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Partially Cut: Occupied or Not?

What are my options? – A proposed survey approach

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Site Occupancy, options? A plot by plot approach

The intent of this approach is to assess site occupancy in areas that have been partially harvested with a remaining heterogeneous stand structure, such as in areas where lodgepole pine has been harvested from the stand for Mountain Pine Beetle (MPB) salvage[1]. Plots would be located within similar strata using a grid approach at one plot per ha.

The intent is to identify options to increase site occupancy, and hence volume growth within the stand.

The present survey system(s) has provided a range of results in stands with varied structure. Often the results were seen as lacking an accurate description of the stand structure and opportunities for additional stocking and future volume production. The present system(s) uses plot averaging which dilutes the potential for interpretation and recommendations.

Some features desired in a new system

A new system needs to be biologically based and allow for inexpensive assessments of areas with complex stocking. It needs to allow for easy interpretation and subsequent treatment recommendations. It can be used in conjunction with additional information assessments to provide the complete suite of information needs for an area.

Biological concepts relating to the approach:

- Each site has a relatively stable carrying capacity for site occupancy.
- The site can be considered fully occupied over a range of densities. There is a wide range of stand density (basal area BA, stems per ha, or volume per ha) in which stand growth is at its maximum. Density is a quantitative measure of site occupation. Common units of measure include: BA per ha, stems per ha or an expression of the number of trees and their size, such as stand density indices.
- Larger trees take up more space than smaller trees; therefore fewer larger trees are needed to occupy the same space than occupied by smaller trees.

  As well, a stand can carry more basal area with larger diameter stems than with smaller stems. Therefore a stand of 25 m^2/ha of BA per ha may be fully occupied with an average stand diameter of 15 cm and be less than fully occupied if the average stand diameter is 40 cm.

How does this work?

By doubling the diameter of a tree, the basal area of that tree increases by four times, but the space the tree needs for full growth potential only increases by

[1] For a simpler approach, planning to identify retention in groups or clumps allows for the use of traditional even aged assessment methodologies. Where this is not feasible we recommend using the approach described in this document.

about three times (Gingrich 1967). Therefore as the stand quadratic mean diameter increases, the basal area of a stand must also increase to maintain the same level of stocking.

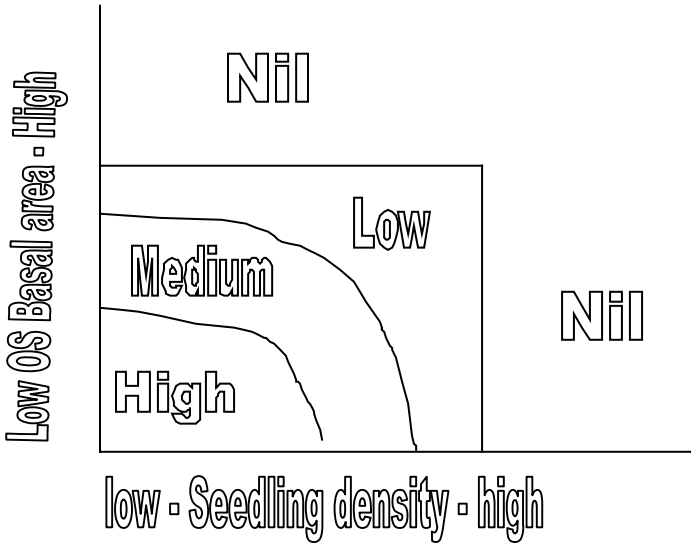
- Larger trees can reduce the potential growth of smaller trees when growing together if they out-compete them for light (O'Hara 1998) (i.e., shade the smaller tree) and or moisture and nutrients (e.g., the smaller tree is within the drip line of the overstory tree or subject to root competition). O'Hara et al. (2001) show a direct link between overstory Leaf Area Index (LAI) and understory growth potential, where understory growth increment increases as overstory LAI decreases. At 20 % of overstory LAI understory production of Scots Pine and Norway spruce exceed overstory production.

Interaction of overstorey and understorey trees.

There is a site occupancy relationship between overstory basal area and understorey seedling density. Trees in the overstorey can affect the growing conditions for trees below. Consideration of overstory tree size, density and distribution will impact the potential requirement for understory stems to achieve full growth potential.

The figure below illustrates the approach that we recommend for assessing site occupancy, and with that opportunities or requirements for additional regeneration, at a single sample point in a partially cut stand (not the situation averaged across a block).

Opportunity for additional stems to create full site occupancy



At a sample point, if seedling density is low and overstory basal area is low, then there is a **high** opportunity to add to the future volume growth of the stand by adding-in extra trees at this place (assuming ground conditions permit this). Or, to state this idea another way, at this sample point, the sparse understory will result in considerably less understory volume production than could be achieved with higher understory stocking. At a second sample point in the stand where overstory basal area is high, there may be no opportunity to add to future stand volume growth by increasing understory tree density. At a third point, with medium overstory basal area, the potential for understory trees to contribute to volume production may be reduced because there is reduced growing space available to them. Even if seedling density is low, there is only a medium opportunity to add to volume production by beefing-up understory tree density.

This is a somewhat simplified approach, factors that may complicate the relationship are:

- Vigour of the overstory trees and their potential for growth. You could have a high BA of overstory trees that are nearly dead , resulting in a high opportunity for increased site occupancy.
- The silvics of the understory species may or may not lend themselves to survival or growth in various overstory conditions. Shade intolerant species may be found in relatively high densities under medium overstory densities and not be utilizing the site occupancy effectively.
- Whether or not the overstory BA is patchy or uniform. Patchy overstories may result in skewed results, however the plot-by-plot approach should be able to limit this factor.
- The size of the overstory trees will influence the amount of growing space available (as Gingrich described). Where the BA is made up of larger stems, the value of high can be higher along the Y-axis to allow for more understory stems.

Martin et al. (2003) propose that the preceding conceptual (qualitative) relationship of "opportunity" to overstory basal area and understory tree density can be developed into a specific (quantitative) relationship by combining three fundamental tree and stand growth relationships:

1. The relationship between overstory basal area and understory light. Increasing overstory basal area reduces light to the understory (Figure 2).
2. The relationship between understory light and seedling growth. Reducing understory light reduces seedling growth (Figure 3).
3. The relationship between volume growth and seedling density. Volume/ha growth increases and then plateaus as seedling density increases. We can obtain this for the no overstory state from TIPSY (Figure 4).

Once combined, the potential to add to future understory volume by increasing understory density can be estimated from overstory basal area and understory tree density (Table 1). For example, if a regeneration plot contains four acceptable trees at a sample point with no overstory, Table 1 suggests the understory will yield 14% less volume than it could with optimal stocking. With nine or ten trees in the regeneration plot at this location, a 14% improvement in understory production can be expected.

Table 1. Relative volume loss based on understory (US) seedling density and overstory (OS) basal area. This is the yield relationship that is at the core of the new stocking assessment approach. From Martin et al. (2003) – First Approximation.

US tree density (# per 0.005 ha plot)	Overstory basal area (m2/ha)						
	0	5	10	15	20	25	30
0	1.00	0.77	0.53	0.34	0.22	0.14	0.09
1	0.64	0.49	0.34	0.22	0.14	0.09	0.06
2	0.39	0.30	0.21	0.13	0.09	0.05	0.03
3	0.23	0.18	0.12	0.08	0.05	0.03	0.02
4	0.14	0.11	0.07	0.05	0.03	0.02	0.01
5	0.08	0.06	0.04	0.03	0.02	0.01	0.01
6	0.05	0.03	0.02	0.02	0.01	0.01	0.00
7	0.02	0.02	0.01	0.01	0.01	0.00	0.00
8	0.01	0.01	0.01	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Site occupancy approach – examples

The approach that is suggested uses the concepts identified above and is meant to provide a simple to use and calibrate approach to determine options to increase site occupancy and subsequent stand growth. We present the simplest version that will help the manager decide on whether added stocking is an option or desirable.

As well the simplified approach is discussed in relation to three other potential approaches.

NOTE: If additional information such as an inventory or silviculture label or links to growth and yield models is desired, additional information would be required and may be done on a subset of the plots.

Creating the appropriate table:

The intent is to choose categories of additional potential growth using the two variables, overstory BA and sph in the understory.

In column one the BA is distributed from 0 to High – where high must be quantified for the area you are assessing. Day (2002) used 60% of the original BA to fit beneath the code requirement for reforestation obligations.

	sph					
BA	Low					High
High						
0						

Depending upon the growth potential of the site this value will change. For our example here we will use 30 m^2 (60% of original BA of 50 m^2) - as the top value with 5 m^2 intervals (this allows for use of a BAF 5 prism).

The stems per ha go from 0 to 1200 in increments of 200 to allow for counting of individuals within a 3.99 m radius plot (1/200 of a ha).

	sph						
BA	0	200	400	600	800	1000	1200
30							
25							
20							
15							
10							
5							
0							

This matrix allows for the ranking of opportunities - obviously at 1200 sph the area has exceeded the minimum stocking requirement and is likely at the even-aged target stocking, so there is no legal obligation to add stems. There may be some potential growth gains, but no legal requirement.

Using Table 1 above (extracted from Martin et al. (2003)) we can populate the table by making some informed assumptions. The combinations of overstory BA and SPH that provide an opportunity for a 0-15% gain in understory growth through added regeneration are given a *Low* rating for additional growth. Those combinations with an opportunity for a 15-35% growth gain are put into the *Medium* Category, while those with a > 35% additional growth opportunity are put in the *High* Opportunity Category.

Table 1 – using the above values to rank the opportunities.

	sph						
BA	0	200	400	600	800	1000	1200
30	9	6	3	2	1	1	0
25	14	9	5	3	2	1	1
20	22	14	9	5	3	2	1
15	34	22	13	8	5	3	2
10	53	34	21	12	7	4	2
5	77	49	30	18	11	6	3
0	100	64	39	23	14	8	5

This table was created using an iterative approach, whereby plot data were collected and placed within the matrix. The break points for the categories were chosen based on field notes on what level of opportunity was found at each point. The break points should be calibrated as such for each distinct combination of site and stand conditions where this procedure is to be used.

Tables such as this could then be made part of the Forest Stewardship Plan as a tool to:

1. Set stocking standards for partially harvested heterogeneous stands;
2. Assess reforestation achievement relative to the standard; and
3. Measure opportunities to increase site occupancy for suitable harvesting activities. A general set of rules should be provided, such as: if greater than some proportion of the block has a high opportunity, the block is not considered stocked and requires treatment.

Stand scenario:

A mixed Fd/Pl stand is harvested to remove pine from an area of mountain pine beetle attack. The area is mainly open with patches of totally intact timber and pockets of tree clumps. It has come back to Pl naturally. The total area is large and has not been stratified to describe the various residual stand structures (this is only one scenario, another is that the area is stratified using air photos and the open areas are surveyed using even aged standards, with the partially cut areas assessed using the opportunity approach and the unharvested left un-assessed).

For sampling create a grid over the strata with one plot per ha.

At each point, you tally:

- The number of suitable stems within a 3.99 m radius plot. Transform that number to SPH.
- (multiply counted stems in the plot by 200) and record for that plot.
    - The definition of a suitable understory stem should be similar to that of a well spaced preferred or acceptable species.
    - Counted stems are below 12.5 cm DBH.

- The number of unsuitable stems within the 3.99 m radius plot. This is to help gauge total density and help with treatment options.
- The residual basal area at the point center using a prism. Multiply the number of suitable overstory trees in with the prism by the BAF of the prism.
    - The definition of a suitable overstory stem should include:
        - % live crown of greater than 15%,
        - Height to diameter ratio of less than 100.
        - The reason for a suitable overstory definition is that non-suitable or nearly dead trees should not pose a significant competitive threat.
        - Ignore unsuitable overstory trees, except to describe and locate danger trees when encountered.

Plot 1 – found in an open area with two larger trees near the point center.

Using a 5 BAF prism a RBA of $10m^2$ was found by swinging the prism at point center. At the same plot 6 suitable seedlings were counted within a 3.99 m radius plot (1200 sph). There is a low opportunity for additional stems at this point.

	sph						
BA	0	200	400	600	800	1000	1200
30	9	6	3	2	1	1	0
25	14	9	5	3	2	1	1
20	22	14	9	5	3	2	1
15	34	22	13	8	5	3	2
10	53	34	21	12	7	4	2
5	77	49	30	18	11	6	3
0	100	64	39	23	14	8	5

High opportunity		Growth Opportunity > 35%
Medium opportunity		Growth Opportunity > 15 - 35%
Low opportunity		Growth Opportunity < 15%

Plot 8 – is in a small clump of overstory trees (3 in all).

In this case three trees were 'in' giving us 15 m^2 along with 1 suitable stem found within the 3.99 plot (200 sph). This translates to a Medium opportunity.

	sph						
BA	0	200	400	600	800	1000	1200
30	9	6	3	2	1	1	0
25	14	9	5	3	2	1	1
20	22	14	9	5	3	2	1
15	34	22	13	8	5	3	2
10	53	34	21	12	7	4	2
5	77	49	30	18	11	6	3
0	100	64	39	23	14	8	5

Once the all plots have been tallied a summary of the plot information is created and recommendations provided.

While the person is collecting this information, they should also keep notes on why specific numbers appear, such as plot in intact forest, plot is heavily disturbed or is within a high slash load that is rare on the block. These types of comments will help define treatment options if any.

Sample data

			Opportunity				
Plot #	BA at sample point (m2/ha)	SPH	Low	Med	High	Vol Growth Opp Total %	Rating using Growth ops
1	10	1200	1			2	Low
2	5	1400	1			2	Low
3	10	1000	1			4	Low
4	50	0	1			0	Low
5	0	1600	1			1	Low
6	0	1400	1			2	Low
7	25	1200	1			1	Low
8	15	200		1		22	Med
9	60	0	1			0	Low
10	0	1200	1			5	Low
11	5	1800	1			0	Low
12	10	0			1	53	High
13	0	1400	1			2	Low
14	10	1000	1			4	Low
15	5	1200	1			3	Low
16	30	0	1			9	Low
17	0	800	1			14	Low
18	0	1400	1			2	Low
19	15	1800	1			0	Low
20	0	1200	1			5	Low
			18	1	1	6.24 - Avg	Low
			90%	5%	5%		

The decision whether to treat (plant, site prep and plant or create a more suitable seedbed) or not is up to the prescription maker. In this sample block 5% of the area has a Medium opportunity for additional stems, 5% with a High opportunity. The average amount of increased understory growth that would be possible with ideal stocking, based on the Martin et al. (2003) table, is 6.24%.

With this information in hand options can be assessed and an approach identified, it may be to fill plant, it may be to do nothing and wait for additional infill, it may be to further harvest the stand and provide more open areas for additional regeneration. Growth projections may help with the solution along with operational feasibility considerations, i.e., can the gaps be found in the field.

This block is well stocked. The areas where there are opportunities are limited and not contiguous, making finding them difficult. A map showing the plot locations, and if desired, a ranking by plot can be used to help quantify the results.

There are spatial aggregating formulas that are available to help

If there were more open space (i.e., more High opportunity plots) this may have been a candidate as an overflow-planting block.

However, what if there is an abundant area in this category. Then you have to make a decision either to order trees and organize a planting contract or leave the area untreated (and perhaps accept a lower productivity). There is a need to think long term about these options.

If the pine left in the overstory is already old, then you are almost guaranteed that either it will die, or you will be back in the block trying to harvest it, especially in the larger patches, likely before the understory layer has developed to a merchantable size (now this will depend on species – likely not an issue with Douglas-fir). So now you need to consider if you will damage those underdeveloped understory clumps. If not, then there is a strong rationale to establish them now since they will provide for structural diversity while better utilizing the site over time. If there is a strong potential to damage them, why even worry about them now?

There is no easy answer from numbers alone. We must urge people to think till it hurts!

Tool not Solution

The approach is a tool, not a solution. The numbers used in the example are examples only, it is expected that local numbers would be created using local situations and the understanding of site occupancy over the range of stand types and site productivity.

Comparison with other approaches[2]:

Presently there are two main regeneration survey methods in place in B.C. The even-aged and multi story approaches. The even-aged approach uses the average of a minimum number of 3.99 m radius sample plots to identify whether a stratum meets or exceeds the minimum stocking standard. The system was designed to assess clearcut openings regenerated over a relatively short period of time. It has rules for counting stems based on tree suitability (preferred and acceptable designations), intertree distance, minimum height, height in relation to competing brush and health and damage criteria.

Calculation of Confidence Intervals for Even Aged Survey Results

						M = 6
Plot #	Tot conifers	Cw	Fd	Hw	FG	WS
1	6		6			6
2	7		7			6
3	5		5			5
4	0		0			0
5	8		8			6
6	7		7			6
7	6		6			6
8	1		1			1
9	0		0			0
10	6		6			6
11	9		9			6
12	0		0			0
13	7		5	2		6
14	5		5			5
15	6		6			6
16	0		0			0
17	2		2			2
18	7		7			6
19	9		9			6
20	6		6			6
Total	97		95	2		85
Average						4.25
Per ha					WSS/Ha	850

S =	2.573	
Sx	0.575	
T	1.729	
TSx	1.0	
CI90	199	
LCL	651	Less than MSSpa
		More plots would be needed
MSS	700	
Survey Result WSS	850	

[2] A recommendation is to use a comparison of the Site Occupancy Approach with the three systems compared here on sites where the traditional stocking assessment has not provided an acceptable outcome.

Using the sample data collected and presented for the Site Occupancy Approach, the block in question would require more plots to meet the required lower confidence interval with a minimum stocking standard of 700 with a target of 1200 (M value of 6).

We recommend that this approach be used as one of the testing approaches for comparing assessment methodologies on blocks that meet the heterogeneous post harvest stand structure from Pl removal.

A modification of this approach using lower stocking where an overstory is found has been suggested and a version of that approach is used by some in the USFS (Pers. Com. Carl Fiedler, University of Montana, April 2001). If a minimum stocking of 400 sph with a target of 800 and an M value of 4 is used, the block is considered stocked at 475 sph.

Calculation of Confidence Intervals for Even Aged Survey Results

Plot #	Tot conifers	Cw	Fd	Hw	Pw	FG	M = 4 WS
1	6		6				4
2	7		7				4
3	5		5				4
4	0		0				1
5	8		8				4
6	7		7				4
7	6		6				4
8	1		1				1
9	0		0				0
10	6		6				4
11	9		9				4
12	0		0				0
13	7		5	2			4
14	5		5				4
15	6		6				4
16	0		0				0
17	2		2				2
18	7		7				4
19	9		9				4
20	6		6				4
Total	97		95	2			60
Average							3
Per ha						WSS/ha	600

S =	1.622	
Sx	0.363	
T	1.729	
TSx	0.6	
CI90	125	
LCL	475	Above MSSpa
MSSpa	400	
WSSpa	600	Stocked

Using this approach and changing the Minimum and Target numbers has not been embraced by practitioners. It is not suited to sites with high levels of variability, as stats are difficult to meet and does not suitably describe where, if any, opportunities exist to enhance stocking. With this said, we recommend looking at this option to see what benefits modifying the present system might provide and what limitations it has, that can be used to create an alternative system.

The second main stocking assessment procedure used in B.C. is the Multi-Story Survey Procedures and Uneven-aged Stocking Guidelines. It too is based on sampling 3.99 m radius plots by counting stems in four categories based on size. The categories are Layer 1 - trees greater than 12.5 cm DBH, Layer 2 - trees between 7.5 cm and 12.4 cm DBH, Layer 3 - saplings greater than 1.3 m tall and less than 7.5 cm DBH, and Layer 4 - seedlings below 1.3 m and above a minimum countable height. The guidelines describe minimums and targets by layer. There are no statistics required for this approach (due to the high level of variability encountered).

It too has rules for counting stems based on tree suitability (preferred and acceptable designations), intertree distance for all but the largest category, health and damage criteria.

When the sample plot data were assessed using this approach the following was found:

Assessment using the Multi Storied Stocking Approach

Multiplier	200				M = 6
Plot	Layer 1	Layer 2	Layer 3	Layer 4	M
1	0			6	6
2	1			7	6
3	2			5	5
4	3			0	0
5	0			8	6
6	0			7	6
7	1			6	6
8	1			1	1
9	1	1	1	0	0
10	0			6	6
11	1			9	6
12	2			0	0
13	0			7	6
14	1			5	5
15	0			6	6
16	3			0	0
17	0			2	2
18	0			7	6
19	1			9	6
20	0			6	6
Total	17	1	1	97	85
Average	0.85	0.05	0.05	4.85	4.25
Per ha	170	10	10	970	850

TSS	600	800	1000	1200
MSSpa	300	400	500	700
MSSp	250	300	400	600

Stocked by layer four 850 > 700 MSSpa

The block would be considered as stocked in layer 4, not in any of the other layers. This approach was designed to provide some level of comfort that smaller stems were on site as future recruits for larger size classes in areas managed using single tree selection. The Pl removal blocks do not have a specific need for recruitment into different size classes, instead they will likely be managed using an even-aged approach, i.e., all stems will be available for harvest at the same time, therefore all stems are considered as potential future crop trees and do not have different standards attributed by layer.

A third approach as been suggested by Day (2003) for blocks at Gavin Lake whereby a proportion of the original basal area is used to classify whether the block is stocked when used in conjunction with the percentage of minimum and target stocking found on site.

When this approach was used with the sample data the following was found.

Gavin Lake Approach.

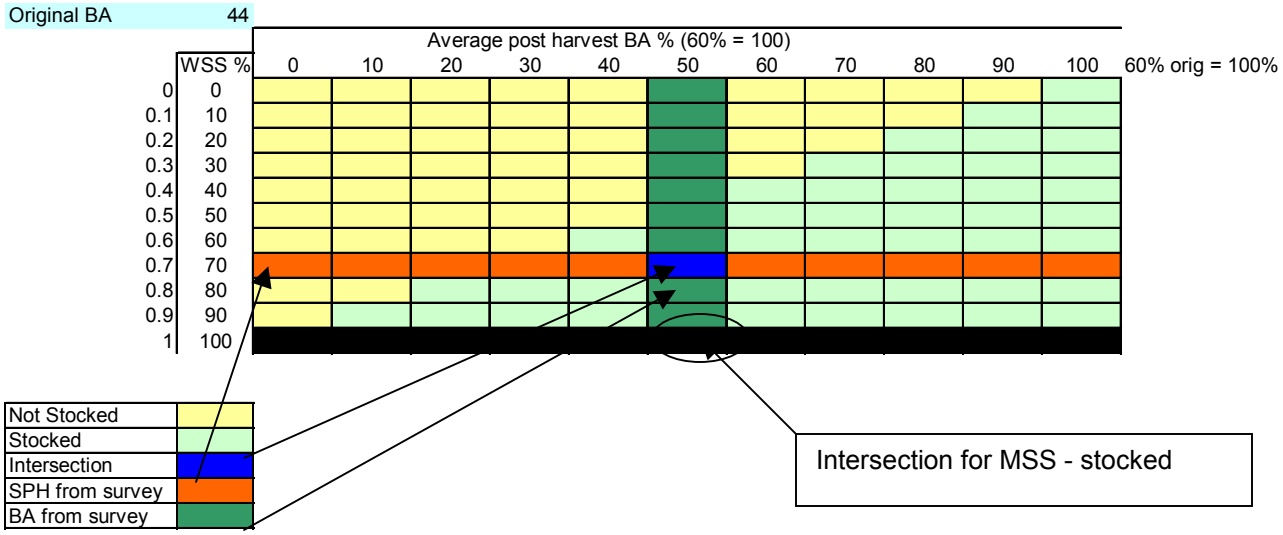
The assumptions - 60% of the original BA is stocked
Well spaced are counted by a percentage of MSSpa, MSSp, TSSpa

Original BA	44
60% of orig BA	26.4
Average RBA	12.5
Target sph	1200
MSSpa	700
MSSp	600

Calculation of post harvest stocking			Target		
BA	12.5	Div by	26.4	Equals	47%
SPH target	850	Div by	1200	Equals	71%
SPH MSSpa	850	Div by	700	Equals	121%
SPH MSSp	850	Div by	600	Equals	142%

Stocked at target

Table using the sample data using the Gavin Lake Approach.



The intersection of the data is at BA 50%, WSS 70% is which is within the stocked portion of the matrix. Shown as the intersection point in blue where the orange line at 70 % WSS (well spaced stocking) crosses the green column of 50% BA which is in the light green zone, indicating stocked conditions. The black bar on the bottom represents the survey met 100% of the Minimum Stocking Level.

Discussion:

The above approaches all describe stocking based on an average of all plots. This is in comparison to the plot-by-plot description of stocking or site occupancy using the Site Occupancy Approach. The result of the Site Occupancy Approach provides more of an overview of the block, not a blended version of the potentially high variability.

While the sample plot data used in this example showed the block to be stocked by the above approaches, it called for more plots using the even-aged approach with an M value of 6. By walking the block and putting in 20 samples it is clear that the block is close to full occupancy, and additional plots would not provide additional useful information.

A comparison of a range of structurally diverse blocks is needed to test the SOA system more thoroughly.

The advantage of the Site Occupancy Approach is its simplicity and ability to accommodate the different site requirements of overstory versus understory stems.

Scope and Limitations of the Report

The suggested system is based on preliminary model runs of understory opportunities. As well it has only been field tested at one site. It is meant to be calibrated for each area and limits for High, Medium and Low opportunity must be agreed on by knowledgeable practitioners. It therefore requires further field testing and assessment. We recommend

the new approach be used to compare results with the traditional survey methods on at least 5 blocks where the conventional survey results have not provided useful information.

Data on growth opportunities should be updated when new information becomes available.

Comparison of Desirable Features of a Stocking Assessment Procedure

Using Martin's (2003) list of desirable features for a system to assess stocking in partial cut stands we find the following (SOA – Site Occupancy Approach, EA – Even aged approach, UA – Uneven-aged approach, GL – Gavin Lake Approach):

Desirable Feature	Rating of the system for that feature
Robust where heterogeneous	SOA – Good Captures heterogeneity well – plot by plot presentation
	EA – Poor Needs many samples to meet stats
	UA – Moderate Workable but based on the premise of recruitment not even aged stocking.
	GL – Good Uses both overstory and understory as components of the stocking
Credible – based on best available knowledge	SOA – based on concepts of site occupancy based on size relationships and growth and yield projections
	EA – not sure of background
	UA – based on concepts relating to BDQ relationships for single tree selection – not created for even-aged management.
	GL – based on a translation of the Silviculture Regulations – no formal science
Regeneration focus	SOA – Yes
	EA – Yes
	UA – Yes
	GL – Yes
Silv System Neutral	SOA – Yes – has the ability to assess overstory and understory independently and together.
	EA - No based on even aged (clearcut) systems
	UA – No
	GL – Yes – has the ability to assess overstory and understory independently and together.

Desirable Feature	Rating of the system for that feature
Tools not rules	SOA – Can be tailor made to suit the situation – will need to field test
	EA – rule based
	UA – rule based
	GL – has some flexibility to create
Multi-purpose	SOA – Designed for single purpose, need to add on additional tasks for additional information, such as Inventory label.
	EA – Methodology requires multi-purpose data collection
	UA - Methodology requires multi-purpose data collection
	GL – Need to add on for additional info
Simple Field Procedures	SOA – very simple
	EA – commonly used and known, but not overly simple, requires familiarity with statistics.
	UA – some find it complex, summarizing the data may be time consuming.
	GL – relatively simple for data collection, summary is straightforward once calculations are done. Need to know preharvest BA.
Cheap sampling	SOA – cheap and quick
	EA – moderate
	UA – moderate to possibly expensive
	GL – similar to EA, moderate.
Comprehensive	SOA – No – needs add-ons to be comprehensive
	EA – Somewhat does not separate overstory and understory.
	UA – Yes – breaks out various layers, not overly descriptive for layer 1 trees.
	GL – Yes – can be very comprensive if a stand table is created with health and vigour categories.

Desirable Feature	Rating of the system for that feature
Current conditions	SOA – yes – once matrix is created will provide direction
	EA – Yes.
	UA – Yes
	GL – No – requires preharvest BA
Continuous – no jumps between classes	SOA – somewhat continuous, has breaks by sph and BA
	EA – No
	UA – No
	GL – as per SOA

The site occupancy approach uses the concept of a suitable stem, which would not be broken into preferred and acceptable. Instead the species that are suitable would be listed for the site and if the stems meet the suitability requirements they would be counted. To provide the required silviculture or inventory label additional data collection and summaries are required.

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Figures

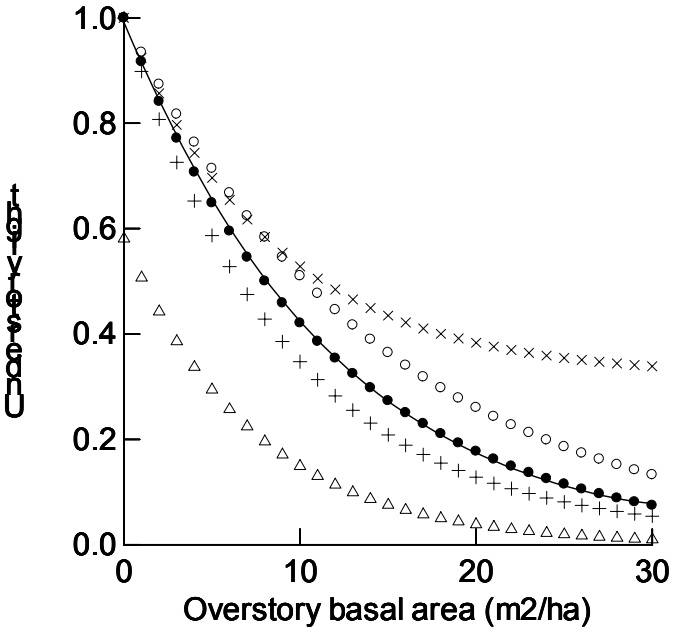

Figure 2. Relationships between overstory basal area and understory light for pine ('x', Puettmann n.d.), aspen (open circle, Comeau 2001), alder/birch (solid circle, Comeau 1998), maple/birch (cross, Puettmann n.d.); maple (triangle, Thomas and Comeau 1998). The Comeau 1998 relationship was selected for use in the stocking assessment system. From Martin et al. (2003).

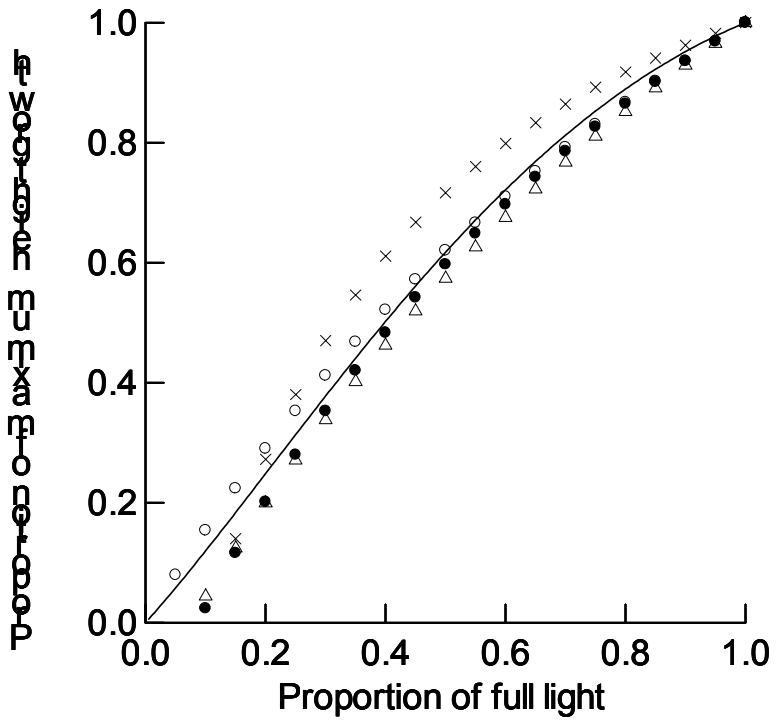

Figure 3. Understory light and seedling height growth relationships for Douglas-fir (open circle, Drever and Lertzman 2001), lodgepole pine (solid circle, Coates and Burton 1999), interior spruce (triangle, Coates and Burton 1999) and subalpine fir ('x', Coates and Burton 1999). Solid line is the relationship that is used in the stocking assessment system. From Martin et al. (2003).

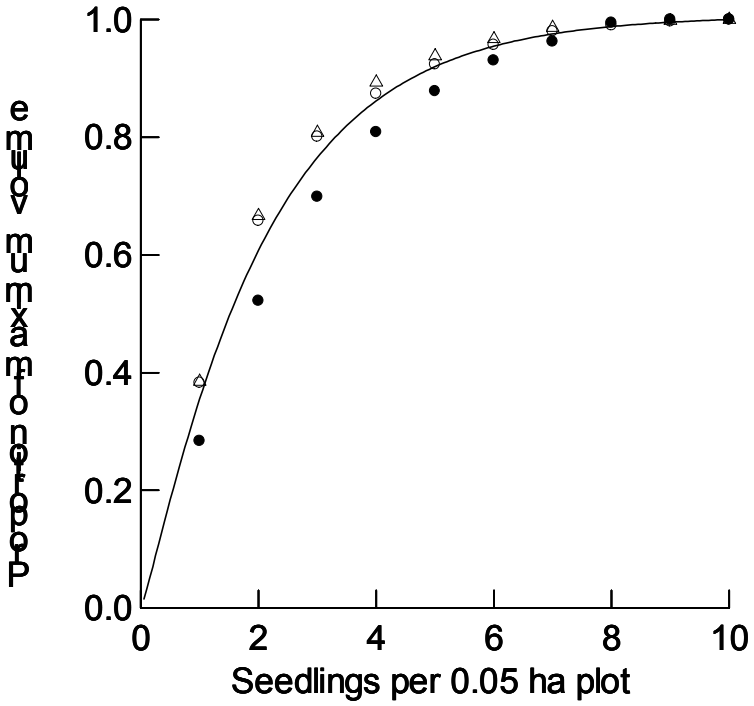

Figure 4. Seedling density and volume production relationships for plantation Douglas-fir on site index 19 m (open circle), lodgepole pine on site index 17 m (solid circle), and interior spruce on site index 21 m (triangle) predicted by the stand growth model TIPSY. Solid line is the relationship used in the stocking assessment system. From Martin et al. (2003).