Squamish Forest District

Extension Note

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Seedling Survival in the Coast-Interior Transition: Squamish District

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INTRODUCTION

The Coast–Interior Transition in southwestern British Columbia is a narrow geographic area that lies between, and overlaps, two much-larger areas of the province traditionally known as the Coast and the Interior. The Coast–Interior Transition corresponds to the Submaritime Seed Planning Zone as described in the Forest Practices Code's *Seed and Vegetative Material Guidebook* (BCMoF and BCMoE 1995). The area is characterized by many species of commercial trees and varieties of competing vegetation, a variable annual climate, and steep ecological gradients. Regeneration concerns include: soil moisture, temperature, competing vegetation, stock quality, delayed planting, planting time, and site preparation (Scagel et al. 1992a, 1992b).

In 2001 the Transition Zone Working Group (TZWG)[1] initiated a study of plantation survival in order to summarize data about staked–seedling survival trials. This extension note summarizes the results of staked survival surveys that were established within the Transition Zone of the Squamish Forest District between 1986 and 1998.

METHODS

Data from two sources were included in the analysis **(Table 1)**. The Seedling Survival System (SSS) was a province-wide monitoring project whereby 100 seedlings are staked in a line per installation. The data are archived within a provincial database. The sites selected for SSS sampling in the Soo TSA had good access and represented operational plantation methods as well as developing methods (e.g., larger stock type). The BC Ministry of Forests' Squamish Forest District updated this monitoring system in 2000 with Regeneration Performance Assessments (RPA), whereby 49 seedlings were staked per installation. The SSS and RPA survey data were combined because their formats were similar, i.e., with one tree species per survey line. The analysis was based on previously entered data, without any field verification. Only survival is reported and growth is not analyzed.

The Coast-Interior Transition subzones analyzed include the Southern variant of the Dry Submaritime subzone in the Coastal Western Hemlock zone (CWHds1); the Southern variant of the Moist Submaritime subzone in the Coastal Western Hemlock zone (CWHms1); the Moist Warm subzone in the Englemann Spruce–Subalpine Fir zone (ESSFmw); and the Wet Warm subzone of the Interior Douglas-Fir zone (IDFww). Coastal subzones were excluded. About half of the SSS sites had been site prepared **(Table 2)**. All of the SSS and most of the RPA data were derived from clearcut silvicultural systems, and some of the RPA data were derived from partially cut sites.

RESULTS AND DISCUSSION

Scagel et al. (2001) indicates there are considerable knowledge gaps regarding factors affecting survival in the Coast–Interior Transition. Assuming an average planting density of 1200 trees/ha, the average well-spaced stocking of 750 trees/ha (based on free-growing surveys) suggests there may be mortality of 37% of planted trees. Further plantation mortality could be masked by ingress of naturals. Patchy distribution of naturals

[1] The Transition Zone Working Group is a collective of representatives from government and industry, formed in 1990, to improve silviculture in the Coast–Interior Transition, exchange ideas and reports, and co-ordinate research trials and other co-operative efforts.

Table 1. Data sources.

Data source	Years harvested	Years planted	Years measured	Trees established (no.)
Seedling Survival System	1943-97	1986-98	1986-99	17 472
Regeneration Performance Assessment	1994-99	2000	2001	882

Table 2. Proportion of site preparation methods used on SSS areas.

Site-preparation method	%
None	47
Chemical	32
Wildfire	12
Prescribed burn	5
Other	4
Total	100

and survey procedures may also affect those stocking results (Scagel et al. 2001). The ambiguities of assessing natural vs. planted trees can be resolved by monitoring staked trees at establishment.

Natural ingress can often offset mortality losses of planted stock in the Transition. However, the shift in species composition (e.g., western hemlock replacing Douglas-fir) may raise concerns about timber supply, and about silviculture prescription obligations.

The quality of the data was unexpectedly poor. It was difficult to demonstrate clear trends from the survey results due to irregular sample sizes and high variability. The re-measurement ages were inconsistent, and it was difficult to compare results among different years. Interpretation of the survival results is closely related to sample size. Small samples in later re-measurements are quite variable and tend to offset trends. Standardized re-measurement years, for example, after 1, 2, and 5 growing seasons, would have facilitated a better comparison of results.

The largest sample sizes occur in the first two years; however, this information does not accurately reflect the environmental effects that cause mortality because seedlings of that age may still be benefiting from nursery influences. Mortality trends can be highly variable; i.e., rapid early mortality vs. prolonged chronic losses reflect an interaction between a number of factors such as species, climatic conditions, stock type, and the expression of other limiting factors. The variability in survival, even within the early years, is great enough to frustrate further analysis of specific combinations such as species and stock type.

Overall Survival

Since 1987, for the province of British Columbia overall, the average seedling survival two years after planting has been greater than 85% (BCMoF 2000).

Overall survival in the Coast–Interior Transition was 83% in Year 1 and 75% in Year 2. Thereafter, survival ranged from 52 to 74% for all trees in the SSS and RPA datasets (**Figure 1** and **Table 3**). By smoothing out the irregularity in survival after Year 2, survival trended to 65% at Year 5 (Figure 1).

Biogeoclimatic Subzone and Site Series

The ESSFmw subzone had the best survival (Table 3). Survival was slightly lower in the IDFww than in other zones. The largest sample size occurred in the IDFww, accounting for almost half of the established trees. Poorer survival was observed in the IDFww 04, and slightly better survival was observed in the CWHds1 03 and CWHms1 01 **(Table 4)**. A further breakdown of just Douglas-fir by site series showed similar results to Table 4, except that survival in the IDFww 04 was slightly lower. Generally, it is difficult to identify problematic site series because of the sampling variability.

Tree Condition and Pests

The proportion of trees tallied as in 'good' condition was 60% or better for Years 1, 2, and 5. The proportions of fair and poor trees were small **(Figure 2)**. Most of the damage to trees occurred in the first two years, and then declined. The decline in 'good' seedlings in Year 3 may be related to trees outgrowing the 'nursery effect'. The leading causes of damage were browsing by deer, herbaceous competition, stem disease, and drought **(Table 5)**.

Species

The best survival, after two years, occurred with ponderosa pine and Engelmann spruce, and the poorest survival was observed with western white pine and western larch. Douglas-fir survival was below average, and this species comprised more than two-thirds of the re-measured trees. It is difficult to identify problematic species because of the high variability in survival, and small sample sizes **(Table 6)**.

Stock Type

Bare root stock comprised <10% of all the established seedlings. Survival of bareroot stock and large container stock was relatively good, while small container stock had slightly poorer survival **(Table 7)**. This supports a general trend toward improved performance with larger stock (e.g., Newton et al. 1993).

Planting Year and Season

The RPA data established in 2000 show substantially improved early survival. However, Douglas-fir still falls below the average; this is a concern because Douglas-fir is the most commonly planted species in the Coast–Interior Transition. The SSS data do not show any clear improvement in survival in recent years **(Table 8)**. The dip in third-year survival, regardless of the planting year, is unexplained, and is likely due to variation in the dataset. Survival over the first three years was substantially better for spring planting compared to fall planting **(Table 9)**. Comparisons between planting seasons are suspect at older ages because of small sample sizes.

Regeneration Delay

No strong relationship could be established between regeneration delay and survival. Survival decreases as planting delay increases for the SSS dataset; however, this accounts for

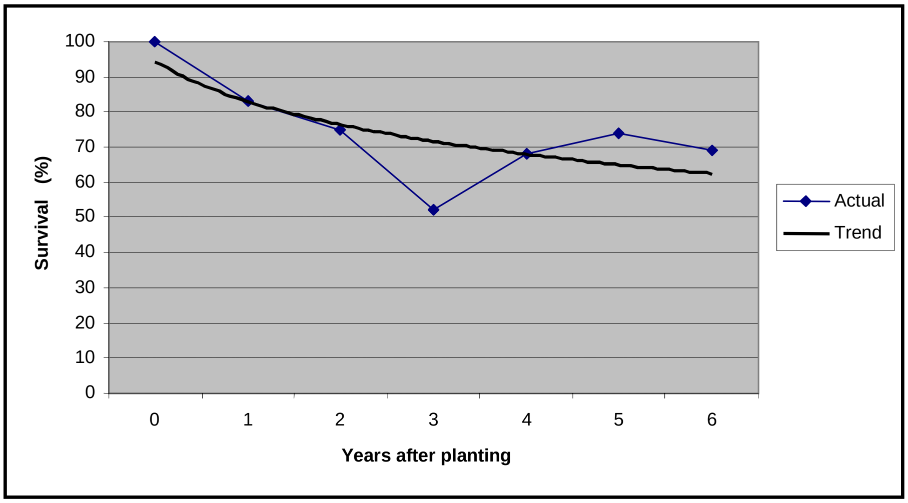

Figure 1. Average survival of all seedlings over six years.

Table 3. Survival and sample size of all trees, by biogeoclimatic subzone.

Subzone	Survival							Sample size						
	Year 0 (%)	Year 1 (%)	Year 2 (%)	Year 3 (%)	Year 4 (%)	Year 5 (%)	Year 6 (%)	Year 0 (no.)	Year 1 (no.)	Year 2 (no.)	Year 3 (no.)	Year 4 (no.)	Year 5 (no.)	Year 6 (no.)
CWHds1	100	76	84	51	72	73		3 155	1 055	1 155	600	900	500	
CWHms1	100	81	76	57		62	68	3 887	1 592	1 040	500		495	600
ESSFmw	100	99	76		81	90	73	1 996	496	1 147		400	300	100
IDFww	100	82	70	50	57	76		7 474	2 494	2 994	900	800	600	
All trees	100	83	75	52	68	74	69	16 512	5 637	6 336	2 000	2 100	1 895	700

Table 4. Survival and sample size of all trees by biogeoclimatic site series (sample size n>100).

Subzone and site series	Survival							Sample size						
	Year 0 (%)	Year 1 (%)	Year 2 (%)	Year 3 (%)	Year 4 (%)	Year 5 (%)	Year 6 (%)	Year 0 (no.)	Year 1 (no.)	Year 2 (no.)	Year 3 (no.)	Year 4 (no.)	Year 5 (no.)	Year 6 (no.)
CWHds1														
01	100	25						200	200					
03	100	97	88	63	70	68		1 600	300	700	200	800	400	
04	100	81	71	39				855	255	155	300			
05	100		87					200		200				
06	100	80						200	200					
CWHms1														
01	100	96	88	69		70		1 687	492	440	400		395	
04	100	89	55				80	500	300	200				200
05	100	66	71				56	1 100	500	300				300
ESSFmw														
01	100	100	96					196	196	147				
04	100	97	70		81	89		1 600	300	1 000		400	200	
IDFww														
01	100	92	68	30				1 894	394	894	200			
03	100	75	82	63	61	94		3 180	1 100	1 100	300	200	300	
04	100	82	60	49	57	57		2 400	1 000	1 000	400	500	300	

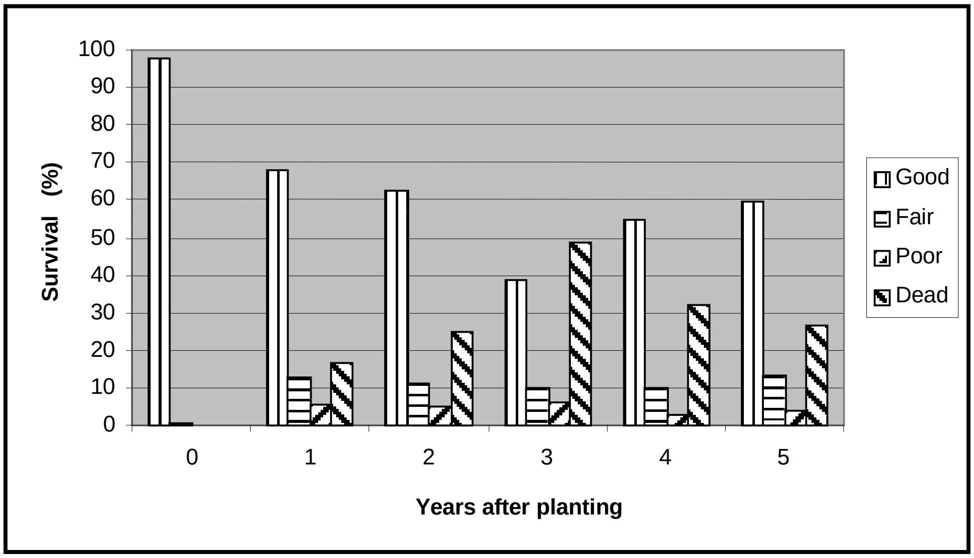

Figure 2. Condition of all trees.

Table 5. Summary of pest damage.

Pest	Total %	Total no.	Year 0 (no.)	Year 1 (no.)	Year 2 (no.)	Year 3 (no.)	Year 4 (no.)	Year 5 (no.)	Year 6 (no.)
Deer	19.8	827	16	222	302	147	111	29	
Unidentified	19.1	795		151	279	120	77	168	
Herbaceous competition	13.8	576	9	236	94	104	8	30	95
Stem disease	12.1	503	20	165	211	29	37	34	7
Drought	5.6	234	5	229					
Snow	5.0	210			102	32	10	43	23
Foliage disease	4.1	170	20	107	13		7	21	2
Dieback disease	4.1	169	1	100	37	13		10	8
Shrub competition	3.7	156			10	44	36	32	34
Chemical injury	3.5	145			42	7	96		
Fire	2.4	100			100				
Logging wound	2.3	97			97				
Vegetation press	1.2	50		6	11	33			
Other <1%	3.3	137	24	21	31	22	28	11	
Total	100	4 169	95	1 237	1 329	551	410	378	169

only 8% of the variation. The average third-year survival for Douglas-fir seedlings that were planted 1–6 years following harvest is quite variable, as shown in **Figure 3**.

Aspect

There is a trend toward survival increasing from south and west to east and north **(Figure 4)**. No relationship was found between increasing elevation and survival.

CONCLUSIONS AND RECOMMENDATIONS

This extension note summarizes an analysis of the results of staked seedling-survival surveys that were established in the Coast–Interior Transition between 1986 and 1998.

Interpretation of the SSS dataset is limited by high variability and inconsistent sample sizes. Nearly 17 000 seedlings were staked at establishment. Approximately a third of the seedlings were sampled for each of the first two years, and then re-measurement sample sizes declined over time. The quality of the dataset does not permit detailed analysis of specific factors that affect survival.

Survival was 82 and 73% for the first two years, respectively, and then trended to 65% at Year 5.

Most of the damage to trees occurred in the first two years, and then declined. The leading causes of damage were browsing by deer, herbaceous competition, stem disease, and drought.

Table 6. Survival and sample size of all trees, by species (sample size n>100).

Species	Survival							Sample size						
	Year 0 (%)	Year 1 (%)	Year 2 (%)	Year 3 (%)	Year 4 (%)	Year 5 (%)	Year 6 (%)	Year 0 (no.)	Year 1 (no.)	Year 2 (no.)	Year 3 (no.)	Year 4 (no.)	Year 5 (no.)	Year 6 (no.)
Ba	100					88		400					200	
Cw	100	71	83		67		57	1,200	600	400		200		200
Fd	100	82	72	51	59	74	66	10 036	4 441	3 889	1 600	800	1 395	300
Lw	100		71		42			1,080		400		200		
Pw	100		61					300		200				
Py	100		83		82			1,100		400		400		
Sx	100	99	82		83		86	2 196	296	847		400		200
All trees	100	83	75	52	68	74	69	16 312	5 337	6 136	1 600	2 000	1 595	700

Table 7. Survival and sample size of all trees, by stock type (sample size n>100).

Stock type	Survival							Sample size						
	Year 0 (%)	Year 1 (%)	Year 2 (%)	Year 3 (%)	Year 4 (%)	Year 5 (%)	Year 6 (%)	Year 0 (no.)	Year 1 (no.)	Year 2 (no.)	Year 3 (no.)	Year 4 (no.)	Year 5 (no.)	Year 6 (no.)
Bareroot	100	76	85		75		84	1 550	500	700		300		300
PSB.313A	100	59	68	27	49	53		2 550	1 100	500	400	300	300	
PSB.313B	100	83	61	67	69	85	66	3 235	1 355	1 055	400	800	600	300
PSB.410	100			30				400			200			
PSB.415B	100	81	69			77		4 644	1 049	2 195			695	
PSB.415D	100	99	85	65	69	61		3 333	1 233	1 586	700	500	200	
All trees	100	83	75	52	68	74	69	15 712	5 237	6 036	1 700	1 900	1 795	600

Table 8. Survival and sample size of all trees, by planting years (sample size n>100).

Planting year	Survival							Sample size						
	Year 0 (%)	Year 1 (%)	Year 2 (%)	Year 3 (%)	Year 4 (%)	Year 5 (%)	Year 6 (%)	Year 0 (no.)	Year 1 (no.)	Year 2 (no.)	Year 3 (no.)	Year 4 (no.)	Year 5 (no.)	Year 6 (no.)
1987	100	84	73			74		855	855	855			400	
1988	100	59			70	72		1,200	800			400	300	
1989	100	25	71		74	64		700	200	700		400	200	
1990	100	91	88	62	79	92		2,100	1 300	700	300	600	200	
1991	100	87	86	63	54			2,780	700	1 200	300	400		
1992	100	91	76	22		90	81	1,500	500	200	200		300	300
1993	100		52	41			56	1,900		700	400			300
1994	100		66	77		71		1,800		400	200		300	
1995	100		72					795		395				
1996	100	5		55				700	200		400			
1997	100		28					900		400				
2000	100	99	94					882	882	686				
All trees	100	83	75	52	68	74	69	16 112	5 437	6 236	1 800	1 800	1 700	600

Table 9. Survival and sample size of all trees, by planting season.

Planting season	Survival							Sample size						
	Year 0 (%)	Year 1 (%)	Year 2 (%)	Year 3 (%)	Year 4 (%)	Year 5 (%)	Year 6 (%)	Year 0 (no.)	Year 1 (no.)	Year 2 (no.)	Year 3 (no.)	Year 4 (no.)	Year 5 (no.)	Year 6 (no.)
Spring	100	85	79	58	67	73	68	12 169	4 294	4 589	1 500	1 600	1 495	600
Fall	100	75	63	34	71	75	73	4 343	1 343	1 747	500	500	400	100

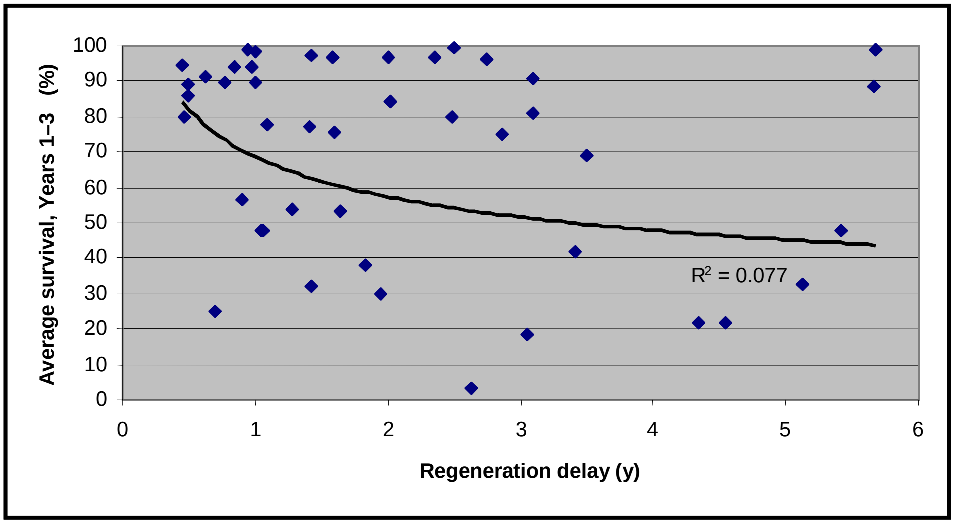

Figure 3. Average survival of Douglas-fir for Years 1 to 3, vs. regeneration delay (n=45).

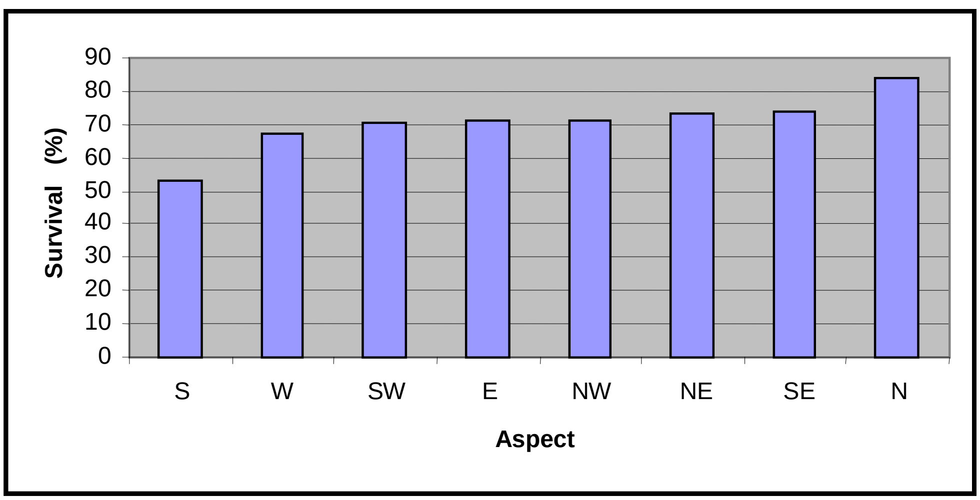

Figure 4. Survival vs. aspect.

While it was difficult to identify problem sites series because of high variation, poorer survival was observed in the IDFww 04, and slightly better survival was observed in the CWHds1 03 and CWHms1 01.

Again, it was difficult to make comparisons among species due to variable sample sizes. Douglas-fir comprised more than two thirds of the re-measured trees, and survival was below average for the dataset. The best survival was observed with ponderosa pine and Engelmann spruce, and the poorest survival was observed in western white pine and western larch.

The dataset did not yield clear trends on the effects of stock type, regeneration delay, or elevation on survival. Trees planted in 2000 showed substantially improved early survival, and it is expected that the recent RPA survey data will yield better results than the older SSS data. However, Douglas-fir still falls below the average; this is a concern because Douglas-fir is the most commonly planted species in the Coast–Interior Transition. Otherwise, there were no clear trends in improved survival in recent years. There is a trend toward survival increasing from south and west to east and north aspect.

In general, the available data describing plantation survival in the Coast–Interior Transition is poor, making it unexpectedly difficult to quantify the reasons for mortality of planted stock, and to assess performance associated with different silvicultural practices.

More data of better quality are required to determine what the important causes of seedling mortality are, and which silvicultural practices are the most effective. Understanding causes of mortality is important for effective use of regeneration resources. A strategic, designed approach should be adopted with clear objectives whereby resources target specific concerns (i.e., stock types, site series). Existing installations such as research trials, and RPA sites should be maintained and data should be collected consistently, for example, at Years 1, 2, 5, and 10. The RPA format of 49 staked trees should be applied on a larger scale to facilitate adaptive management, and to establish baseline data. The large body of SSS material is mostly too old to salvage, but the sites established since 1997 should be maintained.

KEYWORDS

Seedling survival, plantation performance, Coast–Interior Transition, British Columbia.

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