Research Report

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Linking ecologically based productivity information to timber supply analysis units using site series sampling

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Abstract

Timber supply analyses are used to estimate the possible harvest level of timber volume over the long term. Site index is one of the inputs of these analyses. When site index is underestimated, as is often the case for older stands, it will lead to underestimated yields. This creates a significant negative effect on harvest levels in the timber supply analyses. Better site index information is obtainable by using ecologically based site indices; however, an efficient way of applying the site index estimates is needed. The purpose of this project was to develop a technique for incorporating better site index estimates into timber supply analyses. We used simple random sampling to determine the proportion of each site series in a management unit. Site index estimates were available for these site series. To link the site index information to timber supply analysis units, we initially created analysis units using inventory information. The site series proportions were then used to form new ecologically based analysis units, and yield tables were generated from the associated site index information. After an area was harvested in the timber supply model from an inventory-based analysis unit, it was allocated to an ecologically based analysis unit in proportion to the area that the site series occupied in the timber harvesting land base. Once an area was placed into a new analysis unit, it remained there for the duration of the timber supply analysis. We tested this method in the Bulkley Timber Supply Area, where it resulted in a 26% increase in the long-term sustainable harvest level.

KEYWORDS: *allowable annual cut, analysis units, ecological site series, long-term harvesting level, site index, timber supply modelling, yield table generation.*

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Introduction

A timber supply analysis is the process of exploring the effects of forest management strategies and alternative timber harvesting levels on timber supply. Its primary importance is in setting the allowable annual cut (AAC). Five main steps are employed in timber supply analyses in British Columbia (British Columbia Ministry of Forests 2002a):

1. Categorize the land base into analysis units that have similar tree species, productivity, or management regimes.
2. Project timber growth and yield for each analysis unit.
3. Specify the amount, timing, and location of each management activity.
4. Model timber supply with a computer model that simulates forest growth, harvesting, and regeneration.
5. Run sensitivity analyses to examine the impacts of uncertainty in the data and management assumptions.

Timber yields used in timber supply analyses are estimated using growth and yield models, such as the Variable Density Yield Prediction (VDYP) model (Martin 1991) and the Table Interpolation Program for Stand Yields (TIPSY) model (Mitchell *et al.* 2000). Site index, which is a measure of productivity, is a critical parameter in these models. It is the height of a site tree at breast height age 50. Site index is predicted from the species, height, and age of a stand as obtained from forest inventory data. Site indices are often underestimated, particularly in cases in which the estimates are based on old-growth stand attributes (Nigh and Love 1997; Nussbaum 1998). Biased site indices will affect timber supply analyses in the following ways:

- future volumes will be underestimated
- years to green-up height will be overestimated
- sites that have higher productivity than indicated by the estimated site index may be inappropriately excluded from the timber harvesting land base

Several initiatives have been undertaken to correct site index estimates (e.g., Goudie 1996; Nigh and Love 1997; Nussbaum 1998; Farnden 2004). These corrections are not widely applicable and are only available for a few species. Biogeoclimatic Ecosystem Classification (BEC) site series (Banner *et al.* 1993) are well-suited to provide ecologically based site indices (Green *et al.* 1989; Wang *et al.* 1994) and are available for coniferous species in British Columbia (B.C. Ministry of Forests 2003). These site index estimates are more accurate than the inventory-based estimates, especially for older stands (Mah and Nigh 2003). Over the long term, these ecologically based site indices were to be combined with biogeoclimatic site series mapping (e.g., Terrestrial Ecosystem Mapping [TEM] and Predictive Ecosystem Mapping [PEM]) as a way of applying them to the land base. Site series mapping, however, is expensive and time consuming, and obtaining reliable mapping is difficult. This project offers an alternative method of applying ecologically based site index estimates in timber supply applications that avoids the need for PEM and TEM. Management units with reliable PEM and TEM can apply the ecologically based site indices directly.

This paper focuses on the development of a technique that applies ecologically based site indices to obtain better timber supply forecasts.

This paper focuses on the development of a technique that applies ecologically based site indices to obtain better timber supply forecasts. Ecologically based timber supply analysis units were formed through a simple random sampling of the management units and the application of ecologically based site indices. Timber volumes that better represent managed stands were estimated from the applied site indices and timber supply forecasts were made using these managed stand yields. The intent was to remove biases in yield projections due to poor inventory-based estimates of site index. Timber supply analyses have been done on 71 management units in British Columbia (37 Timber Supply Areas [TSA], and 34 Tree Farm Licences [TFL]). The ecologically based site index procedure has to be repeated for each TSA and TFL in which this method is used in a timber supply analysis. Therefore, when designing the project, we needed field and office procedures that could be understood and implemented by research and operational foresters, and that could be done in one field season within a reasonable budget to make it a short-term undertaking.

Methods

Study Area

We tested the ecologically based site index approach in the Bulkley TSA in British Columbia (see Figure 1). This TSA was chosen because it is transitional between the Coast and the Interior, and consequently contains both mountainous and relatively flat areas. This variability in terrain gives a good cross-section of the types of conditions that can be expected in other areas of the province. There were also other operational considerations for selecting this area, such as resource availability and access. The Bulkley TSA covers 762 540 ha, of which 339 874 ha are in the current timber harvesting land

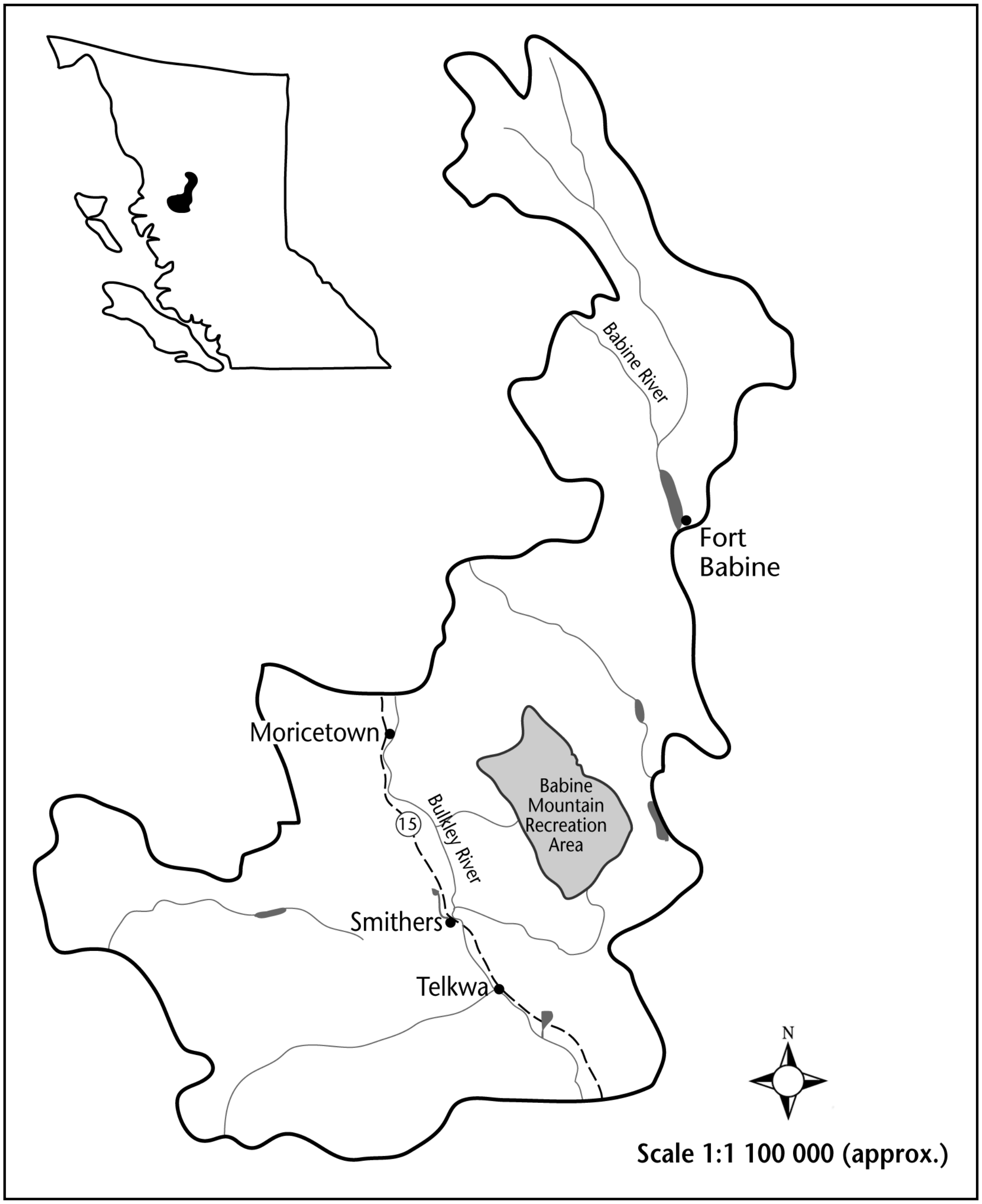

FIGURE 1. The study area (Bulkley Timber Supply Area).

base. Eleven biogeoclimatic subzones and variants occur in the TSA. Table 1 shows the breakdown of the TSA by subzone and variant based on inventory information.

The study area consisted of the entire TSA including productive and non-productive land. Non-productive areas were those that did not support forest vegetation (i.e., water, urban areas, roads, railways, glaciers, and rocks). The timber harvesting land base included all productive land that was harvestable. Some productive land was not eligible for harvesting because it was either private or park land, or was inaccessible.

Sample Selection and Sample Size Determination

Three options for locating the sample plots were considered: simple random sampling, stratified random sampling, and systematic sampling (Kish 1965). Stratified random sampling was not used because logical strata, such as biogeoclimatic subzone and variant, could not be reliably identified before the sample was drawn. Systematic sampling was not used because additional samples could not be easily taken to improve the precision of the estimates without compromising the systematic nature of the sample. Simple random sampling was chosen because it has well-known statistical properties and samples could be added without compromising the design. The sample locations were drawn without replacement from a 100 × 100-m grid aligned with the 20 × 20-km National Inventory Grid established by Natural Resources Canada (Natural Resources Canada 2003). The difference between the sampling frame (grid points in the Bulkley TSA) and the target population (the Bulkley TSA) was assumed to be small due to the pre-determined placement of the grid and the relatively small grid size.

TABLE 1. Breakdown of the Bulkley Timber Supply Area by subzone and variant

Subzone/ Variant[a]	Area (ha)	Area (%)
AT	104 239	13.67
CWHws2	18 148	2.38
ESSFmc	199 633	26.18
ESSFmk	5 719	0.75
ESSFmv3	381	0.05
ESSFwv	60 774	7.97
ICHmc1	27 451	3.60
ICHmc2	20 894	2.74
MHmm2	16 700	2.19
SBSdk	69 239	9.08
SBSmc2	239 514	31.41

[a] Upper case letters indicate zones: AT = Alpine Tundra; CWH = Coastal Western Hemlock; ESSF = Englemann Spruce–Subalpine Fir; ICH = Interior Cedar–Hemlock; MH = Mountain Hemlock; SBS = Sub-Boreal Spruce (Banner *et al.* 1993). The first lower case letter indicates precipitation: d = dry; m = moist; w = wet (Banner *et al.* 1993). The second lower case letter indicates continentality/temperature: c = cold; k = cool; m = maritime; s = submaritime; v = very cold (Banner *et al.* 1993). The digit indicates the variant, and a letter after a digit indicates a phase (Banner *et al.* 1993).

Several factors were considered in determining the sample size. The overriding factors were constraints on time and budget. Within those constraints, the sample size should be large enough to ensure sampling of all site series that occupied at least 1% of the total area. The sample size should also be large enough so that the survey objectives of determining site series proportions to ± 0.02 were met.

The probability (P) that a site series is contained in at least one sample plot is:

$$P = 1 - (1 - p_i)^n \qquad [1]$$

where: p_i = the probability that site series i is contained in a sample plot, and n = the sample size.

In general, p_i depends on the spatial configuration of the site series, the total area occupied by the site series, and the size and shape of the sample plots. A conservative estimate of p_i was obtained by assuming that it is proportional to the area covered by the site series.

Figure 2 shows the selection probability as a function of the percent area of site series and sample size. Most site series occupying 1% or more of the region should be sampled with a sample size of 500 plots.

The minimum sample size (n) needed to meet a specified level of precision in the estimated site series proportions is approximately:

$$n \approx \frac{t^2_{1-\alpha/2,\, n-1} \times \sigma^2}{E^2} \qquad [2]$$

where: $t_{1-\alpha/2,\, n-1}$ = the $(1 - \alpha/2) \times 100$ percentile of Student's t distribution with $n - 1$ degrees of freedom; s = the standard deviation of the estimated proportion of the site series in the management unit; and E = the maximum acceptable error margin when the confidence level is $(1 - \alpha) \times 100\%$.

We set E at 0.02 (i.e., ± 2%) at the outset of the project and estimated that the most common site series

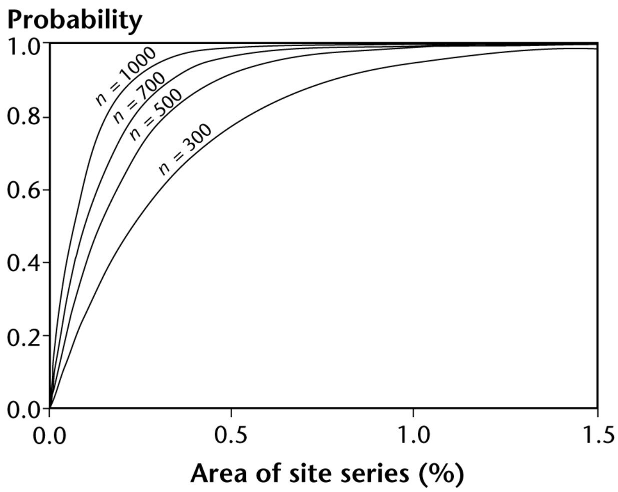

FIGURE 2. Probability that a site series is contained in at least one plot as a function of percent area of site series and sample size.

occupies 10% of the region ($p_i = 0.10$). Based on data from an audit of the forest inventory, the variance was estimated to be 0.06. This gave an approximate sample size of 575 plots. Site series that occupied less area had smaller variances and hence required a smaller sample size to achieve the desired accuracy.

Classifying ecosystems within the BEC system involved establishing a plot and describing the physiography, identifying pertinent ground vegetation, and digging a soil pit to describe the soil profile (Banner *et al.* 1993). Some of these activities can only be done when all of the ground vegetation is present. Therefore, ecosystem classification is restricted to approximately four months of the year. Based on the above sample-size calculations, we decided that 500 plots was an adequate compromise between meeting the project objectives and the constraints of time and funds. This gave an estimated maximum error (E) of 0.0215, which was close to the target error.

Field Sampling

Five hundred random points (plot centres) on the 100 × 100-m grid were selected without replacement within the Bulkley TSA. Each plot centre was located on a forest cover map and on an aerial photograph. Plots clearly landing on landforms, such as glaciers, rocks, or water, were classified from the photographs. In most cases, positive classification from photos and maps was not achievable because ground-based information such as vegetation and soils was required, and because of the uncertainty of locating the plot centres on maps and photographs. All plots that could not be positively classified from the photographs were visited in the field.

Plot centres were accurately located from known tie points. An 11.28 m radius plot (0.04 ha) was established at each plot centre. The plots were ecologically assessed by classifying and mapping each site series in the plot (Luttmerding *et al.* 1990 describes ecosystem classification). The site series mapping was later used to estimate the area of each site series in a plot. Plots that had dangerous access were classified to the predominant site series from helicopters.

Statistical Analyses

The estimated proportion of each site series in the TSA ($\hat{p}_i$) was determined as:

$$\hat{p}_i = \frac{1}{n} \times \sum_{j=1}^{n} p_{i,j} \qquad [3]$$

where: n = the number of plots (500 in this study), and $p_{i,j}$ = the proportion of plot j that overlaps site series i. The standard error (SE) of $\hat{p}_i$ is:

$$SE(\hat{p}_i) = \frac{\hat{\sigma}_i}{\sqrt{n}} \qquad [4]$$

where: $\hat{\sigma}_i$ = the sample standard deviation of $p_{i,j}$

$$\hat{\sigma}_i = \sqrt{\frac{\sum_{j=1}^{n} (p_{i,j} - \hat{p}_i)^2}{n-1}} \qquad [5]$$

Results

Tables 2, 3, and 4 present the proportional contributions of the site series, along with standard errors for some biogeoclimatic zones, subzones, and variants, and site series in the Bulkley TSA. These results are not spatial. We estimated how much area was occupied by each site series, but we did not know where it was. Therefore, we needed a procedure to integrate the site series information with the inventory information.

Application in a Timber Supply Analysis

Inventory-based Method for Creating Analysis Units

Forest inventory data were used to form analysis units by grouping stands based on species composition, age, and site index. Each analysis unit was assigned its own timber volume projection (yield table). Table 5 shows only the analysis units needed to demonstrate our procedure.

TABLE 2. Site series proportional breakdown of the Englemann Spruce–Subalpine Fir zone in the Bulkley TSA. See Table 1 for an explanation of the subzone and variant abbreviations.

		Proportion				Proportion	
Subzone/Variant	**Site series**	**Area**	**SE**	**Subzone/Variant**	**Site series** [a]	**Area**	**SE**
ESSFmc	01	0.1074	0.0132	ESSFmc	31	0.0094	0.0040
	02	0.0028	0.0021		51	0.0080	0.0040
	03	0.0114	0.0044		CA	0.0002	0.0002
	04	0.0261	0.0070		OR	0.0020	0.0020
	05	0.0064	0.0031		SK	0.0017	0.0017
	06	0.0409	0.0083		SL	0.0016	0.0016
	07	0.0100	0.0045		TA	0.0020	0.0020
	08	0.0295	0.0069		W	0.0001	0.0001
	09	0.0034	0.0024		WT	0.0013	0.0013
	10	0.0078	0.0032	***ESSFmc total***		***0.2720***	***0.0185***

[a] Indicates a site series that is not considered to be in the timber harvesting land base (31 = non-forested wetland; 51 = avalanche track; CA = meadow; OR = open range; SK = krummholz; SL = avalanche track; TA = talus slope; W = willow fen; WT = water). Character codes are not recognized site series and were chosen by the field crew. We are reporting the data as collected. Since these areas are not forested, they do not contribute to the timber supply and are not important to this research.

TABLE 3. Site series proportional breakdown of the Interior Cedar–Hemlock zone in the Bulkley TSA. See Table 1 for an explanation of the subzone and variant abbreviations.

		Proportion				Proportion	
Subzone/Variant	**Site series**	**Area**	**SE**	**Subzone/Variant**	**Site series** [a]	**Area**	**SE**
ICHmc1	01	0.0118	0.0047	ICHmc2	01	0.0078	0.0037
	03	0.0094	0.0042		03	0.0108	0.0044
	04	0.0042	0.0028		04	0.0072	0.0034
	06	0.0006	0.0006		05	0.0024	0.0020
	31[a]	0.0020	0.0020		07	0.0018	0.0013
ICHmc1 total		***0.0280***	***0.0071***		08	0.0001	0.0001
ICHmc1a	01	0.0020	0.0020		31[a]	0.0012	0.0012
ICHmc1a total		***0.0020***	***0.0020***		32[a]	0.0007	0.0007
					53	0.0020	0.0020
				ICHmc2 total		***0.0340***	***0.0074***

[a] Indicates a site series that is not considered to be in the timber harvesting land base (31/32 = non-forested fens, marshes, and bogs).

TABLE 4. Site series proportional breakdown of the Sub-Boreal Spruce zone in the Bulkley TSA. See Table 1 for an explanation of the subzone and variant abbreviations.

Subzone/Variant	Site series	Proportion Area	SE	Subzone/Variant	Site series [a]	Proportion Area	SE
SBSdk	01	0.0294	0.0074	SBSmc2	07	0.0101	0.0045
	06	0.0150	0.0052		08	0.0005	0.0005
	07	0.0041	0.0028		09	0.0273	0.0068
	32[a]	0.0040	0.0028		10	0.0281	0.0061
	CF[a]	0.0220	0.0066		12	0.0100	0.0045
	GP[a]	0.0015	0.0015		31[a]	0.0020	0.0020
SBSdk total		***0.0760***	***0.0116***		LP[a]	0.0010	0.0010
SBSmc2	01	0.1397	0.0145		OR[a]	0.0020	0.0020
	02	0.0052	0.0031		R[a]	0.0003	0.0003
	03	0.0037	0.0026		Rd[a]	0.0029	0.0014
	05	0.0331	0.0076		W[a]	0.0004	0.0003
	06	0.0418	0.0081	***SBSmc2 total***		***0.3080***	***0.0185***

[a] Indicates a site series that is not considered to be in the timber harvesting land base (31/32 = non-forested fens and marshes; CF = cultivated field; GP = gravel pit; LP = landing pile; OR = open range; R = rock; Rd = road; W = willow fen). Character codes are not recognized site series and were chosen by the field crew. We are reporting the data as collected. Since these areas are not forested, they do not contribute to the timber supply and are not important to this research.

Ecologically Based Method for Creating Analysis Units

The ecologically based analysis units were first formed by grouping sites with the same site series and anticipated regenerated species. Site series form logical analysis units because they can be used to estimate site index through the site series–site index relationship. As well, site series information is integral to elements in silviculture prescriptions such as species selection and other forest management practices (Government of Canada and Province of British Columbia 1993). Site series-based analysis units with similar productivity were grouped to reduce the number of analysis units that need to be managed in the timber supply model. An area-weighted site index was assigned to the analysis unit. The weights were obtained from the site series sampling.

TABLE 5. Partial list of analysis units in the Bulkley TSA

Analysis unit	Site index range (m @ bha 50)	Analysis unit no.	Age (years)	Area (ha)
Spruce-good site-thrifty	≥ 16	111	41–140	6 131
Spruce-good site-old	≥ 16	112	> 140	10 264
Spruce-good site-managed	≥ 16	113	< 41	3 864
Total area				*20 259*

Integrating Ecologically Based Analysis Units with Inventory-based Analysis

Without site series mapping, we did not know the site series classification of the timber harvesting land base. Therefore, we designed an algorithm to make the transition from inventory-based analysis units to ecologically based analysis units. The two different types of analysis units were integrated by assuming that the distribution of site series in the inventory-based analysis units was the same as the distribution of site series in the sample. As an area is harvested from an inventory-based analysis unit, it is partitioned according to the sample distribution of site series and assigned to the associated ecologically based analysis units. Although our assumption about the distribution of site series contains errors, once all inventory-based analysis units have been depleted then the proportion of land in each site series will be accurate, at least within the bounds of the limits set by the site series sampling. Once the site was transferred to the ecologically based analysis unit, it remained there for future rotations in the timber supply analysis. The details of this procedure are best explained with an example.

Table 6 shows how the current spruce-good analysis units (AU numbers 111, 112 and 113) were transferred to ecologically based analysis units after harvesting. In the Bulkley TSA, 60% of spruce-leading sites were regenerated to spruce (*Picea* spp.) and 40% to pine (*Pinus* spp.). The inventory information included approximate BEC subzone and variant information, and showed that the SBSmc2 variant comprised 73% of the inventory-based spruce-good analysis units. Our site series data indicated that 47% of the SBSmc2 variant in the timber harvesting land base could be classified as site series 01, 2% as site series 02, and 1% as site series 03.

TABLE 6. Old analysis units (AU) and corresponding new analysis units. See Table 1 for an explanation of the subzone and variant abbreviations.

Existing AU	Subzones in existing AU (%)	Site series in subzone (%)	Regeneration Species[a]	Regeneration %	Site index (m)	New AU	Percent of old AU in new AU
111, 112, 113	SBSmc2 (73%)	01, 02, 03 (50%)	Sx	60	18	702	21.9
			Pl	40	18	802	14.6
		05 (11%)	Sx	60	21	701	4.8
			Pl	40	19	802	3.2
		06 (14%)	Sx	60	19	702	6.1
			Pl	40	19	802	4.1
		07, 08, 09 (12.5%)	Sx	60	21	701	5.5
			Pl	40	21	801	3.7
		10, 12 (12.5%)	Sx	60	19	702	5.5
			Pl	40	21	801	3.7
	SBSdk (8%)	01 (61%)	Sx	60	18	702	2.9
			Pl	40	18	802	2.0
		06, 07 (39%)	Sx	60	21	701	1.9
			Pl	40	21	801	1.2
	ICHmc1/1a/2 (10%)	01 (36%)	Sx	60	21	701	2.2
			Pl	40	21	801	1.4
		03 (34%)	Sx	60	21	701	2.0
			Pl	40	21	801	1.4
		04 (19%)	Sx	60	24	700	1.1
			Pl	40	24	800	0.8
		05, 06, 07, 08, 53 (11%)	Sx	60	21	701	0.7
			Pl	40	21	801	0.4
	ESSFmc (9%)	01 (44%)	Sx	60	12	704	2.4
			Pl	40	12	804	1.6
		02, 03, 04 (17%)	Sx	60	9	705	0.9
			Pl	40	9	805	0.6
		05, 06, 07 (23%)	Sx	60	15	703	1.2
			Pl	40	15	803	0.8
		08, 09, 10 (16%)	Sx	100	9	705	1.4

[a] Sx = spruce spp.; Pl = pine spp.

These percentages were derived from the data in Tables 2, 3, and 4. To avoid a large computational burden and to reflect operational reality, these three site series were treated as one group comprising 50% of the SBSmc2 variant. Since 60% of that group will be planted to spruce, this newly regenerated spruce unit (AU 702) will comprise 21.9% (60% × 50% × 73%) of the current spruce-good analysis unit, which is approximately 4 440 ha; that is, for each 100 ha harvested from the spruce-good analysis units, 21.9 ha went into analysis unit 702, and the remainder into other analysis units as per Table 6. This process was repeated for all analysis units. The ecologically based analysis units eventually replaced the inventory-based analysis units as the timber supply modelling procedure progressed.

Timber Supply Projections

Using the site indices derived from inventory data, the area-weighted site index for the timber harvesting land base of the Bulkley TSA was 13 m at a breast height age of 50 years. After applying the site series proportions and estimates of site indices based on site series, the area-weighted site index of the timber harvesting land base increased to 15.6 m.

Figure 3 shows a comparison between the projections of timber supply using inventory-based and ecologically based site indices. In the inventory-based timber supply projection, the site indices for both existing and future regenerated stands were obtained from inventory data. Using the ecologically derived site indices, the long-term timber supply projection was 26.4% higher than that obtained using inventory-based site indices.

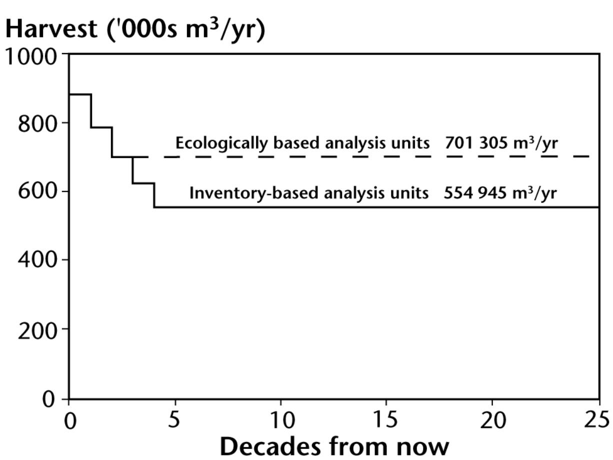

FIGURE 3. Long-term timber supply projections based on inventory-based analysis units and ecologically based analysis units.

Discussion

Site indices that are underestimated result in timber supply projections that do not fully represent the potential of the land base. Consequently, the AAC may be set lower than it needs to be, leading to lost economic opportunities. This paper presents a mid-term solution that overcomes the lack of site series mapping. The results clearly have an effect on timber supply due mainly to using better site indices, not necessarily from the method of application.

Some of the advantages of our method of linking ecologically based site indices to timber supply analysis units are:

- Errors in the inventory data are not carried through the whole timber supply analysis. For example, errors in species composition were eliminated after a stand was initially harvested in the timber supply model. Errors in species classification can lead to biases because the wrong species-specific site index curves and yield tables are used. As well, if species-specific site index adjustment equations are applied, the wrong equation will be selected.
- Since management activities are increasingly related to site series, ecologically based analysis units more closely represent what is actually happening in the forest.
- The site series information has other uses besides yield table generation in timber supply analyses. Data from the randomly located plots can be used to validate terrestrial or predictive ecosystem mapping (B.C. Ministry of Forests 2001). The data may also be used in wildlife habitat capability and suitability ratings, which are based on ecosystem classification (B.C. Ministry of Sustainable Resource Management 2001).

Some of the disadvantages of our method of linking ecologically based site indices to analysis units are:

- Errors in ecosystem classification occur, such as misclassifying site series, that are then carried throughout the procedure.

Site indices that are underestimated result in timber supply projections that do not fully represent the potential of the land base.

- Unlike site series mapping, which is spatial, sampling for site series is non-spatial. Therefore, we know the proportion of the land base that is in each site series, but we do not know the site series locations. Knowing the location of the site series would be useful for applications such as wildlife habitat supply modelling and spatial timber supply modelling.

Flexibility is possible in the sampling design and fieldwork. The number of samples can be adjusted to achieve any desired level of accuracy in site series proportions. The sampling also allows for site index data to be collected for site series and species that require better estimates of site index. The sampling frame can also be adjusted to accommodate different objectives. We elected to sample the whole land base and not just the timber harvesting land base because the timber harvesting land base may change from year to year as new information becomes available, or new harvesting technology opens up land that was previously inaccessible. For example, low productivity sites, as determined from inventory data, may be removed from the timber harvesting land base. After applying the results of this project, however, we may find that these sites have higher productivity than indicated by inventory data, and that they should be in the timber harvesting land base. This would likely be a large concern when considering repressed lodgepole pine (*Pinus contorta* var. *latifolia*) (Goudie 1996) in British Columbia.

One application of this project is in determining the AAC. The Chief Forester of British Columbia considers all information presented to him in these determinations. The extent to which the information is used and the weight that is placed on the information depends on many factors, in particular the quality of the data and whether it is the best available information. The results of this pilot study were presented in the determination of the AAC for the Bulkley TSA (B.C. Ministry of Forests 2002b). The theoretical underpinnings of this project were regarded as sound; however, the reliability of the ecologically based site indices was questioned, resulting in this information being used for sensitivity analysis rather than for base case analysis. Since then, the database relating site series to site index has been greatly improved (Mah and Nigh 2003) and it is reasonable to assume that this information could now be used for a base case analysis.

A new method of assigning site index to forest stands for timber supply analyses was developed that avoids problems with biased site indices from inventory data.

Conclusions

A new method of assigning site index to forest stands for timber supply analyses was developed that avoids problems with biased site indices from inventory data. This method involved creating ecologically based analysis units from ground-sampled ecosystem data. Site index–site series relationships were used in conjunction with ecosystem-based management practices to link ecosystem type to yield tables. In the test area, this resulted in a 26% increase in long-term sustained yield, due mainly to better site index information.

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Test Your Knowledge . . .

Linking ecologically based productivity information to timber supply analysis units using site series sampling

How well can you recall some of the main messages in the preceding research report? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. Site indices that are underestimated result in timber supply projections that do not fully represent the potential of the land base:
   A) True
   B) False

2. Using the ecologically derived site indices, the long-term timber supply projection for the Bulkley TSA was *x*% higher than that obtained using inventory-based site indices, where *x* is:
   A) 4.8%
   B) 13.7%
   C) 26.4%
   D) 35.3%

3. The advantages of this method of linking ecologically based site indices to timber supply analysis units are:
   A) Errors in inventory data are not carried through the whole timber supply; location and proportion of site series on the land base is known; site series information has other uses besides yield table generation in timber supply analysis
   B) Misclassified site series as a result of ecosystem classification errors are not carried throughout the procedure; ecologically based analysis units more closely represent what is actually happening in the forest; site series information has other uses besides yield table generation in timber supply analysis.
   C) Errors in inventory data are not carried through the whole timber supply; ecologically based analysis units more closely represent what is actually happening in the forest; site series information has other uses besides yield table generation in timber supply analysis.
   D) Errors in inventory data are carried through the whole timber supply; ecologically based analysis units less closely represent what is actually happening in the forest; site series information can be used in applications such as wildlife habitat supply modelling and spatial timber supply modelling.

ANSWERS

1. A 2. C 3. C