for each ecosystem group.

Managers should prioritize ecosystem groups for which responsibility is high.

Responsibility is the proportion of an ecosystem group that falls within a given management unit. The greater the proportion, the greater the responsibility. An assessment of responsibility allows managers to understand which groups to prioritize for management decisions related to ecosystem representation. Further, where responsibility is low, a representation analysis cannot be considered meaningful until representation has also been assessed for a substantial portion of the ecosystem group distribution. Ideally, responsibility would be assessed using the same ecosystem classification for which representation is evaluated. However, responsibility can only be assessed at the variant level provincially, until site series mapping becomes available for the entire province. It is nonetheless useful to consider this measure to help consider which ecosystem groups are most important to focus on.

4. Consider ecological function.

Ecosystem groups that have recognized ecological functions should be given priority.

Some types may have ecological attributes that are recognized as being important, (e.g., riparian types or types that contain hardwoods). Uncommon and rare groups are often also vegetationally distinct from upland circum-mesic groups that are widespread, and this may reflect unique ecological niches.

5. Assess spatial distribution.

Ecosystem groups in which the non-harvested portion are poorly distributed or highly fragmented should be given priority. Where possible, representation strategies should be developed for 'nested sets' of ecosystem groups.

It is important to consider whether the non-harvested portion of an ecosystem group is fragmented or poorly distributed relative to the distribution of the entire ecosystem group. If the non-harvested portion of an ecosystem group is fragmented, it may be susceptible to edge effects. One way to assess this is to evaluate potential edge effects is to undertake an edge analysis as part of an ERA (e.g., Wells et al. 2004).

Another concern is whether the non-harvested portion of the ecosystem group is well distributed, because the groupings are proxies for ecosystem types. In reality, the range and gradients of ecosystem types are more complex than the classifications we use. If the non-harvested portion of the ecosystem group is well distributed across the range of the ecosystem group, it more likely that this unclassified variation in ecosystem diversity will be captured. It is possible to evaluate the spatial distribution of ecosystem groups, comparing the distribution of the ecosystem group as a whole to the distribution in the NHLB. For the EKCP, Wells et al. (2004) found that ecosystem groups were generally well distributed in the NHLB, though patches of NHLB tended to be smaller than those found in the full (NHLB + THLB) ecosystem group distribution (groups < 30% NHLB were found in smaller patches relative to the ecosystem group distribution and only where NHLB > 60% were similar distributions observed).

A further consideration is the 'nestedness' of ecosystem groups. Typically uncommon riparian or dry ecosystem types occur 'nested' within more common circum-mesic types. It may be appropriate to consider these nested groups as a whole since this better reflects the distribution and linkages among ecosystem types on the landscape. Addressing representation for nested groups (rather than individually), may be also the best strategy for capturing the unmeasured variation that the classifications do not capture (Wells et al 2004).

6. Consider linkages to Indicators 2.
Once priority groups are established for ecosystem representation it can provide guidance where to focus retention strategies on the management unit. Retention strategies for important habitat elements and types (Indicator 2) should be focused on underrepresented ecosystem groups.

Ecosystem groups can themselves be incorporated as components of Indicator 2. For example, riparian groups, groups containing hardwoods, or groups species important for cavity nesting birds can be incorporated into to Indicator 2 strategy.

Implementation

Data and Analysis

To undertake a representation analysis, based on the approach developed by Bunnell et al. (2003), data are required for three types of information: an ecological classification is needed to identify *ecologically distinct ecosystem types, ecosystem mapping* is required to map the ecosystem types, and a *landbase netdown* is required to determine the distribution of ecosystem types over the harvested and non-harvested forested landbase.

1. Ecosystem groupings.
To identify *ecologically distinct ecosystem types*, a relevant ecosystem classification is required (Huggard 2004). In British Columbia, it is possible to define ecosystems by grouping Biogeoclimatic Ecosystem Classification (BEC) *site series* according to commonalities in vegetation communities. Ecosystem groupings based on site series may be developed by statistical analysis of BEC vegetation plot data (Huggard 2000), and refined by ecological review by individuals with expertise in the BEC variants in question. Bunnell et al. (2003) and Wells et al. (2004) describe the rationale behind developing ecosystem groupings from sites series.

2. Ecosystem mapping.
Since the ecosystem types are based on sites series, site series mapping is required for the management unit in question. Site series mapping can be provided by terrestrial ecosystem mapping (TEM) or predictive ecosystem mapping (PEM). PEM is generally the only practical mapping available for representation analyses since TEM is rarely available for an entire forest management unit. Data issues associated with using PEM mapping for ERA include PEM ‘entities’ that are combinations of site series, aspatial site series ‘deciles’ and PEM accuracy. See Wells et al. (2004) for further discussion and examples.

3. Land base netdown.
To assess ecosystem representation it is necessary to define the harvested and non-harvested forested landscape of the management unit in question. Typically, these definitions are based on landbase netdowns created for Timber Supply Reviews (TSR). The data required to define the land base netdown are the resultant database associated

with a given TSR. Data issues include aspatial netdowns (percent based), and adjusting netdowns to reflect ERA objectives. More information on applying TSR netdowns to ERA can be found in Wells et al. (2004).

Updates and Monitoring

Updates of ecosystem representation analyses will generally be triggered by the availability of new information, rather than initiated at regular intervals:

1. Ecosystem groups.

An ERA requires an update whenever ecosystem groups are revised.

Once ecosystem groups are established, they should require few updates and minimal monitoring unless substantive changes occur to the site series classification that are their basis. Currently however, ecosystem groups either do not exist, or are in draft stages of development. Ecosystem groups require development where they do not yet exist, and existing groups require ongoing review and refinement.

2. Ecosystem mapping.

An ERA requires an update whenever PEM is updated or revised.

PEM accuracy assessments can be used to evaluate accuracy of mapping of ecosystem groups. An assessment of accuracy of mapping of ecosystem groups can help determine where improved mapping may be required.

3. Landbase netdown.

An ERA requires an update whenever a new land base netdown is created.

This generally will occur in conjunction with a TSR. With any netdown, different netdown categories (e.g., operability, riparian reserves, etc.) should also be evaluated to assess the spatial accuracy of mapping of the netdown type, and the likelihood that the area will be excluded from harvesting in the long term.

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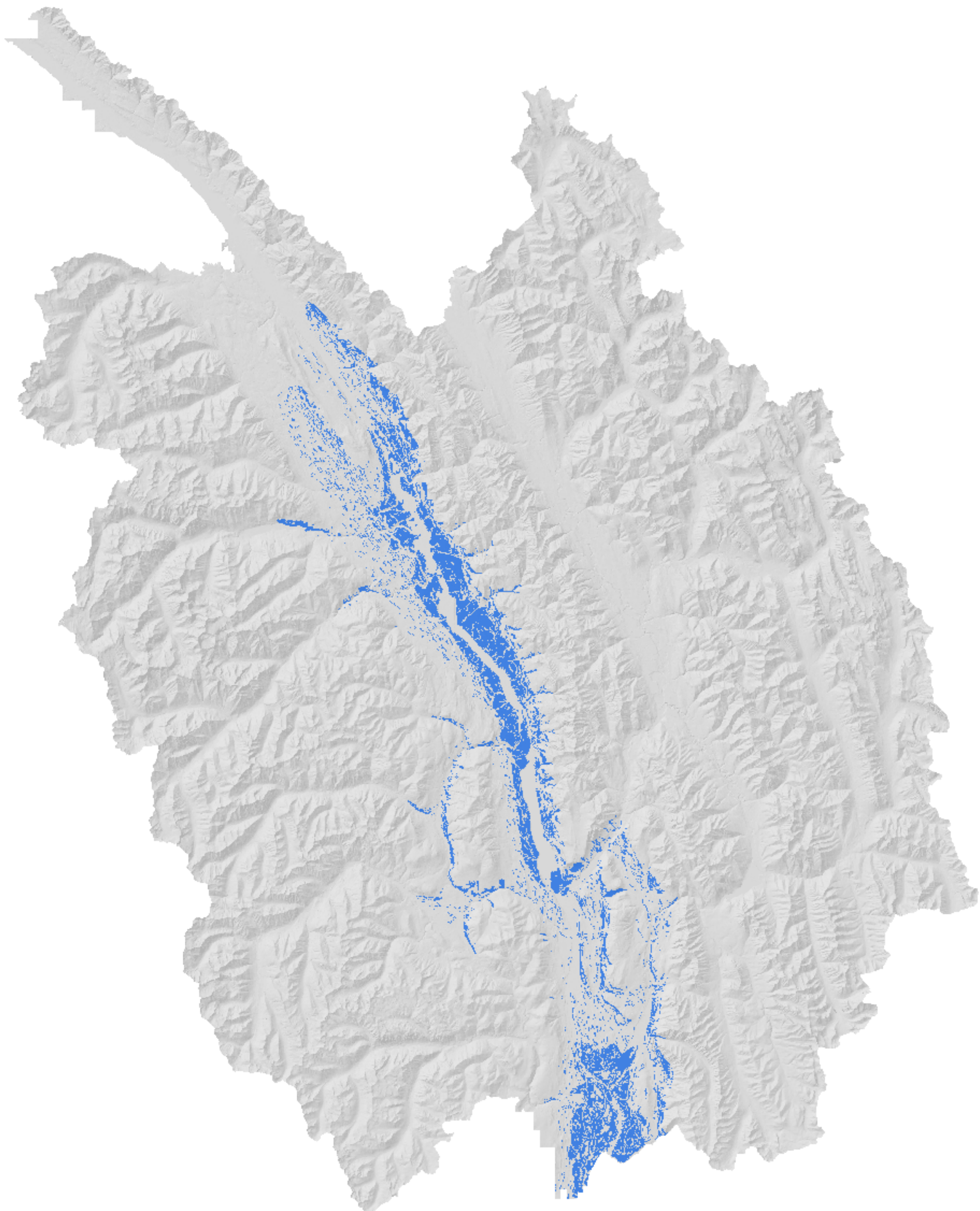
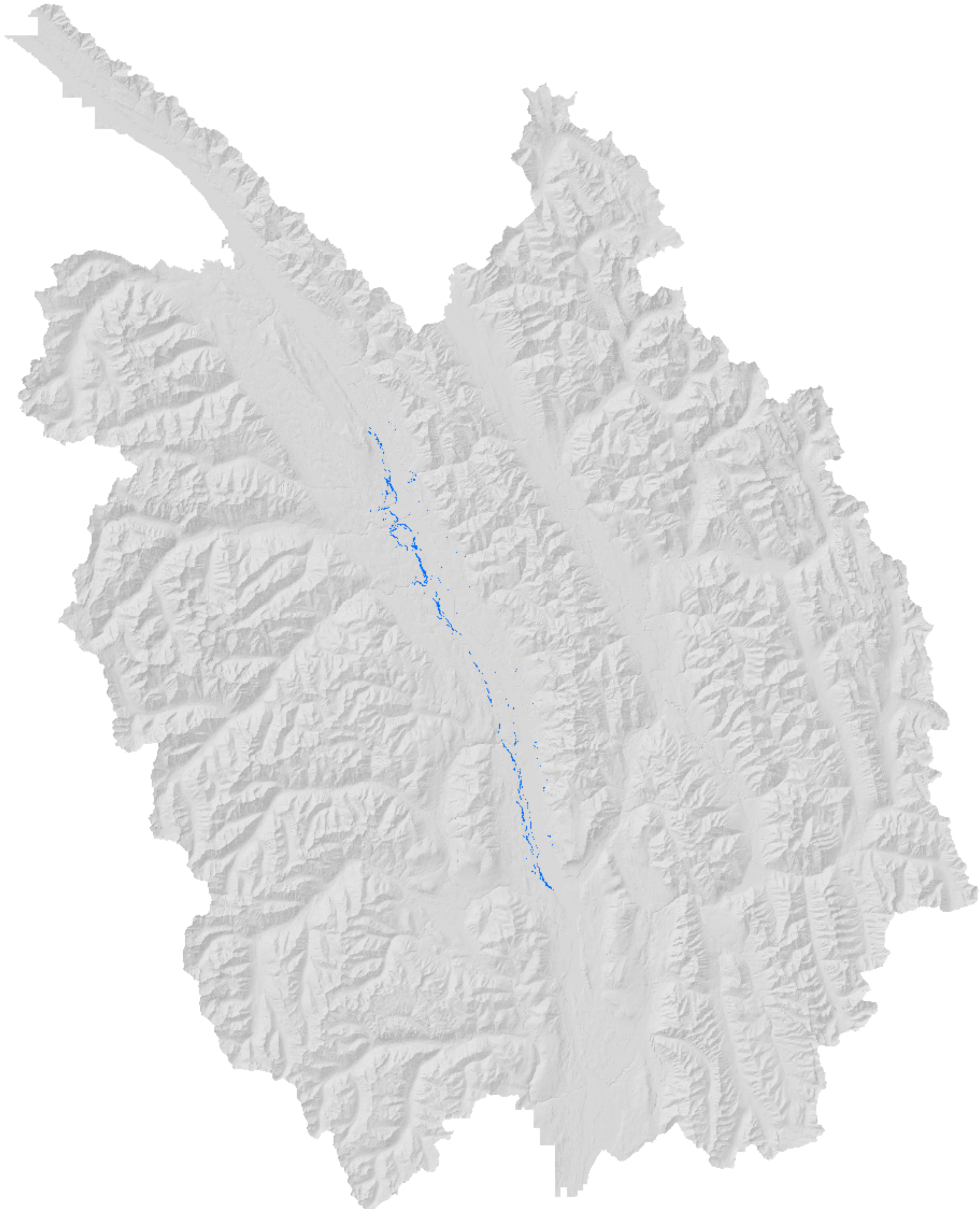
Appendix 3: Distribution of ecosystem groups (Indicator 1).



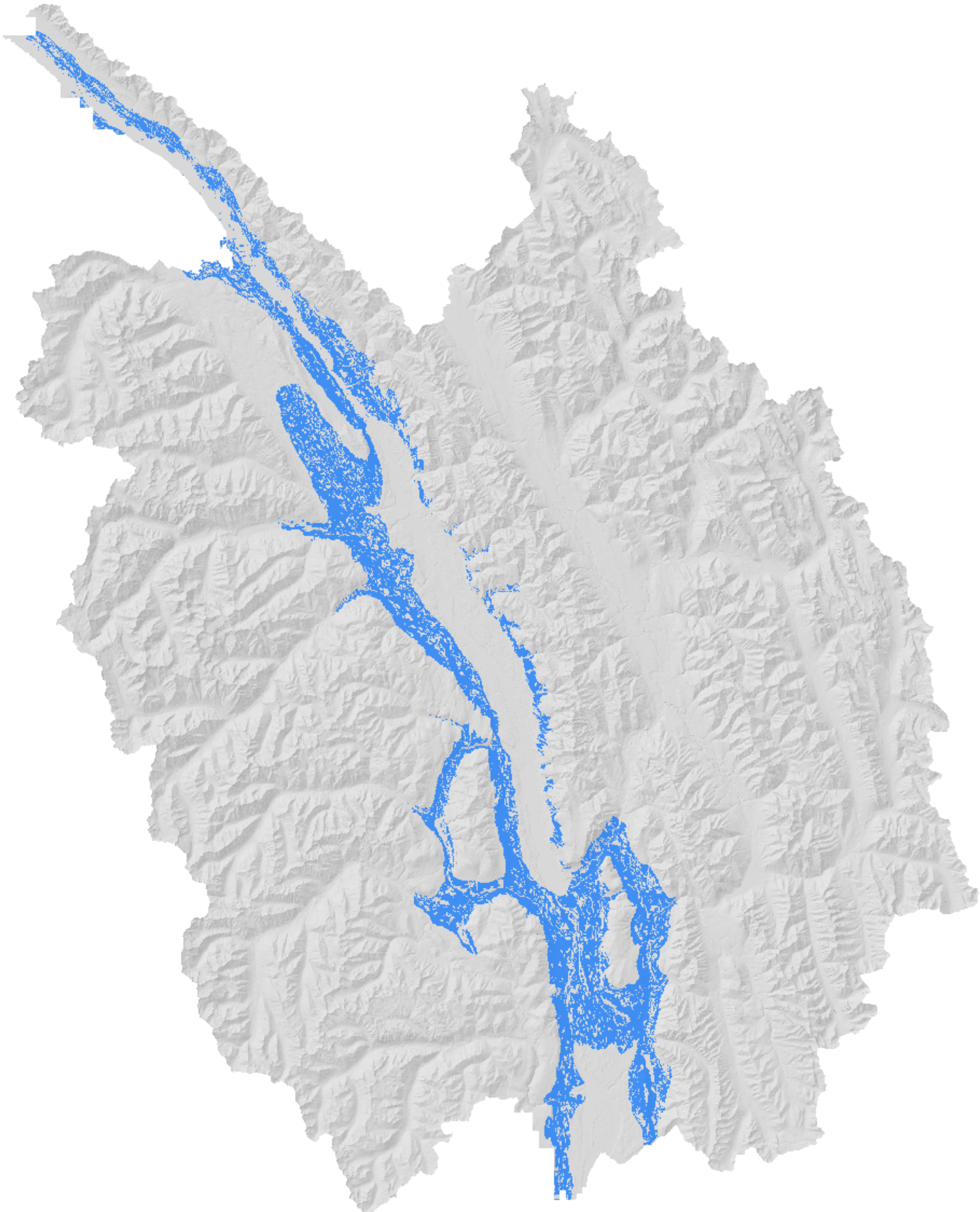
Ecosystem Group 1. Invermere TSA estimated distribution.

Appendix 3 (cont): Distribution of ecosystem groups (Indicator 1)



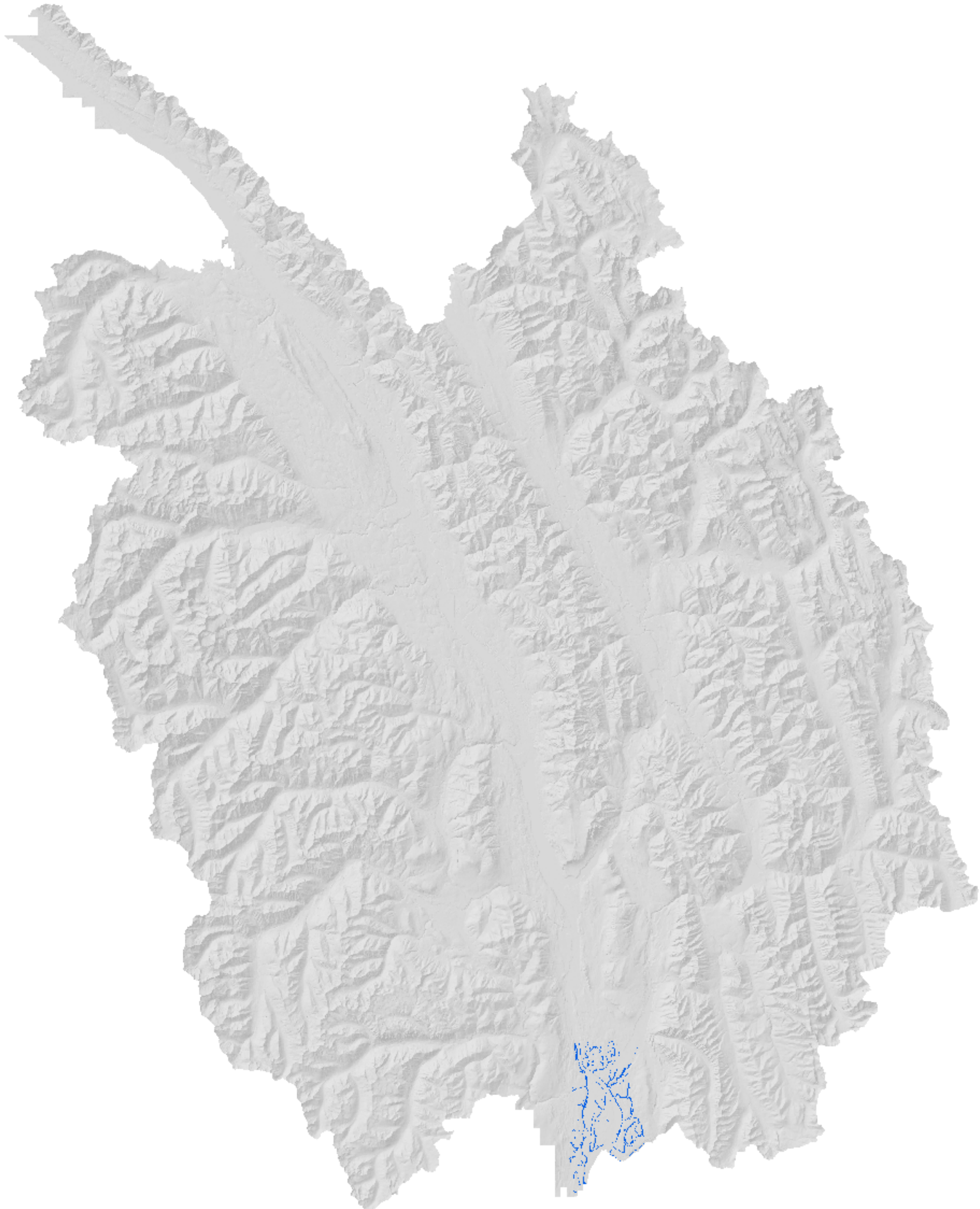
Ecosystem Group 2. Invermere TSA estimated distribution.

Appendix 3 (cont): Distribution of ecosystem groups (Indicator 1)



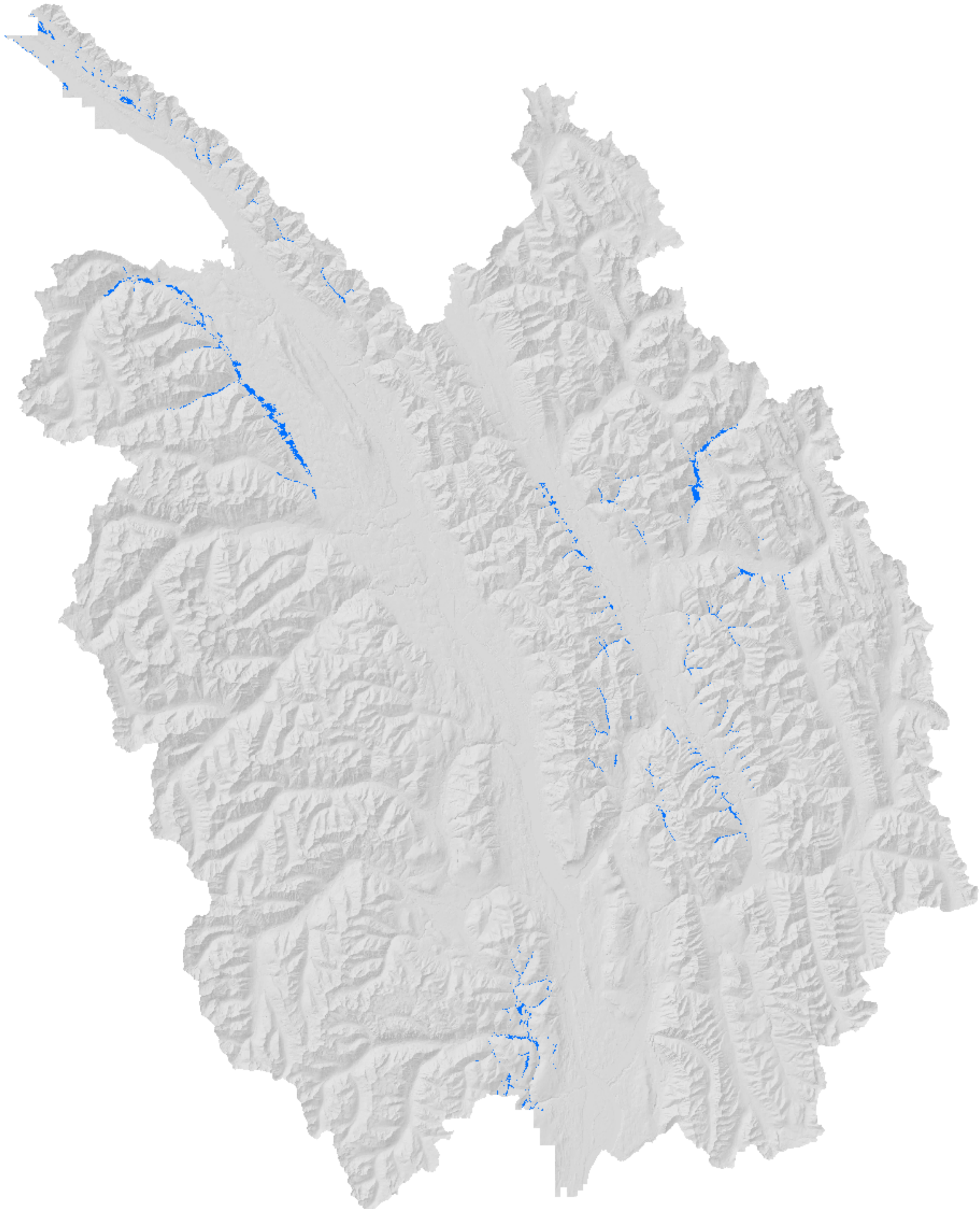
Ecosystem Group 3. Invermere TSA estimated distribution.

Appendix 3 (cont): Distribution of ecosystem groups (Indicator 1)



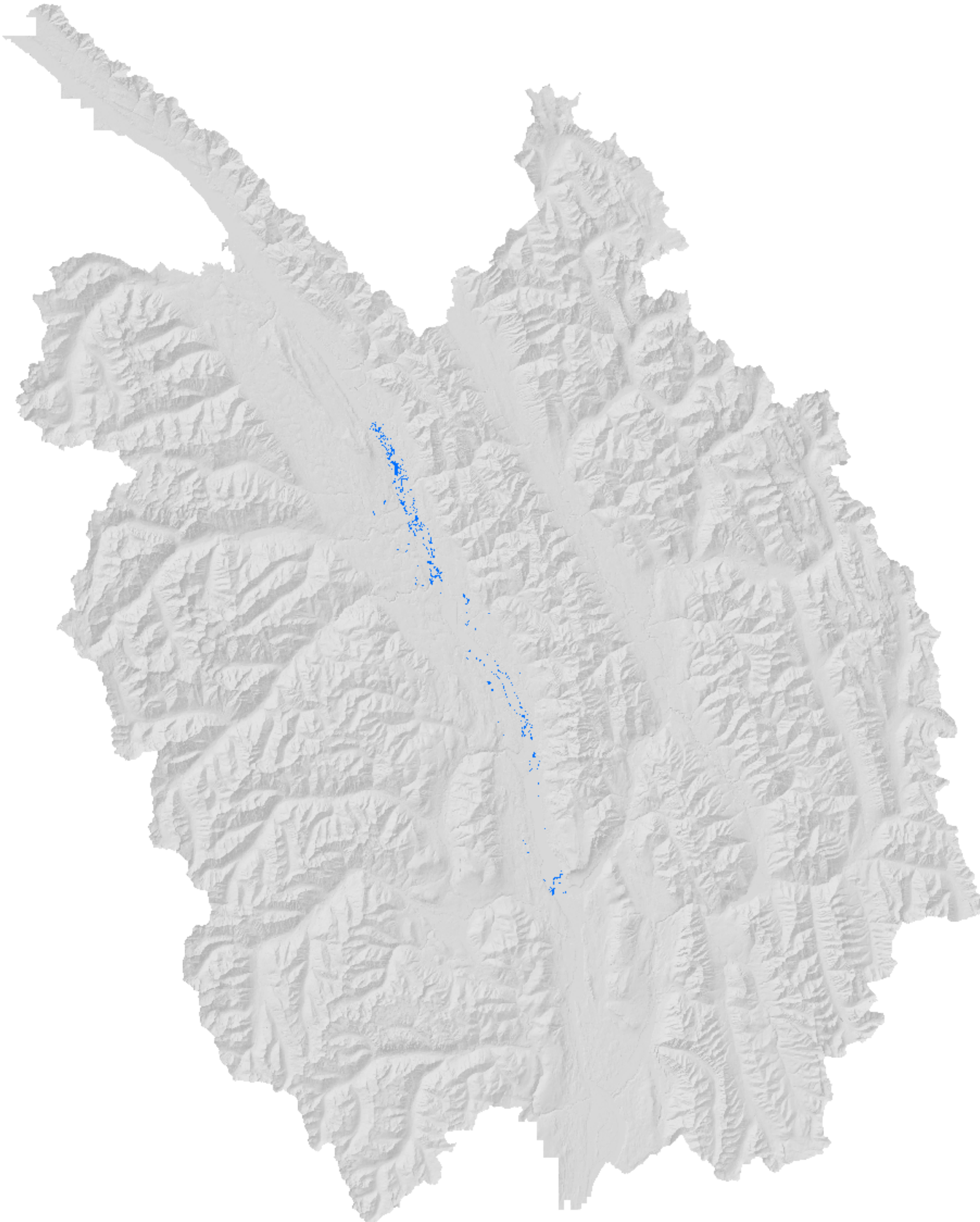
Ecosystem Group 8. Invermere TSA estimated distribution.

Appendix 3 (cont): Distribution of ecosystem groups (Indicator 1)



Ecosystem Group 10. Invermere TSA estimated distribution.

Appendix 3 (cont): Distribution of ecosystem groups (Indicator 1)



Ecosystem Group 16. Invermere TSA estimated distribution.

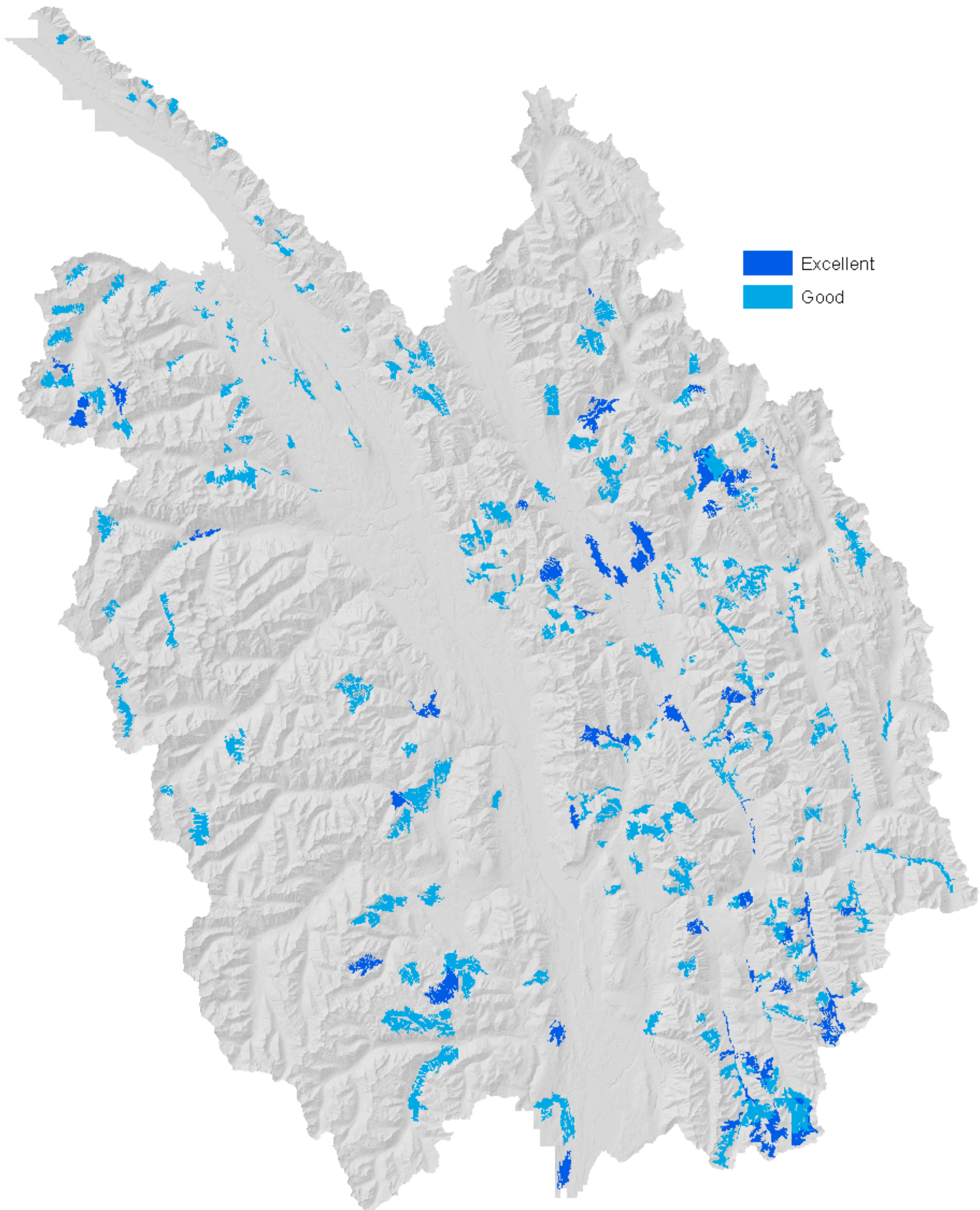
Appendix 3 (cont): Distribution of ecosystem groups (Indicator 1)

Ecosystem Group 24. Invermere TSA estimated distribution.

Appendix 3 (cont): Distribution of ecosystem groups (Indicator 1)

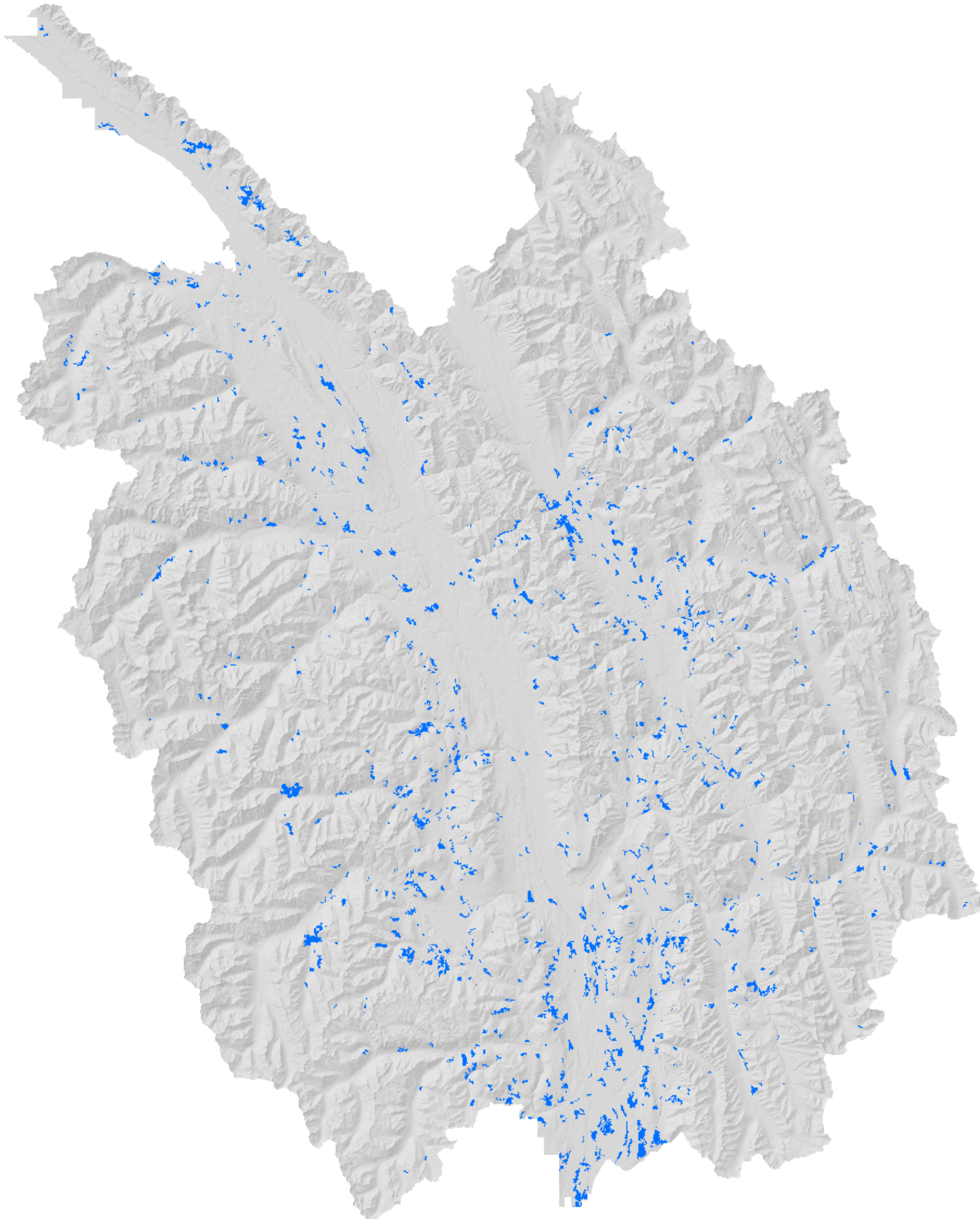
Ecosystem Group 29. Invermere TSA estimated distribution.

Appendix 4: Distribution of habitat types (Indicator 2)



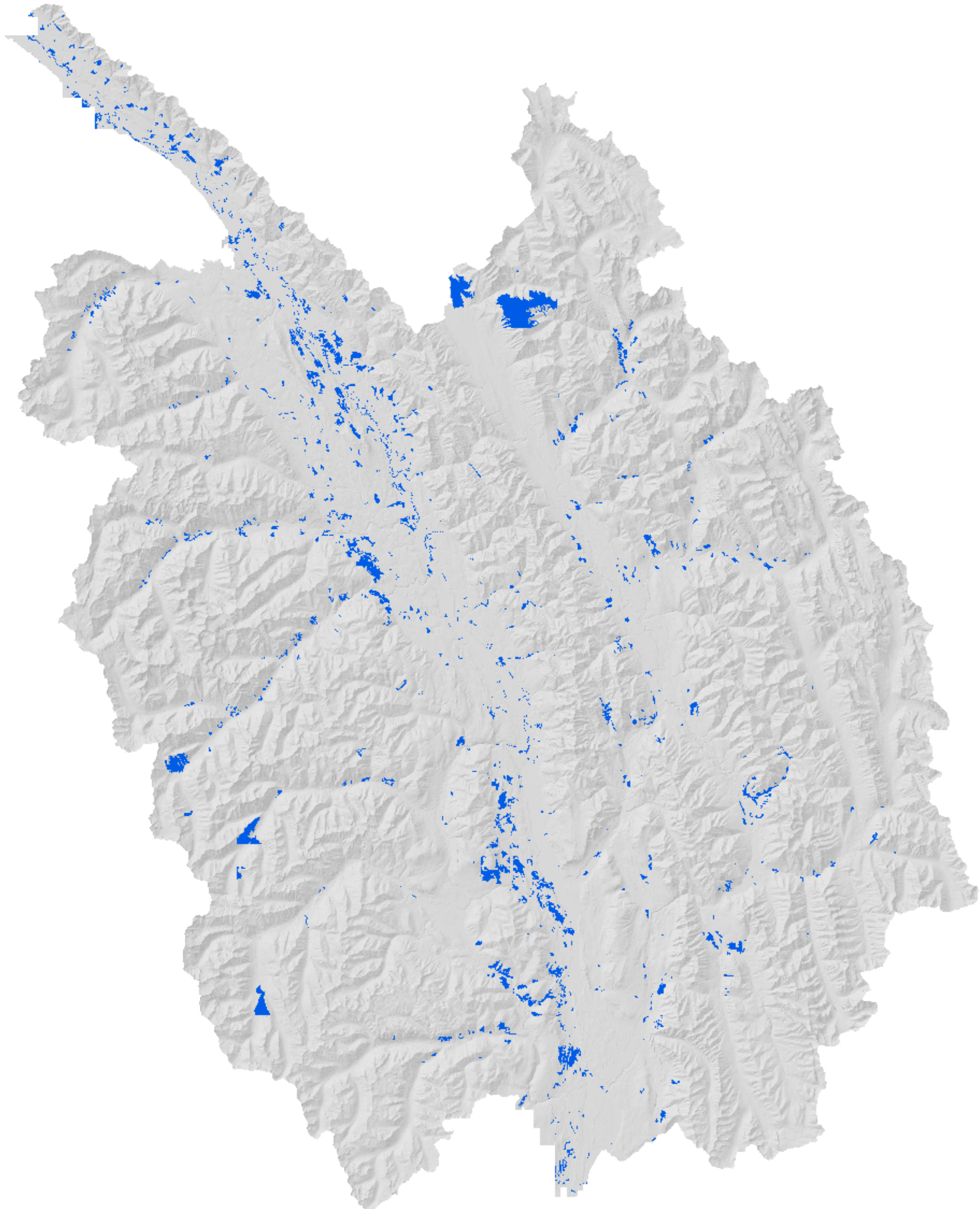
Old Growth Management Area Rankings.

Appendix 4 (cont): Distribution of habitat types (Indicator 2)



Veteran Stands. Invermere TSA estimated distribution.

Appendix 4 (cont): Distribution of habitat types (Indicator 2)



Hardwood Stands. Invermere TSA estimated distribution.

Appendix 5: Description of Indicator 1 and 2 mapping data.

Ecosystem Representation (Indicator 1)

Ecosystem group mapping and information presented in this report are based on the analysis by Wells et al. (2004). PEM for the Invermere TSA (Ketcheson et al. 2004). Ecosystem representation measures were updated for the Invermere TSA using new PEM and TSR3 netdown data (Forsite 2004).

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Old Growth Management Area (Indicator 2)

Old-growth stands were identified by the collaboration group as a priority for draft HCVF identification. Mapping used were based on OGMA classification in the Invermere TSA, undertaken by Al Neal and Licensees, MOF and WLAP staff. A forest cover age class map was developed for each landscape unit in the Invermere Forest District. Using these maps, supported by orthophotos and stereo pairs, logical potential old growth management area candidates were drawn. Arial flights then observed and recorded for each of the polygons; Species composition, Dominant Age Class, Abundance of large size trees, Abundance of Veterans, Abundance of Snags, Condition of the Snags (broken/dead tops), amount of visible course woody debris, Presence of multiple canopy layers, Presence of canopy gaps, percentage of stand composed of avalanche shoots, slope %, Dominate aspect, Stand health, presence of water, presence of aboreal lichen, and connectivity value (local and regional). The flight observers based on the discussion of all of the old attributes discussed, assigned a ranking to the polygon of Poor, Low, Moderate, Good or Excellent. A portion of the polygons were then sampled from the ground to confirm the air calls. The final product from the project was an Invermere TSA and TFL 14 inventory ranking of old growthness for all old seral patches identified. After discussion with Al Neal, 'Excellent', 'Good', 'Moderate' classed OGMAs were selected for use. with OGMAs with old western larch, and stands with old Douglas-fir/ponderosa pine, and Western Redcedar were identified using forest cover mapping.

Stands with veteran trees (Indicator 2)

Rank 2 forest cover data was used to identify younger stands that have a veteran component to look for opportunities to incorporate late seral structure into HCVF stands where no OGMAs are available.

Hardwood Stands (Indicator 2)

The habitat values of hardwood and mixwood stands are well known (e.g. Bunnell et al. 1999; Jamieson et al. 2002), and were considered when locating draft HCFVs. Forest cover is a primary data source for mapping hardwoods (e.g., Jamieson et al. 2002) and were used to map hardwood and mixedwood stands (> 25 % hardwoods).

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