Using Site Series Surrogates to Calculate Ecosystem Representation

Karen Price
October, 2008

Introduction

Ecosystem representation targets were designed to be applied to biogeoclimatic site series. Because site series are not mapped for the entire coast, however, representation is currently based on a site series surrogate: timber “analysis units”. Biogeoclimatic site series describe ecosystems as a combination of climate, topography, soil moisture, nutrient availability and plant community: the biogeoclimatic ecosystem classification system is well-recognised and respected. Analysis units describe principle tree species and growth rate: they focus on the elements of most interest to timber management. There is concern that using analysis units as surrogates for site series may not capture ecosystem representation as intended because first, analysis units and site series may not match well, and second, harvesting might target particular sites within an analysis unit.

This document describes an analysis that considers the possible ramifications of using analysis units as surrogates for site series and offers recommendations for future analysis and planning. The original intent of this analysis was to design representation areas spatially, on real landscapes, using analysis units, and then to test how well analysis units captured site series representation. Such an analysis would be the true test of the surrogate approach. Because permission to use real data was not forthcoming, however, spatial analysis was not possible. Hence, I simulated ecosystem representation and harvest aspatially, assuming that the most productive sites within an analysis unit would be harvested first.

Methods

The analysis is based on a crosswalk table of the Phillips landscape unit compiled by Dave Leversee (Table 1 and Appendix 1). This table cross-tabulates the forested area of the landscape mapped as being within each site series and analysis unit. This landscape is one of the few with available terrestrial ecosystem mapping data. Areas are based on all three site series deciles described for each polygon. The test does not examine current harvesting.

I combined CWHvm1 and CWHvm2 for analysis, because BEC variants were not separated in the data. I excluded non-forested polygons, MHmm1 site series, alder site series (sitka alder-salmonberry) and polygons with missing information (deciduous analysis units are included). I excluded MHmm1 and alder site series because they had very high proportions of the area with no defined analysis unit (over 75% undefined for most site series). In addition, alders have no measures of productivity and hence cannot be ranked. I simulated representation by leaving a target amount of each analysis unit (30% and 70%) unharvested. Each analysis unit includes several site series (see Table 1). To simulate harvest, I assumed that harvest would select the most productive sites within an analysis unit first. Because the data are aspatial, I could not consider the effects of road access, pattern or riparian (or other) reserves on representation.

Table 1. Crosswalk table of site series and analysis units for the Phillips landscape unit. Note that this table includes CWH and MH subzones, but subsequent analysis excludes MH.

FORESTED SITE SERIES		FIR			CEDAR			HEMBAL			SPRUCE		Spruce-Low	DECID		
		Good	Medium	Poor	Good	Medium	Poor	Good	Medium	Poor	Good	Medium	Pine- ALL	All		
TEM SS	SS Name	AU1	AU2	AU3	AU4	AU5	AU6	AU7	AU8	AU9	AU10	AU11	AU12	AU13	! no SSS	**Total TEM**
AB	HwBa - Blueberry	7	184	0	624	444	82	1,922	1,201	40	15	1	0	79	668	**5,267**
AD	BaSs - Devil's club	-	19	-	86	51	18	234	163	4	1	-	-	9	143	**728**
AF	BaCw - Foamflower	9	66	-	281	97	35	765	287	5	2	0	-	35	227	**1,810**
AS	BaCw - Salmonberry	0	76	0	153	19	46	814	175	6	51	0	-	111	108	**1,559**
HS	HwCw - Salal	1	113	-	606	611	203	911	1,706	30	0	-	-	19	1,432	**5,633**
LC	HwPl - Cladina	0	14	-	9	11	4	40	36	-	-	-	-	1	117	**234**
LS	Pl - Sphagnum	-	-	-	0	11	-	0	1	-	-	-	-	-	2	**15**
MB	HmBa - Blueberry	-	-	-	14	84	12	128	541	13	-	-	-	-	969	**1,760**
MH	Hm - Mountain-heather parkland/heath	-	-	-	7	1	7	1	134	40	-	-	-	-	655	**844**
MM	HmBa - Mountain heather	-	-	-	16	236	104	84	1,386	138	-	-	-	-	6,383	**8,347**
MO	BaHm - Oak fern	-	-	-	-	4	0	1	17	1	-	-	-	-	61	**82**
MT	BaHm - Twisted stalk	-	-	-	-	0	-	0	32	-	-	-	-	-	147	**180**
RC	CwSs - Skunk cabbage	-	1	-	9	22	4	69	28	-	18	2	-	19	44	**216**
RS	CwHw - Sword fern	4	90	-	168	31	7	798	74	0	5	-	-	32	49	**1,259**
SA	Sitka alder - Salmonberry	-	0	-	15	24	31	175	202	24	-	-	-	-	3,276	**3,746**
SS	Ss - Salmonberry	-	4	-	10	7	3	205	40	0	52	15	-	25	38	**400**
YG	CwYc - Goldthread	-	-	-	-	11	56	2	64	24	-	-	-	-	55	**211**
YH	YcHm - Hellebore	-	-	-	1	4	11	8	41	-	-	-	-	-	50	**115**
! no TEM data		0	7	0	37	83	59	142	441	78	9	2	1	125	n/a	**984**
TOTAL AU		**22**	**574**	**0**	**2,037**	**1,753**	**682**	**6,298**	**6,569**	**402**	**154**	**21**	**2**	**454**	**14,425**	

I ranked productivity of each site series based on the mean site index for all tree species listed in Land Management Handbook 26 for each site series within the CWHvm1, and based harvest priority on these productivity ranks. Site series within the CWHvm2 have similar relative productivity. Within each analysis unit, I simulated harvest up to the target amount. I considered two scenarios: in one, I harvested 30% of each analysis unit (leaving 70% as representation); in the second, I harvested 70% of each analysis unit (leaving 30%). I was unable to complete analyses for the targets listed in the Ministerial Order because these vary by biogeoclimatic subzone/variant, and the crosswalk table—for simplicity—did not include subzone.

Following harvest simulation, I summed the unharvested area of each site series across analysis units and calculated the percent of each site series remaining in the landscape unit.

Results

Each analysis unit included several site series. Only spruce analysis units matched well with site series (Table 2).

Table 2. Percent of each site series in each analysis unit.

		Ba G	Ba M	Cw G	Cw M	Cw P	Hw G	Hw M	HwP	Ss G	Ss M	Dec
Site index[1]		AU1	AU2	AU4	AU5	AU6	AU7	AU8	AU9	AU10	AU11	AU13
36	SS (09)	0	1	1	1	1	4	1	0	**36**	**78**	8
27	AF (05)	**42**	12	14	7	8	13	8	5	1	1	11
26	AD (08)	0	3	4	4	4	4	4	4	1	0	3
	AS (07)	0	13	8	1	10	14	5	5	**35**	2	**34**
25	RS (04)	**21**	16	9	2	2	14	2	0	4	0	10
22	AB (01)	**31**	**32**	**32**	**34**	18	**33**	**32**	**36**	11	6	**24**
15	RC (14)	0	0	0	2	1	1	1	0	12	12	6
15	HS (03)	6	**20**	**31**	**46**	**44**	16	**45**	**28**	0	0	6
12	LC (02)	1	2	0	1	1	1	1	0	0	0	0
12	LS (13)	0	0	0	1	0	0	0	0	0	0	0
12	YG (12)	0	0	0	1	12	0	2	**22**	0	0	0

[1] Approximate site index based on average for all species listed in Handbook 26 for CWHvm1 (no value for AS 07).

Productive site series were reduced considerably below their target amount, while low-productivity site series were over-represented (Table 3). With targets of 30% unharvested (higher than the current interim targets for the CWHvm1 of 21 – 28%), five productive site series were almost entirely lost from the simulated landscape (CWHvm1/05, 08, 09, 07, 04; same site series for vm2 except no 09). At this harvest level, the zonal site series (01) was reduced to a high-risk level (17%). With a “low-risk” target of 70% unharvested forest, two site series were entirely lost (05, 08), a third (09) was reduced to 5% of its former range, and a fourth was reduced below 30% (07). In this latter scenario, the zonal site series remained well represented.

Table 3. Results of harvest simulation on Phillips landscape unit. Numbers in **bold** are below the target.

	% of site series remaining	
Site series[1]	Target 70% old	Target 30% old
AF (05)	**0**	**0**
AD (08)	**0**	**0**
SS (09)	**5**	**0**
AS (07)	**29**	**0**
RS (04)	86	**1**
AB (01)	87	**17**
HS (03)	100	52
RC (14)	100	63
LC (02)	100	100
LS (13)	100	100
YG (12)	100	100

[1] Site series abbreviation as shown in Table 1 and site series identification number as used in Land Management Handbook 26.

Discussion

This analysis clearly documents the potential difficulty of using analysis units as site series surrogates. By using analysis units to determine the amount to reserve, and assuming that harvesting targets high productivity ecosystems, several high productivity site series in the sample landscape were placed at very high risk. In the simulations, even maintaining 70% of each analysis unit was unable to ensure low risk to productive ecosystems.

These results illustrate two problems associated with the site series surrogate approach. First, analysis units, designed for timber management, and site series, designed to describe ecosystems, do not match well. Second, because of this lack of correspondence, non-random harvest with respect to site series within an analysis unit prevents planned ecosystem representation. Either of two criteria must be met for the site series surrogate approach to work. Either analysis units must match site series, or harvesting must be random. Both criteria fail in the current analysis. Checking whether the first criterion is generally applicable would require analysing other landscapes. There is, however, no reason to assume that the Phillips landscape should be any worse, or better, than other landscapes. Checking the second criterion requires a spatial analysis. However, analyses to date have consistently shown that harvesting targets high-productivity ecosystems[1]; hence the assumption is not entirely unreasonable.

If rich site series tended to be grouped together in some analysis units, at least some moderately rich sites would be protected. Typically, however, analysis units include a range of rich, medium and poor sites, leading to an over-harvest of productive sites. It is interesting to note that targeting the most productive site series within an analysis unit does not represent the worst-case scenario for representation; the worst-case scenario would involve targeting the site series with least area. However, because there is generally less area in productive site series than in zonal site series, the simulation is closer to a worst-case scenario more than to the best-case scenario of random harvest within analysis units.

[1] Holt, R.F. and G. Sutherland. 2003. Environmental Risk Assessment Base Case: Coarse Filter Biodiversity. Prepared for the North Coast LRMP; Price, K. 2003. Testing the hydroriparian planning guide. Report to the CIT.

The results would likely be less severe in a spatial analysis as stand-level retention, particularly riparian reserves, would increase the amount of some site series. For example, the fluvial site series (CWHvm1/09) would likely have more area reserved in practice. There is no way to assess the contribution from stand-level and other reserves (e.g. for red-listed communities) without examining a spatially-explicit example. Conversely, the results would be more severe if they were based on a percent of estimated natural old forest rather than a percent of total forested area[2]. For example, in the CWHvm1, current representation targets range from 21 – 28% of total forest rather than the 30% used in this test. Hence using the percent of natural forest, as stipulated in the legal objectives, would draw down more mesic site series (e.g. in Table 3, retaining 21 – 28% would likely remove much of the remaining CWHvm1/01).

Recommendations

Further Analysis

It would be possible to improve the aspatial analysis by including BEC subzone (i.e. separating CWHvm1 and vm2) and by analysing other landscape units. However, the results of this analysis provide a fairly striking example of the potential problems of using site series surrogates, and I do not think that performing more aspatial analyses will change the finding, although less diverse landscape units may have more consistency. It would be better to complete a spatially-explicit analysis for several landscapes.

1. **Complete a spatial analysis for at least three watersheds/landscapes, where the development plan is based on analysis units, and representation is checked by site series.[3]**

Planning Representation

Because of the strong potential for under-representation of high productivity ecosystems using the current approach (to the extent that several site series could be lost, acknowledging the limitations of an aspatial analysis), it will be important to move towards using site series as quickly as possible. If site series are not yet available, it is still possible to plan representation based on a combination of ssPEM and analysis units, then to modify harvest plans based on field measurement of site series before logging. While ssPEM has low success at predicting location of site series, it is more successful at predicting the proportion of site series within an area. All efforts to facilitate the use of site series should be made.

2. **Use site series (including all deciles) to plan ecosystem representation if available.**
3. **If site series are not currently available,**
    a. **plan amount to reserve in a landscape or watershed based on ssPEM and by analysis units (see Appendix 2 for an example),**

[2] Legal objectives apply percent retained to the amount of each site series expected under a natural disturbance regime rather than to the total amount of each site series.
[3] Apparently, this step has already been completed, but the results are being held. "*We've done this already…but I'm not sure we want to release the information yet*" Warren Warttig.

b. determine site series in the field while identifying logging sites (as standard practice); ensure that these data are recorded and used to update the estimated area of each site series left based on ssPEM,

c. as information improves, modify harvest plans as necessary to ensure representation of site series.

4. Modify legal objectives to require that analyses of representation use the best available data.

5. Require that site series information is used to update calculations of watershed- and landscape-unit level representation as it is collected.

6. Focus efforts to determine site series in watersheds that will be developed; these efforts should be broader than site-by-site planning.

7. Focus efforts to determine site series on high productivity analysis units first (in areas where they are available for harvest) as these have a higher proportion of high productivity site series and red and blue-listed plant communities.

Appendix 1. Comparing TEM to SSS data (by Dave Leversee)

Input SSS data:

- Site Series Surrogate ("Surrogate"). Analysis Unit (AU) created from Site Index (SI) and species (ITG), combined with BEC data. Sources are Forest Cover (CFCI and ILMB) and BEC.

Input TEM data:

- various projects, different contractors and dates. Important data is Site Series (SS) in 3 deciles. Sources are field plots and airphoto interpretation and BEC.

Note: To keep the analysis as simple as possible, BEC, Stand Age/Structure, and non-forested components are not considered in this analysis. This means that just AU and forested SS will be compared.

Step 1: "Cleaning" the data.

a) Make sure that all 2-letter TEM SS codes are identified in the TEM manual and try to find the meaning of codes that are "unique." Match a Site Series Name to each SS code (e.g. HS = HwCw – Salal).
b) SS codes rely on BEC to complete the "name" definition, so do this before next step. Also, make sure that each SS code occurs in only one BEC subzone variant (no duplicates). If duplicates are found, then give one a new, temporary code.
c) disregard BEC for both Surrogate and TEM data. BEC should have be the same but some TEM data sets use an older version. The correct BEC data can be added back to the data after the two layers are combined. This leaves just the Analysis Unit (SI+ITG) from the Surrogate data.
d) weed out TEM polygons with entirely non-forest SS values in all 3 deciles

Step 2: Combine the two coverages

a) "Union" the two maps and create a table from the resulting database
b) Flag all polygons that are forested in one data set, but non-forested in another.
c) Create a "hectare" column and calculate for each record (= area / 10,000). Because there will be many small slivers, include several decimal points.

Step 3: Simplifying the TEM data for crosswalk with Surrogate data.

a) Create 3 columns to list the polygon hectares of each decile (area * decile%)
b) Identify all forested SS values (it's possible that some are only in 2^{nd} or 3^{rd} decile).
c) For each forested SS, summarize the total hectares in all 3 deciles that it occurs in. For example, if AB occurs 60% in Decile1 and 10% in Decile2, then AB's total area is 70% of the polygon area.
d) Create new columns for each forested SS with total hectares (dec1+dec2+ dec3). In the Phillips example, this means adding 18 columns to the table where each record has the total area for each SS represented.

Step 4: Analyze the data

a) use "frequency" to summarize the amount of each SS in each AU.
b) Format table in Excel to see how much of the SS is captured by any Analysis Unit. This example is from the Phillips TEM data.

Appendix 2. Example of planning based on ssPEM and analysis units.

1. Estimate the area of each site series in watershed based on ssPEM: for example, 100 ha of CWHvm1/01/04 (translate this into 50 ha of CWHvm1/01 and 50 ha of 04[4]), 40 ha of CWHvm1/05, and 500 ha of CWHvm1/03.
2. Based on this estimate of the amount of each site series, calculate how much of each site series is available for harvest: in this example, 30% of the area of each is about 17 ha of CWHvm1/01 and CWHvm1/04, 13 ha of CWHvm1/05 and 167 ha of CWHvm1/03.
3. Plan harvest based on analysis units as usual (e.g. 30% harvest of hemlock-good, 30% of hemlock-moderate).
4. Determine actual site series in the field, during harvest planning.
5. Once the limit for a particular site series is reached based on the ssPEM estimate and full TEM, modify plans to ensure that limits are not crossed. For example, a planned 40 ha cutblock in hemlock-good may have 20 ha of site series CWHvm1/05. In this case, the cutblock could only harvest 13 ha of the CWHvm1/05, and no further harvesting of CWHvm1/05 could occur within the watershed unless further TEM updated the estimate of the total amount of CWHvm1/05 within the watershed.
6. Keep track of all site series mapped (harvested and unharvested) in order to update representation of site series.

[4] Some PEM analyses include estimates of the proportion of each site series within groups: if available, these can be used to improve estimates.