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COASTAL WESTERN RED CEDAR REGENERATION: PROBLEMS AND POTENTIALS

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ABSTRACT

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Western red cedar (Thuja plicata Donn) is a climax species with silvical characteristics thatfavor its use in wet and/or shaded (brushy) sites, and in root rot ormild frost pockets. Past research conducted on natural regeneration demonstrated that a very large amount of seed is required to produce a stand. It is now usually planted on sites where it is a desired crop species. Research in progress on slashburning effects suggests that western red cedar growth may be improved by burning these types of sites, even though nutritional status may decline. Initial mycorrhizal associations of western red cedar may be positively affected by a low impact burn, and negatively affected by a high impact bum.

Recent MacMillan Bloedel studies in planted seedling performance of western red cedar stock-types indicate that three and five-year survival can range from 65 to 95 %. Height growth can range from 35 to 80 cm over five seasons. The majority of mortality appears to resultfrom drought stress during the first growing season. Two year-old bareroot stock tends to be most cost effective for minimizing establishment costs. However, larger containers tend to be more cost effective for achieving rapid height or volume growth. Bare root performance can be significantly increased through root pruning.

Future stand establishment research must continue to improve the small database on seedling physiology, water relations, nutrition, mycorrhizae, and the effects of various forest management practices. Options should be explored for stand and rotation strategies.

INTRODUCTION

Along the coast, western red cedar *(Thuja plicata* Donn) is found from sea level to the upper montane forests and from northern California to the Alaska panhandle (Fowells 1965). The elevational limits of the species vary with latitude. In coastal British Columbia, it occurs abundantly in the Coastal Western Hemlock and Coastal Cedars Pine Hemlock Biogeoclimatic Zones, commonly in the Coastal Douglas-fir Zone, and uncommonly in the Mountain Hemlock Zone (Pojar 1983; Krajina et al. 1982). In Washington and Oregon, it is a major tree species in the Western Hemlock and Sitka Spruce Zones; and a minor tree species in the Mixed Conifer Zone along the Cascade and Olympic mountain ranges, and in the subalpine Pacific Silver Fir Zone (Franklin 1981).

The silvicultural range of western red cedar extends over the zones in which it is most common. Best growth occurs on wetter sites with soils that are nutrient rich (Krajina 1969), such as on moist alluvial sites. However, it does grow on many poor sites, but at slower rates (Krajina et al. 1982).

Relative to associate tree species, western red cedar is suggested to have the highest foliar nutrient requirements for N, K, Ca, and Mg (Ballard and Carter 1986). Western red cedar accumulates calcium and magnesium in its foliage and is known to promote cycling of these nutrient bases (e.g., Alban 1969); because of this, it is often a preferred browse species and may be a preferred crop species during juvenile spacing (as a nurse and/or crop species).

A number of silvicultural attributes make western red cedar a desired tree species:

1. Low susceptibility to root rots that can plague Douglas-fir and western hemlock,
2. Low number of insect pests,
3. Tolerant of wet soils and flooding, and

4. Shade tolerance (Krajina et al. 1982).

This paper will discuss regeneration of coastal western red cedar from a historical and regional perspective, provide detail on planting stock *and* early stand performance, and close with silvicultural challenges for the future.

REGENERATION PERSPECTIVES

• Historical Perspective

For over 3000 years, western red cedar has been a ubiquitous forest tree in the coastal climax forests. Large, long-lived specimens have been harvested over much of its natural range. However, this stand dominance has been lost on many sites. This has resulted from poor natural regeneration and slow natural growth rate relative to the current length of forest rotations. For example, Schmidt (1955) noted, that for 28 plots in coastal B.C., western red cedar represented an average volume of the previous stand of 43.2 %, but it only represented 1.3 % of the regeneration. A similar trend may now be occurring in Alaska, with western red cedar only representing about 10 % or slightly more of the regeneration (P. Hennon, Pers. Comm.)[1]

Despite a very large cone crop on a regular basis, seed dispersal and successful germination are often inadequate for natural regeneration of a clearcut (Garman 1951, Hetherington 1965). Garman (1951) reported on a survey covering 1 to 5 chains (20 to 100 m) from the timber edge of mixed stands, demonstrating that it took 860,000 western red cedar seeds to produce 1000 seedlings, as compared to 138,000 for Douglas-fir and 100,000 for western hemlock. Direct seeding had been considered potentially feasible for western red cedar and western hemlock in coastal B.C. (Garman and Orr-Ewing 1949); however, subsequent studies (Garman 1951, 1955) demonstrated that it is not uncommon to need an overwhelming amount of seed in the case of western red cedar. Factors involved include high mortality during germination and seedbed quality, along with site-specific environmental effects such as temperature and light regimes, moisture regime and other edaphic conditions, competition, smothering, and grazing by small animals (Minore 1983).

Schmidt (1955) clearly demonstrated the ability of western red cedar to propagate vegetatively through layering and cuttings, which can further accentuate uneven distributions. However, under certain conditions, natural regeneration is satisfactory (e.g., small clearings with favorable conditions, and many sites in S.E. Alaska).

Overall, western red cedar ranks third in regeneration requirements in coastal British Columbia (Yeh 1981). Although a considerable amount of cedar regeneration has historically been natural, the following points have led to a stronger emphasis on planting (Minore 1983):

failure of western red cedar natural regeneration to establish on some sites,

high seed to seedling ratios on other sites

the need to control stem distribution of second growth crop trees.

• Regional Perspective

Artificial regeneration of western red cedar began in earnest in the Pacific Northwest and B.C. during the late 1960's and early 1970's. Planting of pure stands is not common and western red cedar is often used in association with other species, with the cedar being planted in the wetter areas within a setting. It is also considered useful for root rot pockets and heavy brush areas. In addition, recent work by MacMillan Bloedel indicates that western red cedar appears more suited to mild frost pockets than western hemlock or Douglas-fir.

In 1987, the Vancouver Forest Region in coastal B.C. used about 6.4 million western red cedar, out of a

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total of about 32 million seedlings (about 20 percent western red cedar; Mr. B. Storey, Pers. Comm.) ; north coast proportions may be similar but are complicated by the Prince Rupert Region containing considerable land in the northern interior of B.C. The proportion of western red cedar planting in the Pacific Northwest is probably similar to the provincial average in B.C., which is about 3.5 percent (C. Krebs, Pers. Comm. [3]; B. Storey, Pers. Comm.) These two regions appear to differ in early stand management, whereas western red cedar is often favored in spacing or early thinning operations in B.C., the opposite can be true in the Pacific Northwest.

In Alaska, western red cedar has only been planted on a trial basis and, similar to B.C, it is also favored in early stand management (P. Hennon, Pers. Comm.)

In B.C., tree species selection guidelines, based on climatic and ecological site data, exist for the various regions (e.g., Klinka et al. 1984), and western red cedar is recommended for a number of site conditions.

EARLY STAND PERFORMANCE

Western red cedar normally occurs in mixed stands under both natural and artificial regeneration. Site preparation affects both forms of regeneration in a similar way and is discussed at the end, followed by mycorrhiza.

• Natural Stands

Western red cedar often grows slower than its associates (Krajina 1969). However, height data from Carnation Creek Experimental Watershed and from Long Beach, both on Western Vancouver Island, demonstrate that this is not always the case. At Carnation Creek, western red cedar averages 1.1 to 1.4 m total height in a 6 year-old well drained setting, and 1.2 to 1.8 m in a 9 year-old poorly drained setting, which is similar to, or better than, western hemlock and planted Sitka spruce (Curran et al. 1986). At Long Beach, 14 year-old western red cedar averages 2.0 to 3.1 m, which is also similar to, or better than, western hemlock and Sitka spruce; it has also occupied the setting as good as western hemlock and better than Sitka spruce (Curran and Ballard 1986). However, at Carnation Creek, two of the four settings studied do not have much western red cedar, probably because of poor seed dispersal into the center of the clearcut area. Western red cedar is also an important nurse species, this includes areas studied on central and eastern Vancouver Island, and at Mission Tree Farm License No. 26, 50 km east of Vancouver.

The nutritional status of western red cedar is quite similar amongst the various study areas. For example, at Long Beach, N, Fe, *Zn, and B* are possibly deficient [4] in western red cedar foliage, with K, P. and Cu also possibly deficient in a number of cases (Curran *and* Ballard 1986). At Carnation Creek and on central Vancouver Island, N, K, Fe, Zn, and B are possibly deficient, with P low in a number of cases and S considered a limiting factor if fertilizer N were added (Curran et al. 1986).

• Planted Stock

In the late 1960's and early 1970's, operational assessments of a range of morphological stock indicated that large dimensional bareroot stock, planted as early as possible, was most successful. At that time, the two greatest problems with red cedar planting stock were browse *and* cold storage. Aldous (1964) had found western red cedar to be one of the poorest surviving species following cold storage; this occurs either through a general deterioration of stock quality or because of molds.

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4 Foliar nutrient concentrations below 'critical' levels are referred to here as 'possibly deficient' because a true deficiency can only be demonstrated by a growth response to additions of that nutrient

The advent of containerized culture became a reality for western red cedar in coastal British Columbia by the mid70's. To date little is known about the field performance of western red cedar container planting stock (Dr. R. Van den Driessche, Pers. Comm.; Mr. J.T. Arnott, Pers. Comm 6). Survival comparisons of bareroot and containers in western Oregon and Washington during 1973 to 1977 indicated a slight advantage for container stock over bareroot (79 % vs 72 %; Owston 1981).

MacMillan Bloedel Ltd. studies, in affiliation with the B.C. Ministry of Forests and Lands, were initiated in 1980 and 1983 for comparing the performance of large and small, one year-old container types with two year-old bareroot stock.

The first study was on sites that ranged from 50 m to 600 m in elevation and were located in the CWHb1, CWHb4, and CWHd1 variants of the Coastal Western Hemlock biogeoclimatic zone on Vancouver Island. The trial, established in the spring of 1980, compared four small container types (approximately 30 ml cavity volume) of a variety of makes with two year-old bareroot stock. Four provenances were used and the planting sites were chosen as close to the provenance origins as possible (Figure 1; Bower and Dunsworth 1987). The bareroot stock had to be root pruned at the time of planting from 50 cm to 25 cm, to facilitate operational planting.

The five year results of this study indicated that survival ranged from 65 to 90 % and height growth ranged from 90 to 116 cm (Figures 2 and 3). The bareroot stock had the poorest survival and the best five year total height and height growth. The best container performance was from Ray Leach and Spencer Lamaire containers. The biomass allocation evidence demonstrated that the bareroot stock had considerably more root growth over the first three growing seasons than did the container stock. This is most likely because of the root pruning. Root pruning damage probably played a significant role in the high bareroot mortality. The only stock types to have an increase in their shoot to root ratio in the first growing season (an indication of good balance at the time of planting) were the containers with shoot to root ratios at planting of approximately 2.0.

The second study was conducted to compare large containers (PSB 313, 415, and 615) with two-year-old bareroot stock. We also investigated the impact of nursery root culture (chemical and mechanical) on container field performance. The container cavity volumes were 50,90, 300 and 1010 ml. Root culture at the nursery consisted of chemical pruning using copper carbonate in latex paint and painting the cavities.

The study was established in the spring of 1983 at one site in the CWHd1 zone near Port Renfrew on Vancouver Island. The third season results indicated very high survival (94 to 99 %) and good growth (54 to 70 cm). There were no statistically significant differences among stock types for three year survival (Figure 4). However, large containers (1010 and PSB 615) had significantly better height and volume growth than the smaller containers or bareroot stock (Figure 5). For the smaller containers, copper coating led to consistently poorer height and volume growth than their uncoated controls. This may have been because of heavy metal toxicity, small stature at planting, poor root regeneration potential at planting or a combination of the three. However, the larger, 1010 copper treated container showed the best volume and height performance of any of the stock types tested.

Cost Effectiveness

Cost-benefit analyses of these two studies were complicated by the fact that in the first study the poorest surviving stock type was the tallest and had the best growth over five years. However, as in the second study, the low cultural cost of bareroot stock made it the most cost-effective stock type in terms of establishment cost or total height per establishment dollar.

When considering seedling growth (height, volume or caliper), the greatest growth per establishment dollar favored the large container stock types (300 ml and 1010 ml).

Planting Stock Considerations

Both the studies reported here and consideration of operational history suggest five areas for maximizing

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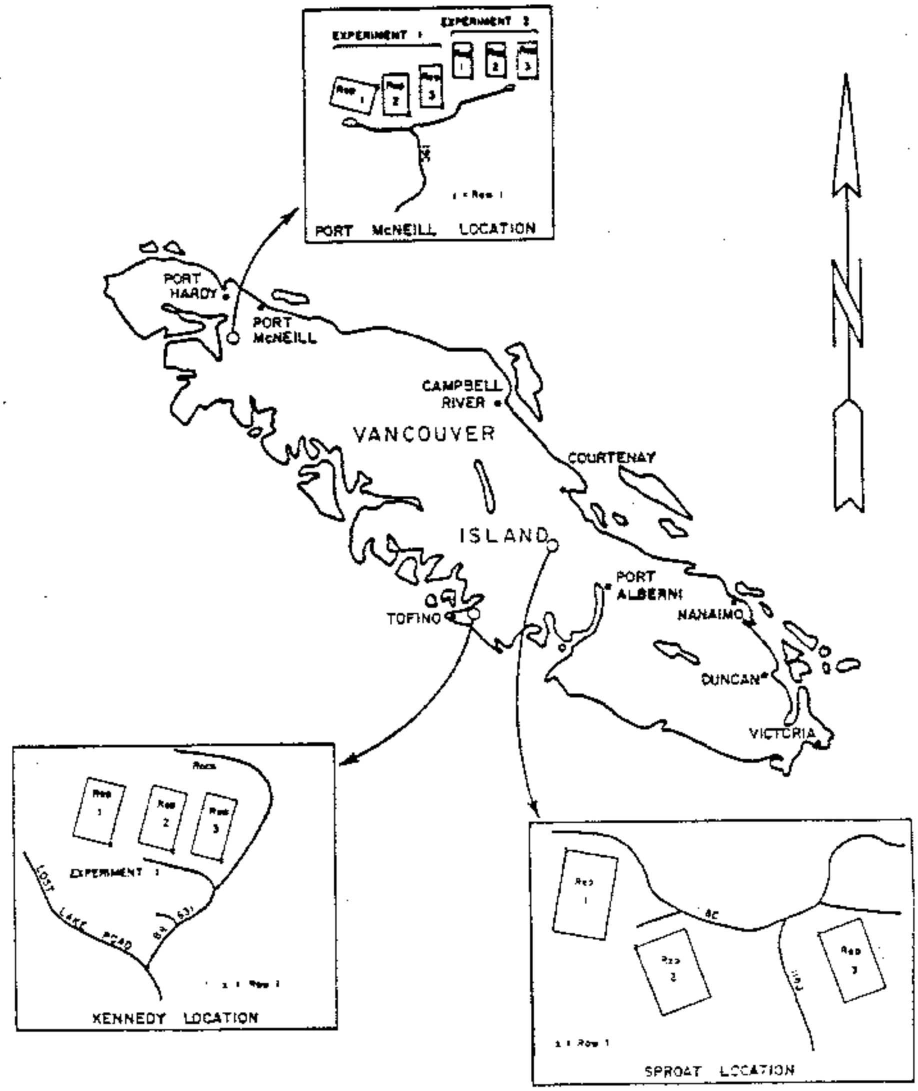

Fig 1. Locations of western red cedar stock type trials

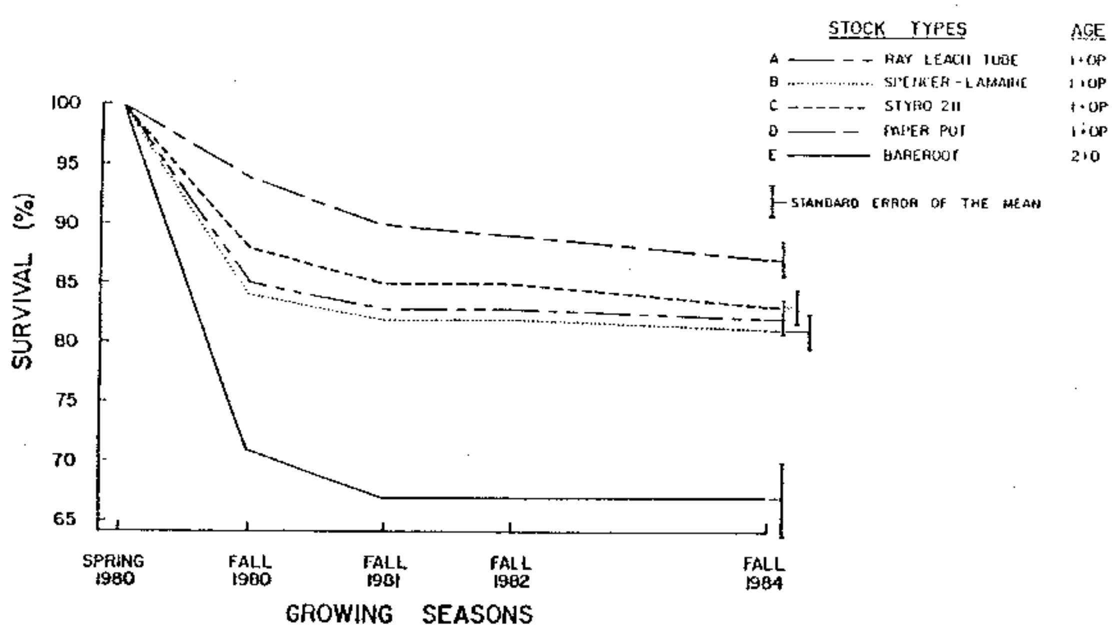

Fig 2. Five-year survival for five western red cedar stock types (survival averaged over locations and provenances).

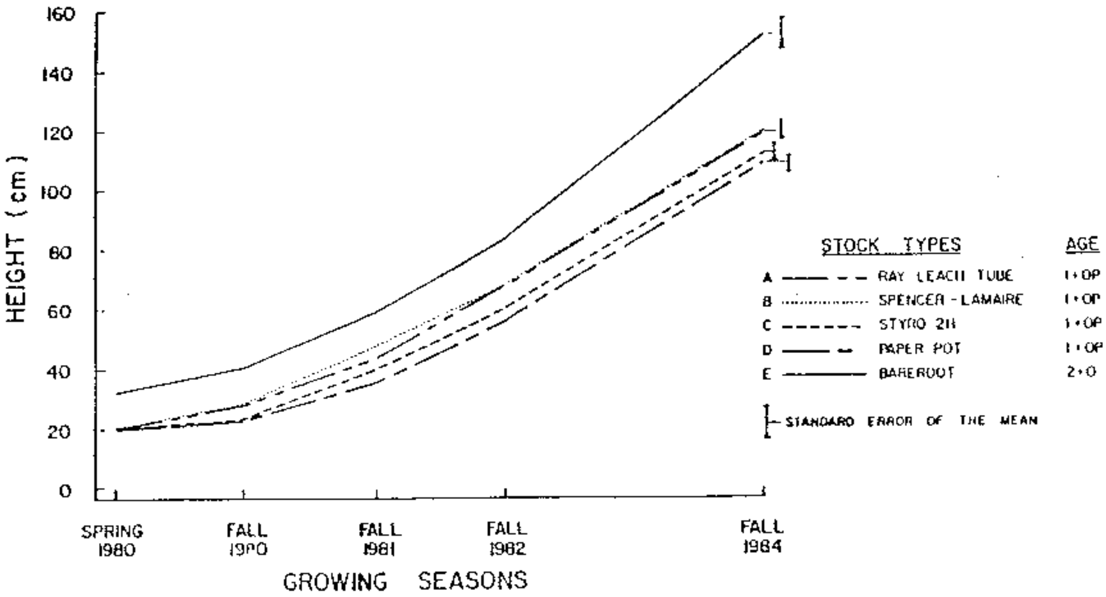

Fig 3. Five-year height development for five western red cedar stock types (averaged over provenance and location)

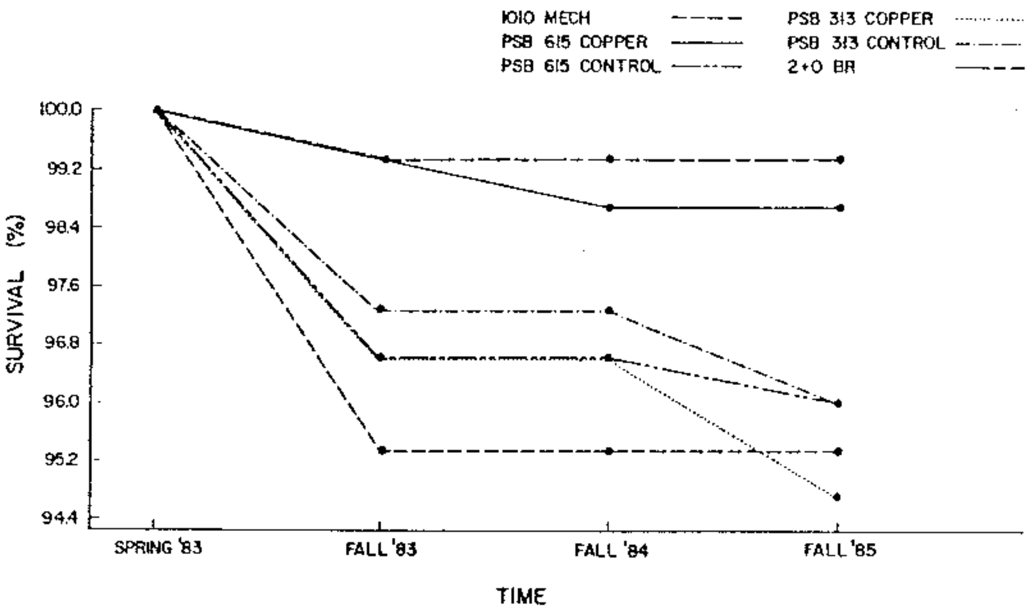

Fig. 4. Average survival over three growing seasons for six western red cedar stock types

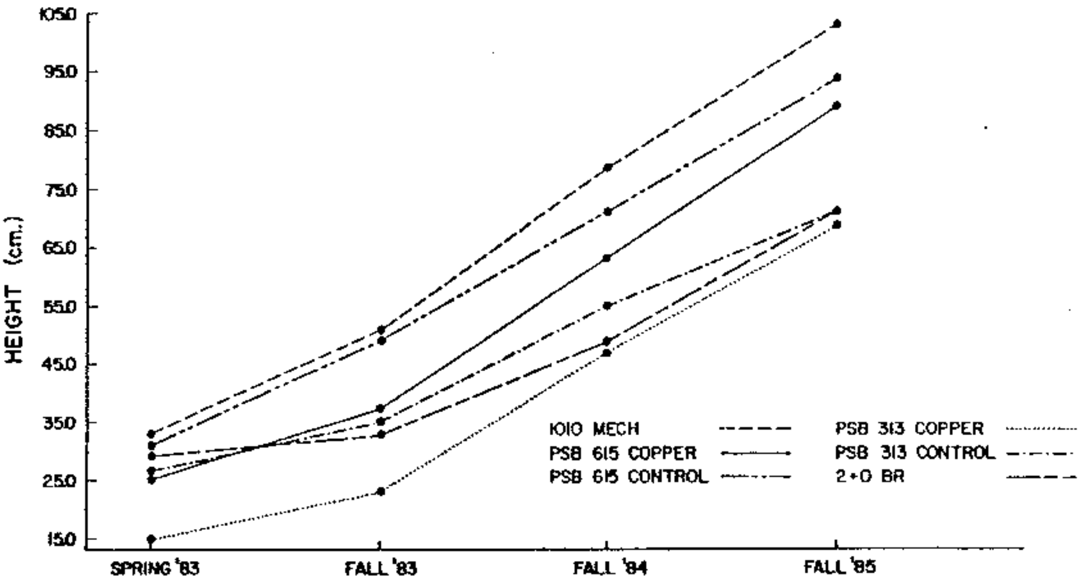

Fig. 5. Average height development over three seasons for six western red cedar stock types

the benefits from western red cedar artificial regeneration:

1. Balance: To minimize the risk of desiccation following planting, bareroot or container planting stock should have a shoot/root ratio less than 2.5 and a caliper of at least 3 mm.

2. Physiological vigor: To ensure minimal deterioration in cold storage (and until stress resistance targets have been established) planting stock should not be stored for longer than 30 days.

3. Timing of planting: Given a history of poor storability, spring planting should occur as soon after lifting as possible (Jan. or Feb.). Fall planting, under appropriate soil climatic conditions, should be encouraged.

4. Browse risk: In areas with high browse risk a number of options exist, the most direct being selection of a less palatable species. A mechanical barrier is successful where cost-effective; for example, a MacMillan Bloedel study on the Queen Charlottes resulted in 80 % survival and 54 cm height after 2 years for "caged" western red cedar as opposed to 60 % and 25 cm for "uncaged" trees. Conversely, a high level of slash and brush may be maintained to impede large mammals.

5. High brush risk areas: In areas where brush risk following harvest is high and treatment is restricted (i.e., riparian zone deferalls, small/steep draws, or uneconomic) western red cedar may be the species of choice because of its high shade tolerance. In these cases relatively large planting stock should be used and planted as quickly as possible, to maximize growth prior to brush canopy closure.

• Seedbed/Site Preparation and Early Stand Management Effects

Site preparation for coastal western red cedar includes slashburning and mechanical site preparation. Herbicides may be used in conjunction with burning or during early stand management, such as conifer release on brushy sites. Conifer release may also be effected through manual brushing and weeding programs, although this is not usually a cost-effective treatment on the coast.

Very little is known about the long-term effects of our forest management practices. Current research on the long-term effects of slashburning will be discussed in some detail. Ballard (1986) discusses some possible implications of other common site preparation practices.

Slashburning can have a number of both long and short-term effects on the seedling environment. Foremost, advanced regeneration *and many* seeds are killed by fire. The burning, and processes that occur afterwards (e.g., the dissolution of the plant ash) determine tree growth and survival by affecting direct and indirect growth factors.

The overall effect on tree growth depends on which factors are effected and if this leads to resource limitations (Chapin et al. 1987). The interaction of limiting resources with the tree's ability to compensate is a complicated ecological process (e.g., Table 1). The resultant plantation performance can vary over time, as plant succession and nutrient cycling change the profile of the resource limitations.

Results from ongoing research suggest that fire may have no effect or may have either a positive or negative overall effect on western red cedar growth and nutrition (Curran and Ballard 1985; Curran and Ballard 1986; Curran et al. 1986; Price 1986). For example, Curran and Ballard (1985) found that, on 14 year-old CFS research plots where western red cedar was a secondary stand component, the initially better growth of western red cedar on an unburned control plot appeared to drop off over time, relative to a slashburned plot (based on height increments measured following methods summarized by Parker and Johnson 1987).

It is not uncommon for management treatments to result in lower nutritional levels and improved tree growth, due to improvements in other more growth-limiting factors. This was the case for western red cedar at Pacific Rim National Park (Curran and Ballard 1986). Variation amongst sites is demonstrated at Carnation Creek (Curran et al. 1986; Price 1986), on western Vancouver Island, where western red cedar growth appears to be favored by burning within one site, but not necessarily so in an adjacent site (Figures 6 and 7). The nutritional status of the Carnation Creek trees appears to increase with increasing fire impact; this included N, P. and S on the poorly drained setting and Ca on the well drained setting (Curran et al. 1986). Final results from the slashburning research will enable refinement of silvicultural prescriptions for optimal growth of the chosen crop species.

Western red cedar can respond very well to conifer release, juvenile spacing, and precommercial thinning (Minore 1983).

• Tree Mycorrhiza

Mycorrhiza are symbiotic fungi plant root associations that are of biological importance and practical significance (Bjorkman 1970). Recent research has

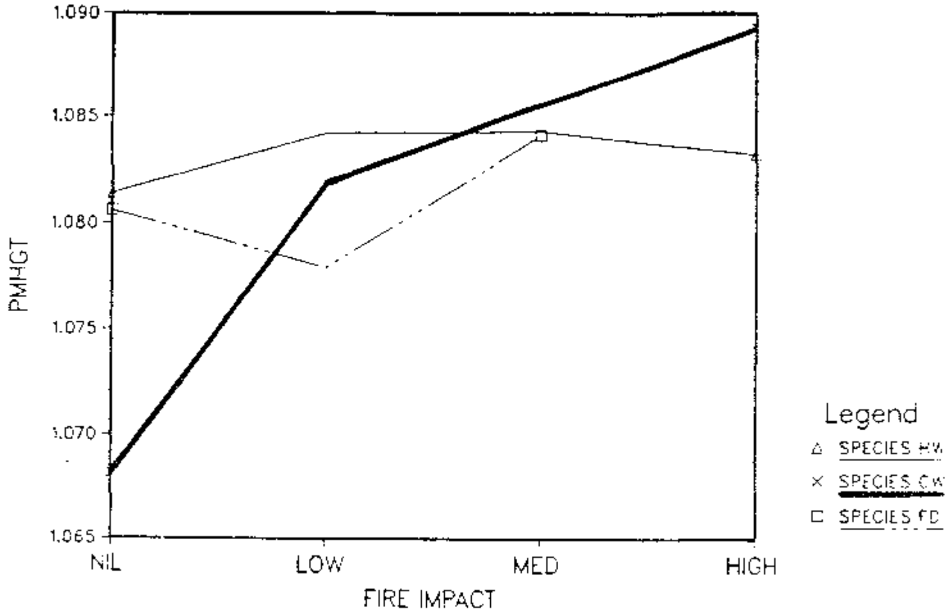

Fig. 6. The predicted means* of total height for each species over the fire impacts for setting RR 8 at Carnation Creek ((Price 1986, based on data summarized in Curran et al. 1986). * Predicted mean of the tree growth was used for comparison because sample size varied.

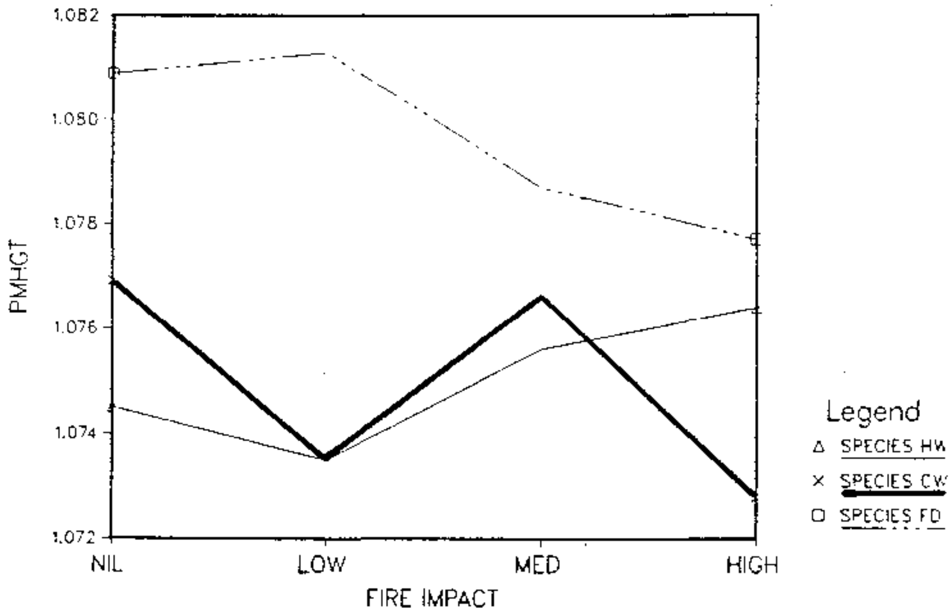

Fig. 7. The predicted means of total height for each species over fire impacts for setting RR 7 at Carnation Creek (Price 1986, based on data summarized in Curran et al. 1986)

suggested that the actual "type" of mycorrhiza associated with tree roots may be of significance in seedling survival and growth in the field (e.g., Cordell and Marx 1980). Previous studies have shown that fire can affect mycorrhizal fungi for as much as 20 years after burning (e.g., Schoenberger and Perry 1982). Western red cedar develops vesicular arbuscular mycorrhizal (VAM), which are endomycorrhiza. Studies on western red cedar mycorrhiza has demonstrated the importance of the forest litter for the mycorrhiza (Parke et al. 1983) and that mychorrhizal specimens are more productive under certain conditions, such as low P levels (Kough et al. 1985).

To explore initial mycorrhizal associations of coastal B.C. trees and possible slashburning effects, a greenhouse bioassay was carried out. The research included soil from sites up to 47 years since burning and others with detailed fire impact monitoring; western red cedar was included in a reburn plot trial (Curran 1986 a). This was followed up by actual field trials by MacMillan Bloedel (Beese 1987). Results are summarized below and a joint UBC MB report is in progress.

For the greenhouse study, the low impact spring burn had an average duff reduction of 2.4 cm, with 12.5 cm remaining, *and* the very highimpact fall reburn consumed virtually all of the remaining duff (Beese 1986). Cedar seedlings grown for seven months with preburn soil had an average VAM colonization level of 11.2 percent. This increased to 27.5 percent for the low impact burn, and dropped to 3.8 percent for the highimpact burn. Control trees had no mycorrhizal colonization (Curran 1986 a). The growth chamber results suggested that low impact burns actually encouraged VA mycorrhiza in western red cedar, but that highimpact burns were detrimental.

The growth chamber results were field tested by Beese (1987), who found that western red cedar nursery stock were generally not mycorrhizal until after planting. The level of mycorrhizal colonization of the seedlings and their root systems was not significantly affected by various fire treatments. However, trends suggested a slight increase in the percentage of seedlings and roots colonized as a result of moderate burning, but detrimental effects of heavier burning. Beese (1987) also noted that burning appeared to have an adverse impact on the coarse endophyte type of VAM, favoring the fme endophyte type. He noted literature that related fine endophyte types to harsh sites. Further research may reveal longer-term effects.

CHALLENGES FOR THE FUTURE

The future for coastal western red cedar regeneration is optimistic. Although the trend has been away from natural regeneration in the recent past, this will continue to be the most cost-effective alternative for many lower productivity cedar sites. Artificial regeneration of western red cedar is currently in a technological catch up position relative to bareroot and container culture of Douglas-fir or western hemlock. The following are areas in which we feel both basic and operational research should focus:

1. Cold hardiness: An understanding of the factors controlling cold hardiness and stress resistance relationships under nursery cultural conditions must be developed to effectively deal with the storability problem in western red cedar.

2. Species/Site Relationships: Documentation of the physiological limitations of red cedar and the site conditions under which optimal *and* acceptable growth might be expected.

3. Mycorrhizae: Research is needed in: identifying the sites and conditions where VA mycorrhizae are important to growth and survival of western red cedar, evaluating the VAM species that are associated with red cedar, selecting those with greatest benefit, determining their distribution, their ability to colonize planted seedlings, and the need for nursery or on-site inoculation, and evaluating the impact and importance of site preparation on these fungal populations and associated microbes.

4. Shelterwood silvicultural systems: To develop cost-effective natural regeneration systems and to assist in the development of red cedar, mixed stand management we must begin to explore the where and how of shelterwood harvesting.

5. Browse control: Cost-effective alternatives to mechanical barriers (i.e., repellants) must be developed; this is likely the most important stand establishment problem with western red cedar.

6. Long-term effects: Continued research is needed on the effects of forest management practices on tree growth and nutrition, and direct and indirect growth factors; this can enable determination of the most cost effective management practices. Relocation of past research sites and incorporation of experimental and sampling designs that utilize microplots within treatment areas are useful considerations for long-term studies (Curran 1986 b).

Table 1. Simplified summary of short-term effects of slashburning on factors affecting tree growth and nutrition[7]

Factor	Possible Effects of Burning	Possible Effects on Tree
DIRECT GROWTH FACTORS		
Available Light	Increased (decreased shading)	Positive, may be neg. if S. facing slope or shade-requiring spp.
Available Water	Decreased infiltrability, and forest floor (and usually upper soil) water holding upper soil) water holding	Negative if serious summer drought on tree micro-site capacity
	Increased in receiving areas	Positive if not excessive
Available Carbon Dioxide for Photosynthesis	Negligible?	Negligible?
Temperature Regimes (air and soil)	Increased range above ground, at surface, and below ground	Positive if respiration decreased at night and/or soil temp. incr.
		Negative if too extreme for species (slope,aspect important)
	Decreased range at surface possible if mineral soil exposed	Positive if decreased heat stress on stem and/or increased heating of root environment.
		Negative if frost heaving occurs
Rooting Substrate	Decreased if erosional losses	Negative
	Decreased if species relies heavily on the forest floor	Negative if significant forest floor loss occurs
	Seedling frost-heaved due to temperature effects	Negative
	Increased if sediment gain	Posit. if not excessive
Soil Nutrients Total Content	Decreased due to atmospheric losses, leaching, & erosion	Negative if any nutrient pool falls below requirements
Soil Nutrients Relative Availability	Increased for N, S, K, Ca, Mg due to rapid mineralization	Posit. unless excessive supply of one nutrient antagonizes plant (e.g.,Ca induced Fe deficiency)
	Decreased for Fe, Mn, Zn, Cu because of effects of increased pH	Negat. if any one becomes growth-limiting
	Increased for Mo because of increased pH	Positive if otherwise if growth-limiting (little known)
	Increase or Decrease for P, B depending on balance of pH, organic matter effects	Positive if increased
		Negative if decreased (e.g., P adsorption by charcoal)

7 Note: after Curran (1986 b), a) Actual effects observed depend on site conditions, fire impact characteristics, tree species and growing stock, and actual factors limiting growth, (e.g., although nutrient levels may decline they might not reach growth-limiting levels); b) Magnitude and duration of observed effects also vary with above; c) Information from a number of references, well summarized by Feller (1982 a, b) and Wells et al. (1979)

Table 1. (Continued).

Factor	Possible Effects of Burning	Possible Effects on Tree
INDIRECT GROWTH FACTORS		
Soil pH	Increased up to 3 pH units (dissolution of mineral ash)	Posit. if not excessive for species requirements or nutrition.
		Negat. if excessive for species requirements or nutrition
Soil Cation Exchange Capacity (CEC)	Increased pH-dependent CEC	Positive because of increased nutrient retention and soil buffering to change
	Decreased if excessive organic matter consumption	Negative because of decreased nutrient retention and buffering
Competing Vegetation	Increased if propagation encouraged, e.g. unburned roots	Negative because of increased competition
	Decreased if propagules consumed or discouraged	Positive
Root Pathogens	Increased if propagation or growth encouraged	Negative (e.g., *Rhizina undulata* is encouraged)
	Decreased if opposite effect	Positive (i.e., only if deep, persistent burn)
Other Pathogens	Decreased if dependant on remaining slash	Positive (e.g. mistletoes)
	Increased if reduces antagonistic agents or encourages alternate host	Negative (e.g., *Ribes* for white pine blister rust)
Wildlife Grazing	Increased	Negative if trees preferentially
	No change in grazing habits	Positive if browse preferentially grazed
		No effect
Mycorrhizae	Decreased if fungi or hosts discouraged	Generally considered negative
	Increased if fungi or hosts encouraged	Generally considered positive
Beneficial Organisms (e.g.earthworms N fixers such *Ceanothus* spp)	Decreased in short-term due to drastic change in environment/substrate	Negative unless rapid recolonization
	May be increased	Positive due to increase in N cycling
		May be negative if in competition with tree

Note: after Curran (1986 b), a) Actual effects observed depend on site conditions, fire impact characteristics, tree species and growing stock, and actual factors limiting growth, (e.g., although nutrient levels may decline they might not reach growth-limiting levels); b) Magnitude and duration of observed effects also vary with above; c) Information from a number of references, well summarized by Feller (1982 a, b) and Wells et at (1979).

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Editor's note: The common name of either western red cedar or western redcedar (just 2 words) is left to the discretion of the authors. The full scientific citation is: *Thuja plicata* (Donn ex D. Don in Lamb.), with the "in Lamb." part as optional, as cited by E.L. Little 1979. Checklist of U.S. Trees. Agric. Handbook #541, U.S.D.A. For. Serv., Washington D.C. 375pp. (Thanks to Karl Klinka for this reference). Most of the papers were submitted as camera ready copies. However, these were all scanned or converted (as were many figures) to facilitate desktop publishing. I apologize for any errors that occured during this process. I would like to thank the organizing committee, chairpersons and volunteers, as well as all speakers and authors, Hilary Stewart for the splendid dinner speach, and to the UBC Conference Centre (thank you Lauren Boni, coordinator).