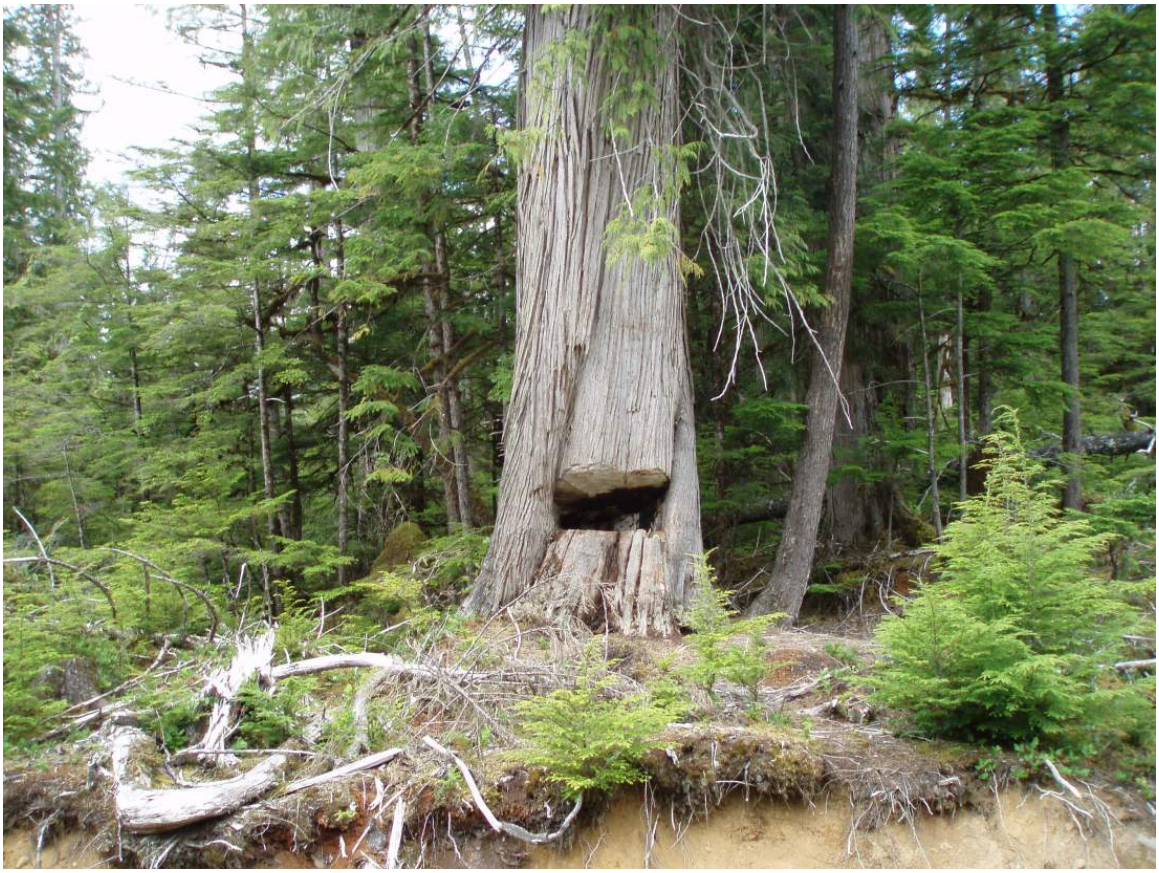
Western redcedar – issues for managing for desirable characteristics under retention of varying levels

Management to promote desired characteristics.



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Report for the Forest Practices Board

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Table of Contents

Western redcedar potential in dispersed retention of varying levels[1].

Management to promote desired characteristics.

Western redcedar has many desirable characteristics. To some extent forest management has the ability to promote densities and shade levels that can promote or detract from those desirable characteristics. The Forest Practices Board in a special investigation on partial harvesting on the BC Coast found relatively high levels of residual stocking and limited planting of redcedar over their study area (Forest Practices Board, 2007). The question of whether the approaches assessed were conducive to the promotion of desired characteristics was raised. What follows is a discussion of what constitutes desirable attributes of redcedar and what management practices and silvicultural regimes are suited to achieving those characteristics. As a byproduct, regimes or strategies that do not promote the desired characteristics will be identified as well.

What makes western cedar unique and in many cases valuable:

Durability and appearance

Western redcedar is often sought after for its excellent durability and aesthetic appearance. First Nations refer to it as the Tree of Life for the myriad of uses it provides.

Figure 1. Examples of the use of clear redcedar - Black Bear Mask[2] and a cedar lined sauna.

[1] This review can be considered as background material for discussion on the suitability of high levels of dispersed retention and the long term management of redcedar.

[2] http://www.hickerphoto.com/indian-masks-7780-pictures.htm - A black bear mask carved by Stan C Hunt on Northern Vancouver Island and on display at Just Art Gallery in Port McNeill.

Clark et al, (2004)[3] report the total export value of western red-cedar products in British Columbia is $750 million. Much of this value is based on its natural durability, which is not fully understood. Durability was originally found associated with old growth redcedar heartwood and was attributed to naturally-occurring fungitoxic compounds particularly ß- and γ-thujaplicin.

Durability of second growth wood is not well understood. Products from second growth when grown over the relatively short rotations as indicated in most Timber Supply Analyses (e.g., 80 to 120 years) may not allow the buildup of the fungitoxic compounds that provide the desired durability. Presently there are more than 12 million redcedar seedlings planted in BC every year, their resistance to heart rot and long term durability are not known (Clark et al 2004). Therefore even with active management the desired durability may not occur without extended rotations.

The aesthetic quality of redcedar is often derived from its reddish color, grain pattern and wood free from knots. Similar to the issues on durability second growth redcedar will often have reduced heartwood and have limited clear wood unless managed specifically to create these desired characteristics of grain and color.

Figure 2. Cedar bolts to be used for shingles or shakes. Note the retention of redcedar in the group behind. Second growth trees will not have the characteristics of these large old trees, no matter how they are grown, unless rotations are lengthened.

Growing redcedar

Western redcedar grows along the Pacific Coast from Northern California to Alaska. In British Columbia it grows mainly in the Interior Cedar Hemlock and Coastal Western Hemlock biogeoclimatic zones. It grows over a range of soil moisture and nutrient conditions. While it will grow on low moisture and nutrient sites, best growth is found on wetter and richer sites[4].

[3] http://www.for.gov.bc.ca/hfd/library/FIA/2004/FSP_R04-013c.pdf
[4] http://testwww.for.gov.bc.ca/hfp/compendium/WesternRedcedar.htm#rangeAmplitude

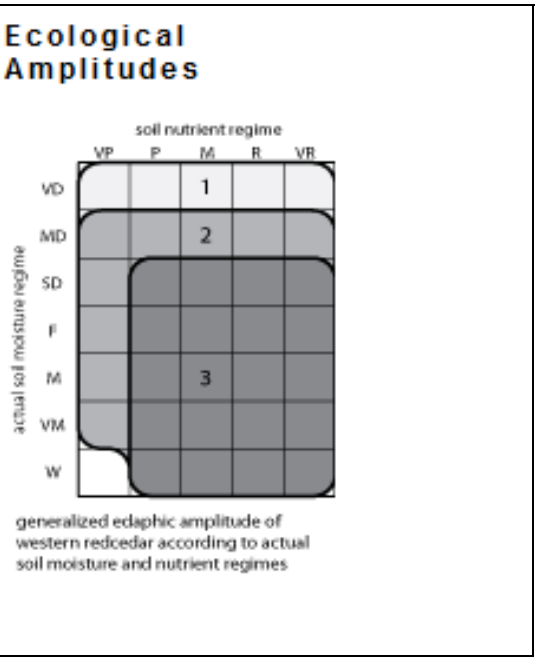

Figure 3. Geographic location Redcedar in BC and its ecological amplitude.

Table 1 Example Site Indices for Redcedar on a range of North Coast sites[5]

			Site Series Summary			
BGC Unit	**Site Series**	**Site Association**	**Species**	**Sample Size**	**Mean Site Index**	**Standard Error**
CWHvh2	01	CwHw - Salal	Ba		16.0	
CWHvh2	**01**	**CwHw - Salal**	**Cw**	**7**	**19.7**	**0.8**
CWHvh2	01	CwHw - Salal	Hw		20.0	
CWHvh2	01	CwHw - Salal	Pl		20.0	
CWHvh2	01	CwHw - Salal - Prince Rupert	Ss		16.0	
CWHvh2	01	CwHw - Salal - Vancouver	Ss		20.0	
CWHvh2	01	CwHw - Salal	Yc		16.0	
CWHvh2	04	HwSs - Lanky moss	Ba	33	27.3	
CWHvh2	**04**	**HwSs - Lanky moss**	**Cw**	**20**	**22.8**	
CWHvh2	04	HwSs - Lanky moss	Hw	43	27.0	
CWHvh2	04	HwSs - Lanky moss	Ss	43	31.6	
CWHvh2	05	CwSs - Sword fern	Ba		24.0	
CWHvh2	**05**	**CwSs - Sword fern**	**Cw**		**24.0**	
CWHvh2	05	CwSs - Sword fern	Hw		24.0	
CWHvh2	05	CwSs - Sword fern	Ss		28.0	
CWHvh2	**11**	**CwYc - Goldthread**	**Cw**		**12.0**	
CWHvh2	11	CwYc - Goldthread	Hw		16.0	
CWHvh2	11	CwYc - Goldthread	Pl		16.0	
CWHvh2	11	CwYc - Goldthread - Vancouver	Yc		8.0	
CWHvh2	11	CwYc - Goldthread - Prince Rupert	Yc		12.0	

Growth potential as indicated by Site Index at Breast Height age 50 for the range of growing sites on the BC coast ranges from 8 to 24 meters depending upon site[5]. The site series shown above were sampled during the Forest Practices Board Special Investigation

5 Site Index Estimates by Site Series found at:

http://www.for.gov.bc.ca/hre/sibec/reports/sisuBybgcUnit2007.xls

on dispersed harvesting. In all cases growth potential is somewhat less for redcedar than for the best species as identified for that site series. Thus cedar if grown using evenaged management with the associated species would form part of the intermediate and codominant layers (site series 1, 5 and 11) and likely an intermediate in site series 04 which is slightly drier than zonal in this wet subzone.

Growth characteristics

Reproduction and early growth

Western redcedar reproduces from seed as well as vegetatively by layering. Three types of vegetative reproduction occur, roots emerge from branches that touch the ground, fallen branches form roots and by the development of branches into stems from fallen trees. Germination and survival from seed is best on disturbed mineral soil substrates, unlike western hemlock that flourishes on decaying wood and organic substrates (Burns and Honkala, 1990).

Regeneration in partial harvest areas logged by helicopter

Partial harvesting in remote areas on the BC Coast is often done by helicopter and constituted the entire sample for the Forest Practices Board Special investigation (Forest Practices Board, 2007). Due to the aerial removal by the helicopter there is virtually no soil disturbance. This results in regeneration of redcedar mainly through vegetative reproduction. The incidence of fungal rot in vegetative regeneration is considered an issue for long-term value (Weetman et al 1988).

Planting is an option that would help minimize rot. However deer browsing of planted seedlings is a considerable issue throughout the BC coast and especially on the Queen Charlotte Islands. Options to manage deer browse are effective but are expensive. Present research indicates there may be genetic characteristics that reduce desirability for browsing (Russell, 2006 as cited by Klinka and Brisco, 2007). With future research and development this may allow for more cost effective artificial regeneration of redcedar.

Form

Western redcedar has the ability to survive and grow in low light conditions found in many old forest types (Klinka et al, 2000). When redcedar remains in the subcanopy, as it does with small gap partial cutting, it maintains its lower branches and has increased taper. This also occurs when it is grown in the open, holding it branches to the ground (Figure 4).

Figure 4. Note the wide low crown extending to the ground in the understory redcedar. Also note the size and longevity of branches in an open grown redcedar on the right. This form does not promote the growth of clear wood or the creation of Monumental Cedar characteristics desired by many coastal First Nations.

Silvicultural systems options

Due to the high shade tolerance of redcedar it has the ability to grow within a range of overstory conditions and therefore a range of silvicultural system options are available. The key then is what characteristics are we are trying to produce through management.

Traditional silvicultural systems are based on regeneration objectives. Even aged systems promote a single age class or cohort that regenerates over a relatively short period. To maximize growth of the cohort, where overstory trees were left to promote regeneration, they are removed once it is established. The size of opening created is usually large enough for full expression of growth, i.e., it is not light limited. Group and open dispersed retention systems fit within this approach.

Uneven aged management traditionally has two main approaches, group and single tree selection.

- Group selection creates gaps or small openings (often from 0.1 to 0.25 ha) within a managed area allowing for a matrix of different age classes in each of the gaps over time. This approach is essentially even age management on a smaller scale.
- Single tree selection is a system that promotes continuous forest cover and requires trees to grow in an understory position. The size of the opening and the amount of overstory retained is a balancing act between growth of overstory trees of all sizes and the ability for recruitment and growth in the regeneration layer.

Other non-silvicultural system options occur where a limited number of trees are removed and the stand remains fully stocked with no regeneration objective. These harvest entries (non silvicultural systems) leave the stand in a condition that can provide for a range of non-timber objectives providing an opportunity to obtain some volume and value from the stand. Due to the lack of regeneration, these entries are not necessarily sustainable for timber without additional harvest entries. If done in a way that removes

future harvest options, this is referred to as High Grading. This approach will not provide for future redcedar with desired characteristics within a reasonable timeframe.

What is it we are managing for?

Timber, monumental cedar, biodiversity, water quality, visuals, slope stability are all identified objectives in areas where redcedar is managed. The list is significant often with overlapping objectives. While the non-timber objectives are important it is also instructive to identify options that create conditions that promote value over time and can meet identified non-timber objectives.

Managers need to ask what conditions are needed for desired redcedar growth and form that will provide desired wood quality characteristics: for example trees with limited lower branches, less taper and increased durability. Crown derived wood has significantly different characteristics than non-crown derived wood, often referred to as mature wood (Jozsa and Middleton, 1994). Juvenile wood in redcedar has a higher relative density (heavier and less insulating properties) than mature wood and has more knots. It therefore has fewer options for use and is less valuable (e.g., TIPSY v 4.1 economic output).

While information on durability is complex and not completely clear for second growth (Clark et al 2004), there is compelling information on growth characteristics and form within various stand structures.

How to manage redcedar to meet timber value objectives

Some questions to ponder:

1. What opening size is suited to sustained growth of redcedar?
2. How does redcedar respond to overstory removal?
3. What would constitute a regime that promotes desired relatively clear wood and few lower branches?
4. What happens when redcedar grows in mixed stands with faster growing species?

What opening size is suited to sustained growth of redcedar?

Western redcedar saplings are shade tolerant and will increase in height growth under relatively low light levels. Drever and Lertzman (2002) found increased height growth as light increased from 0 to 20% full sun. Even with increased height, trees that remain in the subcanopy will often have poor form, i.e., heavy branching and a tapered bole (Klinka et al 2000). Thus opening size is important to allow trees to grow together as a cohort or to remain in the stand for long periods (many hundreds of years) to allow for crown lifting.

How does redcedar respond to overstory removal?

Where redcedar is managed in mixed species stands or using single tree selection it is often overtopped by faster growing species such as western hemlock, true firs and sitka spruce (and of course Douglas-fir where they grow together). Burns and Honkala (1990) suggest that while redcedar tolerates understory conditions it should not be given

excessive crown space. They indicated that thinning from below is preferred as removal of the overstory results in most of the growth allocated to large branches and a spreading crown rather than on the desired stem wood.

Coates (2000) found that for regenerating trees to grow near their full capacity in the ICH biogeoclimatic zone required openings of 0.1 ha if the surrounding canopy trees were 30 m tall. For taller coastal stands he estimated that openings 0.2 to 0.3 ha would be needed to obtain near full growth potential. For example a square opening that measures 0.2 ha would be approximately 45 m by 45m.

To get an indication of opening sizes in areas where harvesting was focused on removal of selected trees, residual basal area is often used to gauge the site occupancy and provide a measure of openness. The following table provides intertree distances based on a range of high retention level basal areas.

RBA m^2/ha	Average DBH of leave trees (cm)	Number of trees per ha	Approximate Intertree distance (m)
40	60	141	8.5
	100	51	14
50	60	177	7.5
	100	64	12.5
60	60	212	6.8
	100	76	11.8

Table 2. Average number of dispersed stems and intertree distance based on a uniform distribution of like sized trees.

As the residual basal area increases the number of stems to make up the BA increases and the amount of open space decreases. As table 2 indicates with a RBA of 40 m^2/ha (considered the low end of high retention) and trees with an average diameter of 60 cm would have an average intertree distance of 8.5 m. While there is not intact forest between these trees the gap size created by this distribution is less than 0.01 ha. If the average leave trees were larger, for example 100 cm in diameter this would equate to 51 sph with an average intertree spacing of 14 m (creating a gap of approximately 0.02 ha). Both of these opening sizes are much smaller than the estimated open sizes suggested for full growth potential. These opening sizes will promote branch retention and high taper in understory redcedar.

What would constitute a regime that promotes relatively clear wood and few lower branches?

For redcedar to provide clear-wood Klinka et al (2000) recommends relatively high initial stocking levels (>2000 sph) with delayed density control once the stems are into the stem exclusion stage. This is a true silviculture regime intended to meet a desired timber

objective. Will other approaches create similar desired outcomes? To some extent time will provide the conditions that create clear wood and large trees. The assumption is that most stands will have some healthy cedar and with enough time the trees will provide for the desired characteristics. When natural regeneration is relied upon in areas of low ground disturbance, much of the regeneration will be vegetative and have internal rot, this may not be a wise assumption.

Figure 5. Pure even aged redcedar stand that is on a trajectory to provide desired characteristics (photo credit Klinka et al 2000).

Time frames to provide a minimum of 30% high value wood

While there is no magic number on when a stand is considered economic, stands that require expensive harvesting methods such as helicopter yarding require a significant portion of high value wood. The following example uses 30% H grade or better. Below is an example printout by log grade based on TIPSY 4.1 of a pure redcedar stand.

		Log Vol. (m3/ha) [10 cm top/12.5+]						
TIPSY Age (yr)	Top Ht (m)	All Grades	Grade H	Grade I	Grade J	Grade U	Grade X	Grade Y
0.0	0.3	0	0	0	0	0	0	0
20.0	7.9	0	0	0	0	0	0	0
40.0	15.5	125	0	0	64	43	14	4
60.0	21.4	379	1	0	277	80	19	2
80.0	25.9	573	19	0	451	83	18	2
100.0	29.4	758	83	0	571	83	19	2
120.0	32.2	900	187	0	610	83	18	2
140.0	34.4	1042	323	0	616	82	18	3
160.0	36.3	1165	453	0	612	79	18	3
180.0	37.7	1258	552	1	605	80	17	3
200.0	39.0	1331	633	1	598	80	16	3

Figure 6. TIPSY4.1[6] output indicating log grades for a Site Index 20 site of pure redcedar planted at 1600 sph.

Note that it is not until the stand reaches 140 years that more than 30% of the volume is from the higher value H grade (estimated value at $150 per cubic meter compared with $100 for J grade). The actual values vary over time, but remain relative due to the desired characteristics of H vs J grade. H grade is a larger log with more clear wood than J grade which is considered a good sawlog[7].

What happens when redcedar grows in mixed stands with faster growing species?

Redcedar will often become relegated to an understory position, resulting in maintenance of the crown and retention of lower branches. Canham et al (2004) report significant competitive effects of hemlock on redcedar growth. They suggest it may occur from a combination of below ground competition and hemlock's negative influence on forest floor nutrient dynamics as its abundance increases in mixed stands. Their study found with increasing amounts of western hemlock there was a strong negative effect on redcedar growth; this was not reciprocal, as added redcedar did not significantly reduce hemlock growth. This has significant consequences where redcedar is being left to regenerate naturally in areas of little or no soil disturbance as western hemlock will dominate the regeneration layer and restrict redcedar growth.

What is the likely future trajectory for high retention partial cut stands?

From the information collected on the growth and form of cedar grown in understory conditions it appears evident that in many cases western hemlock will outgrow it.

[6] http://www.for.gov.bc.ca/hre/software/tipsy.htm
[7] http://www.for.gov.bc.ca/hva/timberp/infopapers/CoastLogPrices_Nov4.pdf

Redcedar when subjugated to an understory role will retain many of its lower branches resulting in lower long-term value. Without active management to promote relatively high early densities followed by well thought out thinning regimes it is not realistic to assume high quality timber from stands for a minimum of 140 years.

Decision tool for cedar management

Determine the objective: If

Other than timber – options are open, choose the system to maintain or enhance the desired objective.

Low value timber – options are open, redcedar will grow under a range of conditions including under high overstory conditions.

1. Mixed wood stands with dense hemlock component. Hemlock will generally outcompete the redcedar resulting in fewer larger more valuable cedar at rotation.
2. Overstory removal in partial harvests will promote wide crowns and large branches in redcedar.
3. Natural regeneration versus planting in areas with minor soil disturbance will promote vegetative reproduction and associated potential for fungal rot.

High value timber – management is required.

1. Create gaps at a minimum of 0.2 ha.
2. Stock with planted cedar and protect against browsing. This could be achieved using browse control devises or using browse resistant stock when available.
3. Use high densities to promote smaller lower branches and crown lift. Western redcedar self-prunes where side shading is complete or nearly so.
4. Thinning should be done with the final product in mind. Oliver et al (1988 as cited by Klinka and Brisco 2007) suggested thinning be delayed until lower branches die to avoid their survival and adding growth. Literature from the 1970's and 1980's (Hamilton and Christie 1971 and Nystrom 1980 as cited in Klinka and Brisco 2007) suggest delaying thinning to age 21 and as late as 30 years leaving 350 sph on high productivity sites to 750 sph on low productivity sites.
5. In mixed stands group or clump cedar when planting to promote competition between the cedar not the faster growing matrix species.
6. Fertilization can improve growth. For effective response an understanding of the nutrient requirements on a site specific basis are needed as growth can be limited by deficiencies in both macro and micro-nutrients.
7. Choose redcedar management based on site specific and landscape level direction.

Where would blocks from Forest Practices Board report on high retention fit within the above process?

The Board found three general categories of retention and future trajectories.

Type 1. Stocked by overstory, value removal does not exceed volume removal (harvesting the profile).

This set of blocks remains stocked and has little or no available space for the regeneration of understory stems. It is therefore in a holding pattern that allows for additional harvest. In some cases significant levels of valuable redcedar were left.

Type 2. Stocked by overstory, value removal greatly exceeds volume removal (high-grading); inadequate sites for regeneration.

This set of blocks had moderate to high levels of retention, much of which is not considered economic. The approach did not create open space to promote redcedar growth. In most cases there was not a clear regeneration strategy indicating desired characteristics of future crop trees.

Type 3. Stocked by overstory, value removal exceeds volume removal; substantial forest health problems due to dwarf mistletoe.

This set of blocks is similar to those in type 2, with an added issue of hemlock dwarf mistletoe. While the mistletoe may provide a competitive advantage to redcedar in some cases the blocks were not opened up to promote growth and were often left for natural regeneration that will be mainly hemlock.

For most blocks examined they would fall into the

- Other than timber or
- Low value options.

In no cases with high retention were openings sufficiently large enough or density of redcedar conducive to creation of high value cedar products.

Conclusion: Active Management is required to obtain redcedar with desired characteristics.

In order to achieve desired characteristics in western redcedar specific management practices must be used. Cedar grown in unmanaged stands will not produce clear wood without relatively high densities of regenerating cedar. Three management practices that could be effective are:

- Open up the stands, create gaps a minimum of 0.2 ha
- Plant redcedar at higher densities, plan on thinning once lower limbs begin to die.
- Choose your sites for managing redcedar based on growth potential and logistics. In some cases active management may not be desirable and managing for other objectives may be the best option.

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