

Amabilis Fir, Western Hemlock and Western
Redcedar from Two Salal Dominated
Ecosystems on West Cracroft Island: Results
Of Site Diagnosis and Foliar Analysis

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Research Report
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Abstract

An examination of an area of West Cracroft Island revealed a mosaic of salal dominated ecosystems on undulating, subdued terrain. Tree growth was better on the wetter and nutritionally richer ecosystems and poorer on the drier and nutritionally poorer ecosystems. Tree growth appears to be below the potential for the ecosystems studied. All species - amabilis fir, western hemlock, and western redcedar on both of the ecosystems examined have chlorotic foliage which is severely deficient in nitrogen. Fertilization with nitrogen would likely induce a phosphorous deficiency in western hemlock. Minor deficiencies were indicated in the case of potassium and magnesium. Salal or the humus form which is dominated by western redcedar boles are possible causes of the poor growth and nutritional disorders. Fertilization with N and P would increase tree growth rates but before it is carried out several factors must be considered: there is a significant component of relatively unproductive ecosystems in the area, access is difficult, and there is a likelihood of an excess of costs over benefits. Salal control with herbicides is also not possible due to the lack of appropriate available chemicals. Manual control is unlikely to be cost effective. One remaining option is to leave the area untreated with a review of this prescription in 10 years.

Introduction

Natural regeneration of amabilis fir, western hemlock and western redcedar is performing inconsistently on salal dominated ecosystems of West Cracroft Island. Even where tree growth appears adequate, the foliage is often chlorotic in these ecosystems.

A site diagnosis and foliar sampling were conducted to attempt to identify the reason for these symptoms. The objective of this report is, firstly, to present the results of this work and, secondly to make recommendations regarding the problem.

Location and Description of the Study Area

The study area is in the Kingcome TSA near the center of West Cracroft Island ($50^{\circ} 32' 49''$, $126^{\circ} 22' 30''$) (Fig. 1,2). Indications are that it is currently vacant Crown land. The forest cover is classified as immature western hemlock (> 20% gross volume), between 21 and 40 years of age and between 0.3 and 10.7 m in height. The site classification is poor, however, the site diagnosis results, (presented later) indicate it is actually a mosaic of ecosystems with widely varying potential productivities. The area is in the Windward Submontane Maritime Wetter Coastal Western Hemlock Biogeoclimatic Variant. Logging of the study area was probably completed in the 1950's and was followed by burning (no records exist), (A.M. Skakun, 1985, Port McNeill Forest District, Personal Communication).

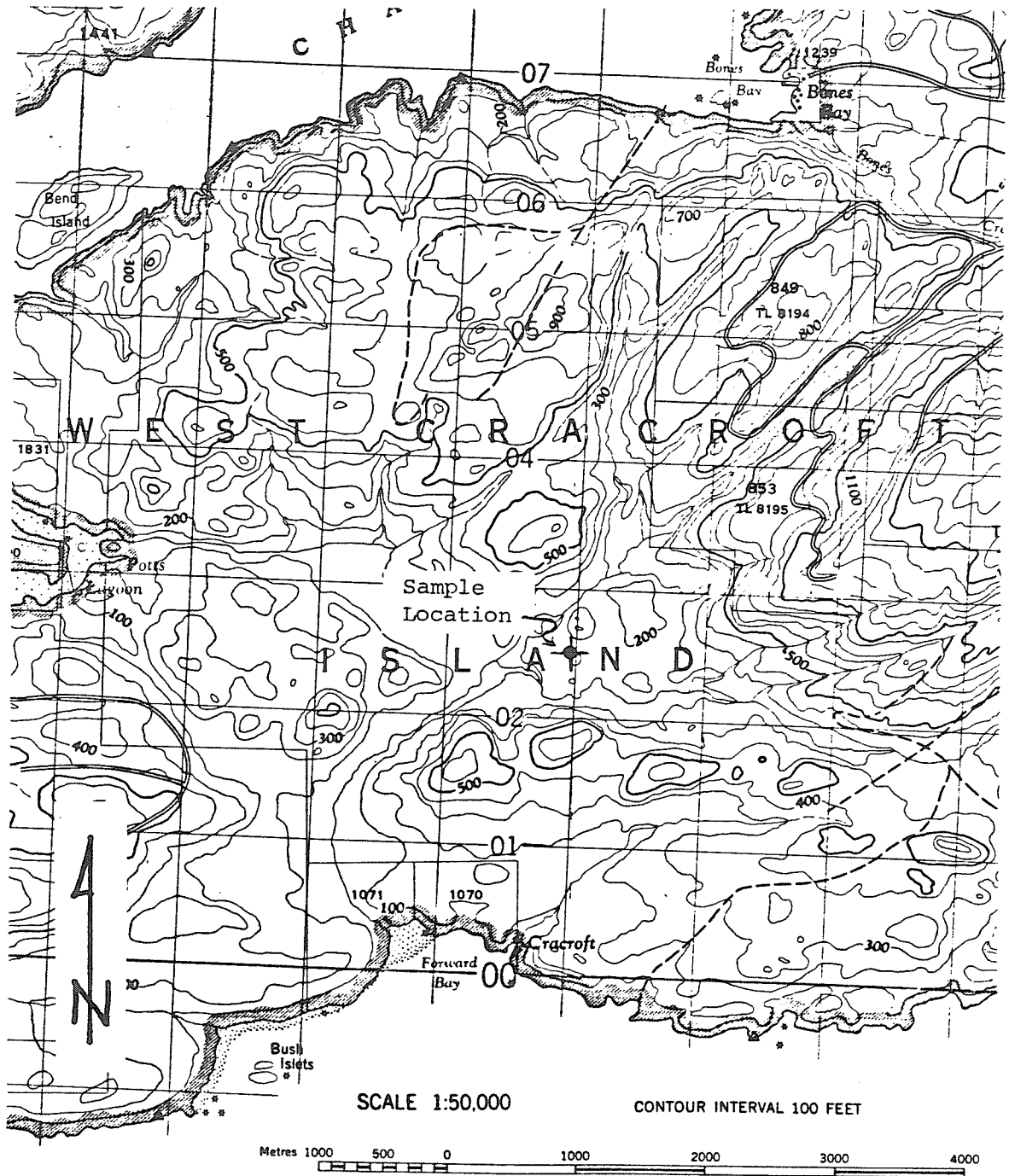


Figure 1. Location of the study area.



Figure 2. Photograph of the study area (indicated by the red circle). The better tree growth occurs in lower-slope topographic positions while poorer tree growth occurs on ridges and upper slopes and in wet depressions.

Two ecosystems were selected for detailed examination in the study area. Tree height growth on one was better than on the other. The characteristics of these ecosystems are summarized in Table 1. The major difference of importance from a forestry perspective is the fact that the ecosystem with better tree growth is wetter (soil moisture regime 6-7) and richer (soil nutrient regime C-D) while the one with poorer tree growth is drier and poorer (2-3/B-C). Both of the ecosystems that were examined and those not studied in the area are dominated by dense salal (Table 2) which is around 40 cm in height.

Table 1. Summary of edatopic features of two ecosystems on West Cracroft Island.

<u>Feature</u>	<u>Better Tree Growth</u>	<u>Poorer Tree Growth</u>
Elevation (m)	138	140
Topographic position	lower slope	ridgetop
Humus Form	Humisaprimull	Lignohumimor
Humus Depth (cm)	-	24
Soil Classification	Humisol	(Duric Ferro Humic Podzol)*
Soil Texture	-	loamy sand, sandy loam
Course Fragment Content (%)	-	60
Rooting Depth (cm)	85 (water table)	>60
Soil Moisture Regime	6-7	2-3
Soil Nutrient Regime	D-E	B-C

* estimated, no chemical analysis was carried out to confirm whether it is a Ferro-Humic or Humo-Ferric Podzol

Methods

Soil moisture and nutrient regimes were identified by examination of features of the ecosystems with better and poorer tree growth according to the methods outlined by Klinka et al. (1984).

At each of the two ecosystems, 5 individuals each of amabilis fir, western hemlock, and western redcedar (the major species present) were aged and their heights and current-year increments were recorded.

Foliage from the trees mentioned above was collected on 3 August 1979 from a location down 1/3 of the crown depth. Two branches were collected from opposite sides of a tree. All current year and previous year foliage was separated from these branches and collected in polyethylene bags. The samples were transported to the laboratory within 12 hours, where they were transferred to paper bags and dried in a forced-air oven at 70°C for 24 hours.

Table 2. Summary of vegetational features of two ecosystems on West Cracroft Island.

<u>Feature</u>	<u>Better Tree Growth</u>	<u>Poorer Tree Growth</u>
	- - - - - cover* - - - - -	
Salal	5	5
Deer fern	2	2
Red huckleberry	1	2
Lady fern	2	-
False azalea	1	-
Salmonberry	1	-
Skunk cabbage	1	-
Bunchberry	-	3
<u>Dicranum</u> sp.	-	1
Fireweed	-	2
Step moss	-	1

* 1 = 1- 5%
 2 = 6- 25%
 3 = 26- 50%
 4 = 51- 75%
 5 = > 75%

After drying, the needles of amabilis fir and western hemlock were removed from the twigs and the mass of 100 needles was determined for duplicate samples. No attempt was made to remove the scales of western redcedar from the twigs. All samples were then cut to 40-mesh in a Wiley Mill.

For nitrogen and phosphorus 0.2 g of sample was digested until clear (around 24 hours) in a hot 5 ml digestion mixture (1 liter of concentrated H₂SO₄, 100 g of K₂SO₄, and 1 g of selenium) and then diluted to 100 ml with distilled water. Nitrogen and phosphorus concentrations were determined colorimetrically in a Technicon Automatic Analyzer.

For potassium, calcium and magnesium a 1 g sample was ashed in a muffle furnace at 475°C for 4 hours. The ash was dissolved in 7.5 ml of hot, 20%

HCl. Water was added to make 100 ml of solution. Cation concentrations were determined via atomic absorption spectrophotometry.

Results and Discussion

The results of the tree measurements on the two ecosystems are summarized in Table 3. The mean tree heights that were measured on the ecosystem with better growth correspond to inventory site class 'good' for amabilis fir and 'medium' for western hemlock and western redcedar (Anonymous, 1981). The current year increment for the trees from this ecosystem corresponds with that for inventory site class 'good', 'medium', and 'poor' for amabilis fir, western hemlock and western redcedar, respectively. Although sampling was not carried out with the intent of classifying the ecosystem from the point of view of tree growth, indications are that the growth of western hemlock and western redcedar is below expectations considering the moisture and nutrient regime of this site (it should be 'good'; Klinka et al. 1984).

On the ecosystem with poorer tree growth the mean tree heights and the current year increment for the three species correspond to the inventory site class 'low' (Anonymous, 1981). Again considering the constraints mentioned previously, this also appears to be below the potential considering the moisture and nutrient regime of this ecosystem (it should be 'poor'; Klinka et al. 1984).

The color of foliage is yellowish-green for all samples (Table 4). In no cases is the color a desirable dark green, suggesting that even the trees with better growth have nutritional problems.

The mass of amabilis fir and western hemlock needles is substantially greater for trees with better growth. Note that, for a given nutrient concentration, the nutrient content of a needle will be related to its mass; i.e. larger needles will contain more nutrient than smaller needles. Information regarding needle mass is important for interpreting a tree's response to fertilization and, once benchmarks are established, may be useful for evaluating its nutrient status.

Table 3. Ages, heights, and current-year increments for 5 each of amabilis fir, western hemlock, and western redcedar from two salal dominated ecosystems on West Cracroft Island.

<u>Species</u>	<u>Growth</u>	<u>Mean Age & Range</u>	<u>Mean Height & Range (m)</u>	<u>Current Year Increment & Range (cm)</u>
Amabilis fir	better	20	12.4	66.8
		-	10.8-13.6	55-76
	poorer	23	2.4	6.6
		14-32	1.5- 3.2	3-15
Western hemlock	better	21	11.3	56.8
		-	7.2-16.0	44-70
	poorer	20	2.8	13
		-	1.7- 3.7	0-30
Western redcedar	better	20	7.9	38.2
		-	6.1-10.6	27-63
	poorer	17	2.3	20
		14-18	1.0- 3.4	10-40

Currently, nutrient status evaluation is based on foliar nutrient concentrations and ratios of nutrients for current-year foliage for samples from the dormant period, (Ballard and Carter, 1985). Of the species studied here, interpretive values are available for western hemlock and western redcedar. Comparing these values with the data from Table 4 (bearing in mind that samples from the present study were collected in early August - the early dormant season) indicates the following:

1. Both species have a very severe N deficiency regardless of growth category;
2. There may be a slight P deficiency in the western hemlock regardless of growth category;
3. P is adequate in western redcedar;
4. N/P ratios indicate that there is no P deficiency for either species, however, one may be induced by nitrogen fertilization in the western

Table 4. Foliage color, mass and nutrient concentrations for amabilis fir, western hemlock and western redcedar from two salal dominated ecosystems on West Cracroft Island and comparative data from the literature for nutrient concentrations.

Species	Growth	Year	Foliage color	Mass per needle - mg -	Nutrient Concentration				
					N	P	K	Ca	Mg
Amabilis fir	better	1	5GY5/8	9.6	.71	.13	.58	.24	.074
		2	5GY5/8	12.3	.77	.093	.45	.37	.079
	poorer	1	5GY6/8	5.6	.67	.15	.64	.25	.062
		2	5GY5/8	6.2	.66	.11	.41	.41	.068
	excellent (mature trees)				.99	.10	.57	.28	.09
Western hemlock	better	1	5GY6/8	2.8	.76	.15	.53	.17	.094
		2	2.5GY5/8	3.9	.81	.088	.47	.23	.12
	poorer	1	2.5GY7/10	1.7	.72	.20	.68	.22	.089
		2	5GY5/8	2.5	.90	.22	.56	.42	.12
Interpretive adequate value					1.45	.35	.80	.10	.10
Western redcedar	better	1	5GY5/8	-	.98	.19	.57	.60	.12
		2	5GY5/8	-	.91	.14	.41	.70	.075
	poorer	1	5GY6/8	-	.85	.22	.71	.66	.14
		2	2.5GY6/10	-	.79	.18	.51	.71	.12
Interpretive adequate value					1.65	.16	.85	.25	.14

hemlock with better growth. No such induced deficiency is likely where poorer growth occurs nor for western redcedar in either growth category;

5. K levels for both species and growth categories indicate a slight to moderate deficiency;
6. Ca levels are adequate;
7. K/Ca ratios are not indicative of any problems;
8. Mg levels indicate little if any deficiency in the case of western hemlock with better growth and western redcedar in both growth categories, and a

possible slight to moderate deficiency in the case of western hemlock with poorer growth;

9. Ca/Mg ratios are not indicative of any problems.

No interpretive values are available for amabilis fir, however, comparison with data from mature trees exhibiting excellent growth and vigor (R. Carter, 1986, Research Contractor, U.B.C., personal communication) indicates that N is substantially lower in the samples collected from West Cracroft Island while the other nutrients are comparable in value.

Comparable results for foliar analysis of western hemlock from ecosystems similar to those of the present study were found by Weetman and Fournier (1985). These authors also found a possible zinc deficiency in this species. They also studied western redcedar and report values for nutrients that are all higher than those of the present study. The major difference was in N with their value of 1.43% compared to 0.98% for this study.

Screening trials employing several elements and varying application amounts were carried out by these authors. After three years of studies it appears that the optimum fertilizer combination and application rate for western hemlock is N300 P150 kg ha⁻¹ (Weetman and Fournier, 1986a) while that for western redcedar is N225 P75 kg ha⁻¹ (Weetman and Fournier, 1986b; J. Barker 1986, Supervisor of Forestry and Research, Western Forest Products Ltd., personal communication).

Currently, formal fertilization studies are underway to establish changes in height and diameter of western redcedar due to these fertilizer additions. Similar studies are planned in the future for western hemlock. It is known, however, from the screening trial results that height increment may double over that of controls after one growing season (Weetman and Fournier, 1985). The problems in evaluating these height increment data are that screening trials are not intended to quantify height growth increases, and that combinations and amounts of nutrients that produce the greatest response in the first year are not the same as those producing the greatest response over the duration of the fertilization effect.

With regard to zinc, it is quite likely that the western hemlock foliage of the present study is low in this element considering the widespread occurrence of this phenomenon in this species (Gadziola, 1984. Project proposal for MScF at UBC). Improvements in growth beyond that achievable by addition of N and P alone may be possible by addition of zinc, provided that the low zinc levels actually do indicate a deficiency.

Several hypotheses have been advanced to explain the problems experienced by Sitka spruce growing on salal dominated sites of northern Vancouver Island by Germain (1985) as follows:

1. Salal outcompetes the conifers for available nutrients;
2. Organic compounds in salal litter resist microbial attack and are toxic to fungi and plants;
3. An allelopathic effect is exerted by salal on conifers;
4. Salal produces a large amount of root-derived detritus raising the C/N ratio which results in reduced nutrient availability to Sitka spruce.

These may also apply to the tree species of the present study. Another distinct possibility is as follows:

The old-growth salal - redcedar ecosystems have built up a humus form which is dominated by western redcedar bole remains (due to their relatively slow decay rates). Thus, mineralization rates are extremely slow. Both salal and conifers compete for the released nutrients but initially salal is more successful. Later, the salal is shaded out by conifer crowns and the trees are more successful. During salal's reign it is contributing to the slow mineralization rate by maintaining a loose porous humus form via its rhizomatous root system. Once salal dies, this effect is eliminated and mineralization rates increase. The cedar bole humus eventually gives way to a humus form that is dominated by smaller conifer litter and dead roots.

If the latter hypothesis is correct and if components of western redcedar other than the bole are slow to mineralize, forest productivity may be adversely affected in stands where this species is a major component. The function of salal-redcedar ecosystems definitely requires detailed study.

Recommendations

Undoubtedly, fertilization with N and P would lead to improved nutrition and increased growth rates of the western hemlock and western redcedar of this study. However, before fertilization is contemplated the following must be considered:

1. The area is composed of a mosaic of ecosystems, a significant portion of these are relatively unproductive due either to lower moisture and nutrient regimes or to a high water table.
2. Access to the area is difficult and thus a fertilization project would be relatively expensive.
3. Fertilization of stands at this age is usually not cost effective.

Control of the salal by herbicides would make more nutrients available for tree growth. Presently, there are no registered herbicides that will kill salal so this is not an option. Manual control of salal is also out of the question due to the great difficulty of carrying out a treatment and the vigor with which salal resprouts after cutting.

The remaining option is to be to do nothing at this time. Stocking is generally good and the trees will eventually (approximately within the next 20 years) close canopy and shade out the competing salal over much of the area. After this occurs tree growth rates should increase. If this option is exercised, then in 10 years the area should be reassessed.

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