FRDA Research Memo

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Effects of Time of Planting of Engelmann Spruce in the Lillooet Forest District, British Columbia – Project 3.06

INTRODUCTION

Summer and fall planting have become acceptable and successful regeneration practices. For high elevation sites, summer and fall are often the only times that planting can be performed. In spite of the numerous successful examples of summer and fall planting, however, silviculturists continue to have two operational concerns:

1. What are the optimal time and site conditions for planting?
2. Are there long-term consequences to time of planting?

In 1985, George Krumlik of the B.C. Ministry of Forests Research Branch initiated a time-of-planting trial in the Lillooet Forest District to investigate these questions for 2+0 PSB 313 Engelmann spruce planted in the ESSFmw and MSdm2 zones. Dave Spittlehouse, Forest Microclimatologist of the Research Branch, initiated microclimate monitoring of these sites, and Mike Goldstein of Soilcon Labs was contracted to continue climate monitoring. Pacific Phytometric Consultants were contracted to establish, maintain, and measure the experiment.

SITES, STOCK, AND CLIMATE

Five freshly logged sites were selected south of Goldbridge in the Hurley River drainage. These sites cover a range of site conditions, site preparation treatments, and elevations of the MSdm2 and ESSFmw (Table 1). The MSdm2 sites, in their valley bottom location, were expected to be prone to frost damage because of the effects of cold-air drainage, topographic shading, and exposure to wind.

The stock used was a local seedlot of Englemann spruce grown in a Lower Mainland nursery as 2+0 PSB 313. The stock was considerably larger than called for by the present stock morphological specifications in the Ministry (Table 2). The seedlings had set bud by early July and were sufficiently hardened off to be planted by early August.

Seedlings were planted on six dates from August to October 1985 and again in the spring in late May of 1986 immediately following snowmelt (Table 3). The planting dates covered a wider range of times and climatic conditions than are usual in operational planting programs (Table 4). One hundred seedlings were planted at each site on each date, for

TABLE 2. Stock morphological description. Morphological description of stock based on a sample of 30 seedlings taken from frozen storage, December 1985.

Morphological trait	Mean	Standard deviation
Height (1985)	19.4	± 3.5 cm
Height (1984)	13.1	± 2.9 cm
Root collar diameter	4.3	± 0.6 mm
Root weight	1.4	± 0.5 g
Shoot weight	2.3	± 0.6 g
Stem weight	1.1	± 0.3 g
Needle weight	1.2	± 0.4 g

TABLE 1. Site conditions and history

	Site				
Site description	ESSF 1	ESSF 2	ESSF 3	MS 1	MS 2
Biogeoclimatic zone[a]	ESSFmw	ESSFmw	ESSFmw	MSdm2	MSdm2
Elevation (m)	1341	1250	1250	1128	1097
Moisture regime	3–4	3–4	4	4	4–5
Nutrient regime	C	B	C–D	A–B	D
Aspect (°)	25	70	250	Flat	Flat
Slope angle (°)	15	20	10	Flat	Flat
Latitude	50°39'	50°40'	50°40'	50°43'	50°44'
Longitude	123°00'	123°01'	123°01'	122°58'	122°57'
Site location	M. Slope	V. bottom	L. Slope	V. bottom	L. Slope
Soil texture	SL	SL	SL	fSL	SL
Soil depth (m)	0.5	0.3–1	0.3–1	> 1	> 1
Site history					
Logged	1984	1984	1984	1984	984
Slashburned	Bum	Burn	Bum	Burn	Not burned
Planting time (hr/100)	1.9	1.3	2.8	1.5	1.8
Opening size (ha)	16	5	14	96	18

[a] Lloyd *et al.* 1990.

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TABLE 3. Planting times

Planting		Planting dates
Summer planting	1	August 13, 1985
	2	August 28, 1985
Fall planting	3	September 10, 1985
	4	September 23, 1985
	5	October 8, 1985
Spring-planting	6	May 24, 1986

a total of 3000 seedlings. The most stressful planting conditions were encountered during the first planting date: very low relative humidity, high temperatures, and relatively high wind speeds. Soil moisture and temperatures, however, were acceptable. Planting seedlings under climatic conditions outside conventionally accepted criteria was intentional to allow us to determine the limits to summer and fall planting.

TABLE 4. Recommended climatic and edaphic conditions for fall planting.

Krumlik[a] made the following suggestions that broadly circumscribe acceptable climatic and edaphic conditions for summer and fall planting.

1. Soil temperatures in the top 25 cm of the soil should be greater than 4°C.
2. Soil moisture in the top 25 cm of the soil should be greater than -1 bar.
3. Air temperature should be less than 18°C.
4. Wind speed should be less than 30 kph.

[a] Krumlik 1984.

Condition and form of seedlings were recorded every spring and fall. The data were used to discriminate between summer and winter damage. Growth measurements were taken every fall in late October.

Climatic indicators were measured year-round for the duration of the experiment (Figure 1). This information describes several general aspects about high elevation climate that have silvicultural implications:

- Large diurnal variations can occur in in air temperature, and may exceed 40°C.
- Freezing temperatures can occur on any day of the year on either MSdm2 or ESSFmw sites.
- Soil surface temperatures can exceed 40°C during the summer months.
- Freezing soil temperatures at 15 cm depth can occur during the wintermonths but only when most of the insulating snowpack has been lost from the site. This mid-winter snow loss occurred on the MSdm2 sites in winter 1988/89. Repeated mid-winter snow loss is indicated by low soil surface temperatures.
- Precipitation is frequent, averaging once every 10 days during the growing season. Its quantity differs substantially between sites (Figure 2). On average, ESSFmw sites received 30% more rainfall during the growing season than MSdm2 sites.
- Soil moisture deficits (less than -1 bar) were rare in the ESSFmw, but occurred every summer in the lower elevation MSdm2 between mid-July and mid-September.

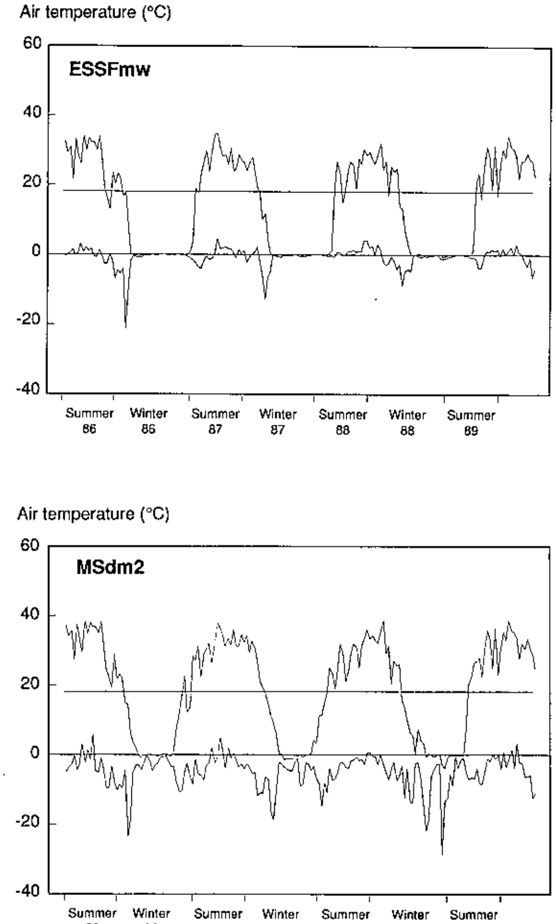

FIGURE 1. Maximum and minimum air temperatures at seedling height for ESSFmw and MSdm2 plantations in the Hurley River drainage. Lines represent weekly maximum and minimum temperatures for four years. A reference line at 0°C is given. The reference line at 18°C represents the upper limit of accepted air temperatures for planting. Notice that the maximum temperature throughout the winter remains close to 0°C and the difference between minimum and maximum temperatures is small. This occurred because the depth of the snowpack exceeded the height of the temperature sensor.

RESULTS

Planting date-related effects on survival and growth were small compared to the effects of site differences. Establishing this experiment in a different year could have resulted in entirely different results because of the year-to-year variation in winter conditions and growing season precipitation.

Overwinter frost and desiccation damage was the most striking feature of the experiment. All mortality was attributed to this damage. Frost damage occurred every winter on the MSdm2 sites, but was most severe in the first winter when 50% of the seedlings in these plantations were damaged (Figure 3). Symptoms included chlorotic foliage; poor needle retention; damaged or killed apical buds and subtending whorl and interwhorl buds; bud death sometimes accompanied by leader dieback; and, in severe cases, pitch exuded from stem lesions.

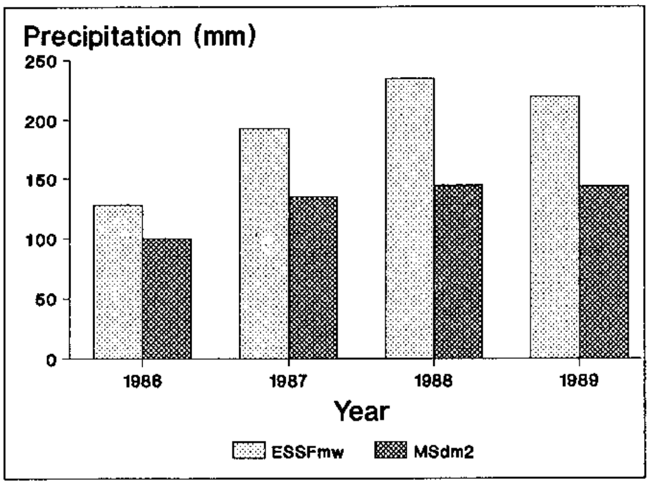

FIGURE 2. Total growing season precipitation for the ESSFmw and MSdm2. Bars are the total precipitation over the growing season (end of May to the start of October). Note the marked year-to-year variation in total precipitation.

These symptoms were most pronounced on seedlings that were not planted close to slash or otherwise sheltered to the south. There was also a tendency for the latest planted seedlings to have higher frost damage than seedlings planted earlier.

Site differences between ESSFmw and MSdm2 are the most important factor contributing to seedling growth (Figure 4), and these differences have continued to increase.

A trend evident on all sites was that the best performing planting was the spring planting and the worst was the latest fall planting (Figure 5). On the ESSF sites, the difference between best and worst plantings was as much as 18 cm total height in 1989. The trend is particularly well expressed by diameter growth for which there was a 4-mm difference between the best and worst planting date. The earliest planting in August showed results similar to those for the spring planting, but later summer and fall plantings showed gradually declining performance. The improved performance of the summer planting of hot-lifted stock has been frequently reported in other studies of fall planting.

An unexpected result was that planting date continues to influence current leader growth. Apparently, the initial slight advantage associated with the spring planting (less than 2 cm in the first growing season, 1986) and the earliest fall planting continues to increase 4 years after planting. The persistence and increase of initial slight differences are consistent with the results of other long-term studies on a variety of species, stocktypes, handling, and site treatments.

CONCLUSIONS

The results indicate there are few limitations to conducting a successful summer, fall, or spring planting in the ESSFmw. In the study area, planting can be initiated as soon as the stock is available, provided that site conditions are suitable, which is usually the case. The situation in the MSdm2 is considerably different: earliest plantings are more likely to have better growth and are less prone to overwinter damage than later planting dates. Late summer (end of August–early September) and late spring immediately after snowmelt (late May) are optimum planting times in this subzone where severe overwinter damage is anticipated.

As yet, there is no practical significance to the differences in survival among the planting dates used in this study. Early planting can take advantage of the more favorable climatic and edaphic conditions, and may allow for maximum root growth as long as seedlings have hardened-off. Greater on-site root growth by seedlings may result in improved physiological adjustment to the site and higher resistance to winter damage.

Seedlings that are well established, healthy, and free of physiological stresses before winter will probably tolerate severe climate conditions better than poorly established, unhealthy seedlings. Careful treatment during lifting, transport and planting, together with attention to climatic and edaphic conditions, is the most effective way of minimizing winter damage during establishment of high elevation plantations.

Compared to spring planting, summer planting may be more cost effective because it eliminates the cost of cold-storing seedlings and the cost of clearing roads of snow to permit access to site, and ensures that the site will still be accessible while there is time to plant. Summer planting also allows greater flexibility in carrying out a planting program. Krumlik's first approximation of planting guidelines (Table 4) are admittedly conservative, but, considering the nature of the microclimate, the stock used, and the logistics of a hot-planting, they remain realistic guidelines. These limits should be regarded as warnings to planting supervisors: if these limits are exceeded extra care must be used in handling and planting. The further planting conditions are outside these limits, the less feasible it may become to achieve acceptable results.

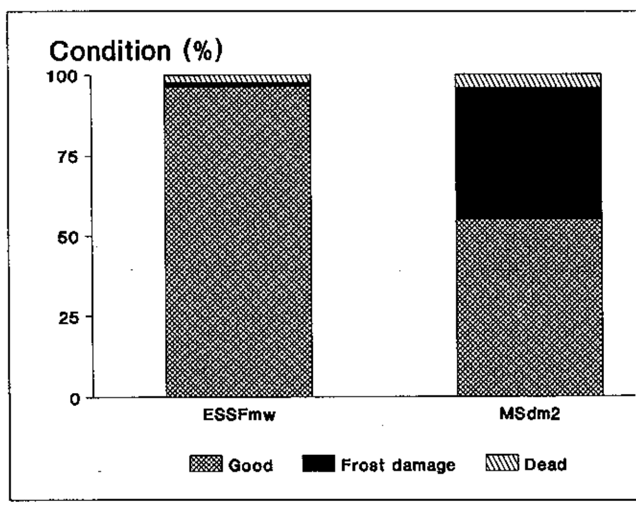

FIGURE 3. Overwinter frost and desiccation damage after the first winter (1985-86). Condition codes refer to: GOOD – undamaged seedlings; FROST DAMAGE – seedlings with various degrees of frost damage; DEAD – seedlings killed over the winter. Condition and mortality are similar to that after the fourth winter.

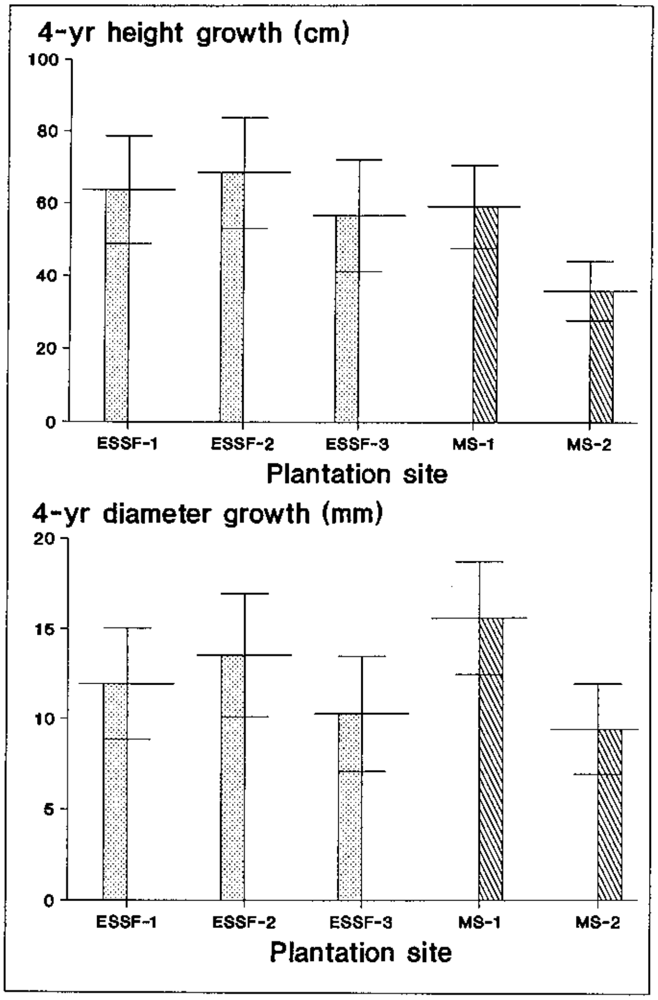

FIGURE 4. Total 4-year height and diameter growth by site. Means and standard deviations over all planting times for each site. Site names identify the biogeoclimatic subzone.

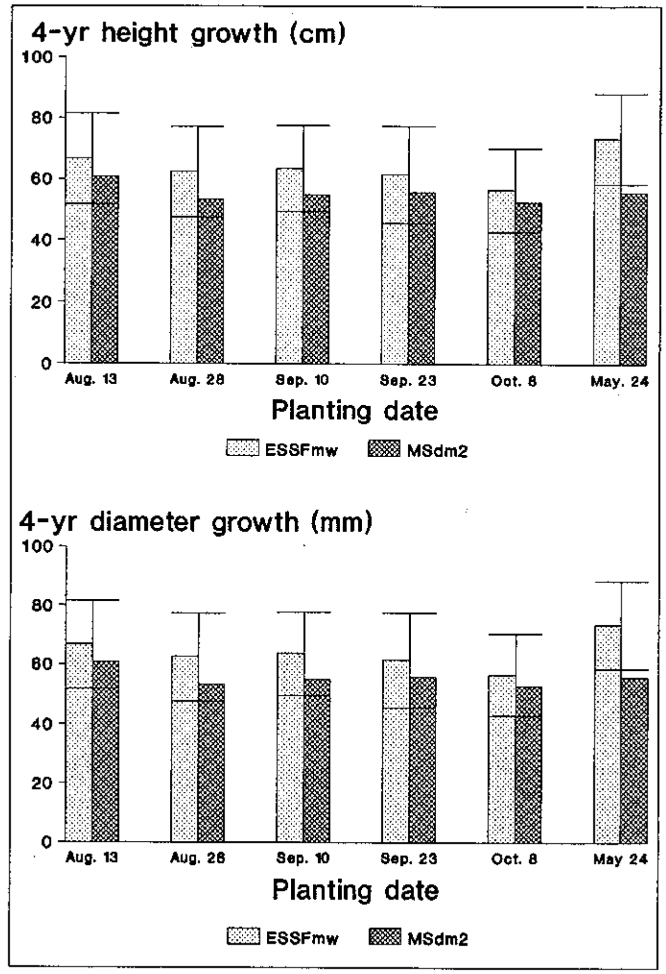

FIGURE 5. Total 4-year height and diameter growth by planting date for ESSFmw and MSdm2. Means and standard deviations over all experimental sites for each planting date in each zone.

REFERENCES

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