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Suitability of Native Broadleaf Species for Reforestation in the Cariboo Area of the Southern Interior Forest Region

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Abstract

A study to gather information about the establishment and growth of broadleaf trees, and to compare their performance with that of common conifer species in the eastern half of the former Cariboo Forest Region (now part of the Southern Interior Forest Region), was established in 1993. Black cottonwood, aspen, birch, interior spruce, and lodgepole pine were planted on sites in the ICHwk2, SBSwk1, SBSdw1, SBSdw2, and IDFdk3 biogeoclimatic variants. Conifers were performing well after 10 years, but survival of broadleaves was generally poor and their growth was moderate at best. Broadleaves readily naturally regenerate in the Cariboo following disturbance, however, and generally have better initial growth than conifers. Therefore, these results should not be considered representative of the overall potential of broadleaf trees to contribute to the maintenance of forest health and timber supply in the Cariboo. This paper provides 10 years of results from this study and includes conclusions and recommendations regarding the potential use of planted broadleaf seedlings in the Cariboo.

Introduction

Regeneration of harvested sites in the Cariboo, as in the rest of British Columbia, has traditionally focused on conifer rather than broadleaf tree species. However, broadleaves are a common component of the forest landscape in the Cariboo and recognition of their role in maintaining biodiversity and habitat values, as well as concerns about timber supply, have stimulated interest in their management. The most common broadleaf tree species in the Cariboo, in descending order of abundance, are trembling aspen (*Populus tremuloides* Michx.), paper birch (*Betula papyrifera* Marsh.), and black cottonwood (*Populus balsamifera* spp. *trichocarpa* (T. & G.) Brayshaw). Together these broadleaves form 2% of the total mature forest volume in the former Cariboo Forest Region (B.C. Ministry of Forests 1990).

From a forest management perspective, broadleaf trees grow more quickly than conifers and reach merchantable size at an earlier age. Broadleaves could also provide a regeneration alternative to conifers on some sites in the Cariboo. They

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are more resistant than most conifers to *Armillaria* root disease (*Armillaria ostoyae* (Romagnesi) Herink) (Sutherland and Hunt 1990), which occurs commonly in the transition between the Sub-Boreal Spruce (SBS) and Interior Cedar–Hemlock (ICH) zones. They also are more frost tolerant than many conifers, especially Douglas-fir (Klinka et al. 1999), which is an important consideration for the dry, cold sites that are common in the Cariboo (Steen and Coupé 1997). Mature broadleaf tree canopies also provide frost protection to understorey conifer seedlings (DeLong 2000) because of reductions in nighttime radiative heat loss (Stathers 1989). Additionally, broadleaves cycle nutrients and enhance soil properties as a result of annual leaf fall (Pastor 1990; Simard 1990). Black cottonwood can also be important to the stabilization of alluvial floodplains and riverbanks (Haeussler et al. 1990).

A study was established in 1993 to compare survival and growth of native broadleaf and conifer tree species on a range of sites in the Central Cariboo, Quesnel, and 100 Mile Forest Districts of the Southern Interior Forest Region. Although the practice of planting broadleaf seedlings is not common in British Columbia (B.C. Ministry of Forests 1998), the decision was made to use planted broadleaf stock in this study to facilitate the comparison with planted conifers, and so that all broadleaf species could be included on each site at the desired spacing and density. Broadleaf trees regenerate easily by natural means, and it was not anticipated that survival and growth of planted stock would differ substantially from that of naturals. The specific objectives of the study were:

1. Compare the survival and growth of three native broadleaf species (trembling aspen, paper birch, and black cottonwood) to that of lodgepole pine and interior spruce or Douglas-fir on five sites in the Cariboo area of the Southern Interior Forest Region.
2. Study the susceptibility of the broadleaf species to specific damaging agents, including insects, disease, large and small mammals, and frost.
3. Study the susceptibility of the broadleaf species to root disease.
4. Gather information regarding appropriate spacing for broadleaf growth.
5. Study the long-term effects of broadleaf trees on soil nutrient status.

Methods

Five study locations were selected across a range of Cariboo ecosystems (Table 1). The sites were prepared in 1992. In the spring of 1993, five tree species (aspen, birch, cottonwood, interior spruce, lodgepole pine) were planted at a 2.5-m spacing (1600 stems/ha) at each site, with the following exceptions: a) Douglas-fir was substituted for interior spruce at Meadow Lake because spruce is not a preferred planting species in the IDFdk3, b) two hybrid poplar strains were planted in addition to the other species at the 13A Road site, and c) additional spacing treatments of 800 and 3200 stems/ha were installed at the Crooked Lake site. Seed selection guidelines were adhered to for conifer seedlings, but seed sources for broadleaf trees were limited. Locally collected birch seed proved to have low viability, making it necessary to use seedlots from the Prince George and Salmon Arm areas. Female aspen clones could not be located at each site, and so all aspen seed was collected from a single clone near Williams Lake. Cottonwood cuttings were collected from a single site near Likely.

Measurements were conducted in 1993, 1994, 1995, 1997, and 2002. All assessments took place in August/September after conifer growth was complete. Height, ground-level diameter, vigour, condition, damage cause, and competitive status were assessed for all trees.

Results

Survival and growth results in this study were confounded by unexpected human activities and natural events, which varied from site to site. The confounding effects were related to natural causes at two sites: a) moose browse at the 13A Road site, and b) competition from natural aspen at the Big Lake site; and to human error at two sites: a) grass seeding and horse damage at the Crooked Lake site, and b) accidental herbicide damage at the Alex Fraser site. The generally poor survival and performance of planted broadleaf trees, along with the presence of confounding factors, has made it impossible to fully achieve the long-term study objectives. Nonetheless, short-term results regarding performance of planted stock are of interest.

Survival and growth

Black cottonwood After 10 years, cottonwood survival was moderate at the 13A Road site (69%) and poor at all other sites (16–42%) (Figure 1a). At the Crooked Lake and Alex Fraser sites, the steepest decline in survival occurred between years 1 and 3 after planting. Livestock grazing caused damage at the Alex Fraser site in the first 2 years after planting, and accidental herbicide damage was also sustained at that site in the fourth growing season, both of which may have contributed to the poor survival. At the Crooked Lake site, competition from seeded grass is most likely responsible for the early decline in cottonwood survival. At Big Lake and Meadow Lake, which are the

TABLE 1 *Study site characteristics*

	Crooked Lake	13A Road	Big Lake	Meadow Lake	Alex Fraser Research Forest
Mapsheet	93A027	93A081	93A031	92P032	93A042
Forest District	Central Cariboo	Quesnel	Central Cariboo	100 Mile	Central Cariboo
BEC variant	ICHwk2	SBSwk1	SBSdw2	IDFdk3	SBSdw1
Elevation (m)	1000	975	900	1050	1000
Aspect	south	n/a	n/a	n/a	southwest
Slope (%)	10–20	0–5	0	0	25–40
Moisture regime	mesic to subhygric	mesic	mesic	mesic	submesic to subhygric
Site preparation	broadcast burn – fall 1992	broadcast burn – spring 1992	winged subsoiler – fall 1992	winged ripper tooth – fall 1992	disc trencher – fall 1992
Mean annual precipitation (mm)	842	719	585	355	585
Mean annual temperature (°C)	4.0	2.4	3.7	2.8	3.7
Frost-free days	165	117	152	122	152

two driest sites in the study, mortality occurred gradually over time. Cottonwood has its best growth where soil conditions are moist (Klinka et al. 1999), which suggests that lack of available soil moisture may have contributed to poor survival, height growth, and diameter growth at Big Lake and Meadow Lake (Figures 2 and 3). After 10 years, height and diameter of cottonwood at these sites was less than half that measured at the wetter Crooked Lake and 13A Road sites. Approximately 60% of cottonwood seedlings at Meadow Lake had dead terminal buds in year 10, which may also be related to the dry conditions.

Aspen Ten years after planting, aspen survival was good at the two driest sites (79% at Big Lake and 83% at Meadow Lake), and poor at all other sites (21–32%) (Figure 1b). Survival was lowest at the Alex Fraser site (21%), where seedlings were heavily grazed by cattle in the first 2 years after planting and later accidentally damaged during an adjacent spot herbicide application. Aspen survival declined steadily over time at Crooked Lake and 13A Road, possibly because of the combined effects of physical damage (mainly bent stems) inflicted by heavy snow loads and browsing by big game (primarily moose). Livestock grazing (primarily horses) also occurred on the Crooked Lake site. Despite the poor survival at these sites, height and diameter growth of surviving seedlings were better than in the drier ecosystems. After 10 years, aspen was approximately twice as tall at Crooked Lake and 13A Road than at any of the other sites (3.5–4 m tall compared to approximately 2 m tall at the other sites) (Figure 2). Aspen diameter was also approximately twice as large at the Crooked Lake and 13A Road sites (approximately 5 cm versus <2.5 cm at the other sites) (Figure 3).

Birch Birch survival after 10 years was good at the 13A Road site (80%) despite the 90% incidence of browse damage (most likely by moose), and was poor at all other sites (<40%) (Figure 1c). It is interesting that cottonwood and aspen sustained much less browse damage than birch at the 13A Road site. Birch survival was lowest at Meadow Lake (8%), possibly because of the dry site conditions, and was also very low (16%) at the Crooked Lake site, where competition from seeded grass and occasional horse grazing occurred following planting. In year 10, birch was taller at Crooked Lake (356 cm) than at other sites, and also had larger diameters (5.2 cm). Birch was considerably shorter at the 13A Road (187 cm) than the Crooked Lake site, but this is probably due to browse damage, since diameters were relatively large (4.0 cm). The poorest birch height and diameter growth occurred at the driest sites, Big Lake and Meadow Lake (Figures 2 and 3). Seedlings at these sites were 62 and 25 cm tall, respectively, after 10 years and had stem diameters of ≤1 cm. Although some browse damage was recorded, the slow growth is more likely related to the dry conditions.

Hybrid poplar Hybrid poplar was tested in this study because of its known potential for rapid growth. Two relatively frost-hardy hybrid poplar strains were selected and planted at the 13A Road site, but survival was poor for both after 10 years (1% for hybrid 1 and 36% for hybrid 2). Despite the attention to selecting frost-hardy strains, most of the hybrid 1 stock died within 5 years of planting, as a result of frost damage. Mortality among hybrid 2 seedlings was also attributed primarily to frost or winter damage, although hybrid 2 was not as sensitive as hybrid 1. A small number of hybrid 2 received browsing damage as well. Growth was poor among surviving hybrid 2 seedlings (mean height of 125 cm and mean diameter of 2 cm), and, in many cases, basal sprouting was observed where the main stem had been damaged. Growth could not be evaluated for hybrid 1 because of the low survival.

Interior spruce After 10 years, spruce survival was good at all sites where it was planted (80–99%) (Figure 1d), and most stems were of good or moderate vigour, despite the fact that 32% of stems at the Big Lake site and more than 80% at the other three sites were affected by Cooley spruce gall adelgid (*Adelges cooleyi* Gill.). Spruce had its best height and diameter growth at the Crooked Lake site (246 cm tall with 6.4 cm diameter), and were smallest at the Big Lake site (150 cm tall with 2.6 cm diameter) (Figures 2 and 3). Unlike pine, spruce did not tend to be taller than the broadleaf trees.

Lodgepole pine Ten-year lodgepole pine survival was moderate to good at all sites (72–98%) (Figure 1e). The lowest survival was at the Alex Fraser (72%) and Crooked Lake (76%) sites, with most mortality occurring within 2 years of planting. At the Alex Fraser site, water-receiving areas supported abundant growth of herbaceous vegetation, and, at the Crooked Lake site, grass seeding resulted in dense growth of grass. These observations suggest that some of the mortality at these sites may have been related to vegetation competition. Lodgepole pine tended to be relatively healthy at all sites, although mottled foliage due to unknown causes was common. Height and diameter growth were variable amongst study sites, with the best growth occurring at the Crooked Lake and 13A Road sites, where

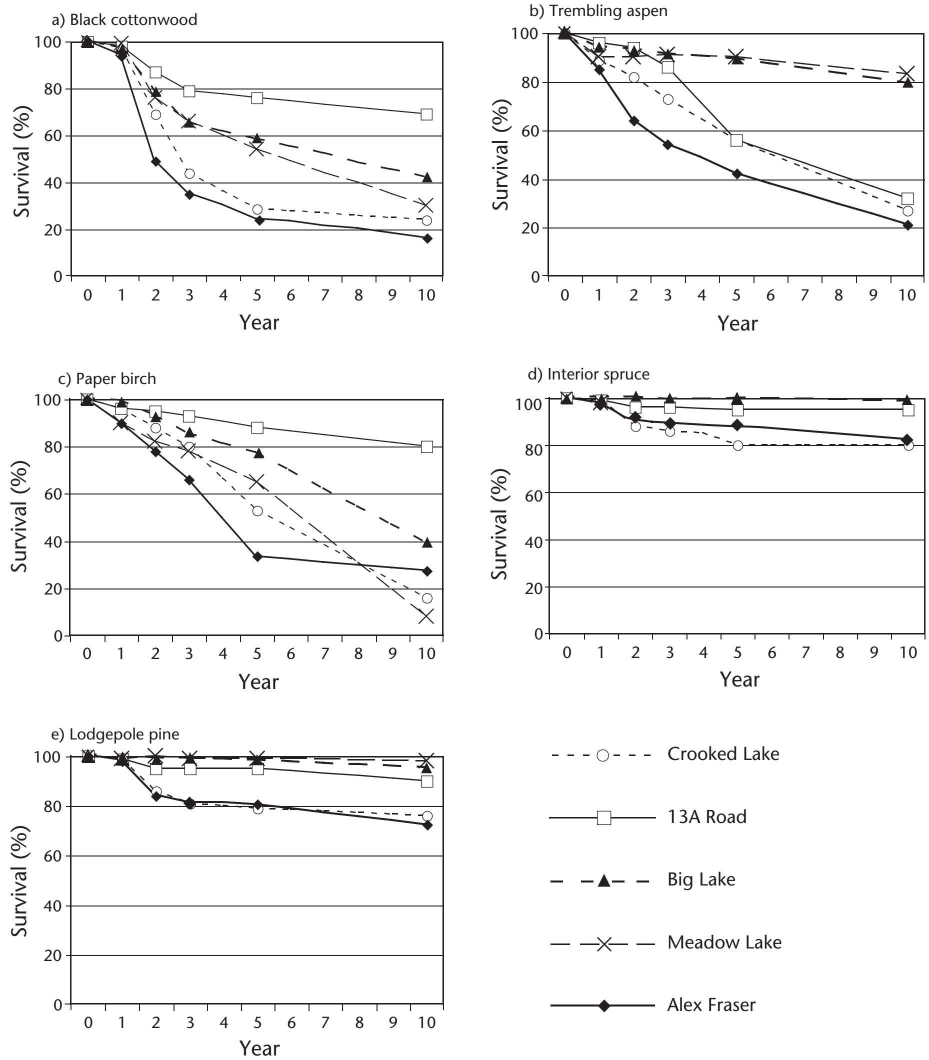

FIGURE 1 *Ten-year survival of a) black cottonwood, b) trembling aspen, c) paper birch, d) interior spruce, and e) lodgepole pine.*

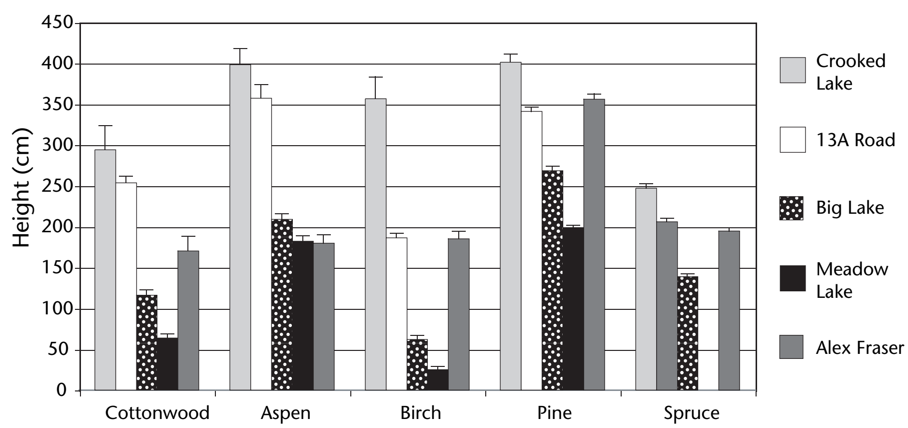

FIGURE 2 *Ten-year height growth of black cottonwood, aspen, birch, lodgepole pine, and interior spruce seedlings at the five research sites. Spruce was not planted at Meadow Lake. Error bars represent 1 standard error.*

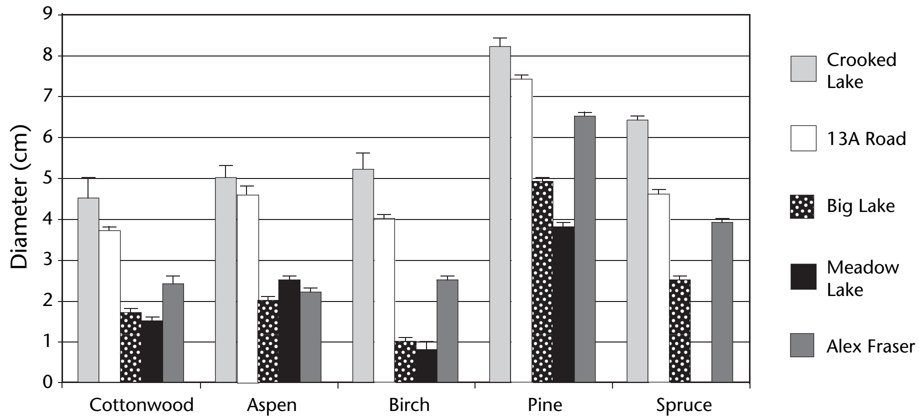

FIGURE 3 *Ten-year diameter growth of black cottonwood, aspen, birch, lodgepole pine, and interior spruce seedlings at the five research sites. Spruce was not planted at Meadow Lake. Error bars represent 1 standard error.*

moisture availability was greatest. The slowest growth was at the two driest sites—Meadow Lake and Big Lake. After 10 years, pine was taller than cottonwood, birch, and spruce at most sites, but tended not to be taller than aspen (Figure 2). Pine tended to have larger stem diameters than all broadleaf trees (Figure 3).

Douglas-fir Douglas-fir was planted only at the Meadow Lake site, and, after 5 years, survival was poor because of frost damage (41%). Mortality decreased only slightly between years 5 and 10 (38% in year 10) but most trees were in poor condition at that time. Mean height and diameter of Douglas-fir 10 years after planting were 19 and 1.1 cm, respectively.

Spacing effects

The effects of spacing were tested at the Crooked Lake site for cottonwood, aspen, birch, pine, and spruce planted at intervals of 1.7, 2.5, and 3.5 m. After 10 years, there were no differences in height or diameter as a result of spacing differences for any of these species. No differences were expected at this age because seedlings were not yet competing for growing space at any of the spacings. Survival differed by up to 16% between spacing treatments for individual species, but there were no consistent trends.

Broadleaf damaging agents

Browse damage that removed foliage and branch tips commonly affected 20–40% of broadleaf seedlings (Figure 4). Stem forking was also common (Figure 5), and was often the result of browse damage. These two types of damage are considered important in juvenile stands because of potential growth losses and the development of poor form.

Discussion and Management Recommendations

The original objectives of this project were to gather long-term information about broadleaf tree growth and the effects of these species on forest health. We intended to make comparisons with common conifer species in order to investigate both the role of broadleaf trees in forest systems and their potential to augment the Cariboo timber supply. Broadleaves that had been grown in forest nurseries, although not commonly used in operational forestry in British Columbia, were planted in this experiment so

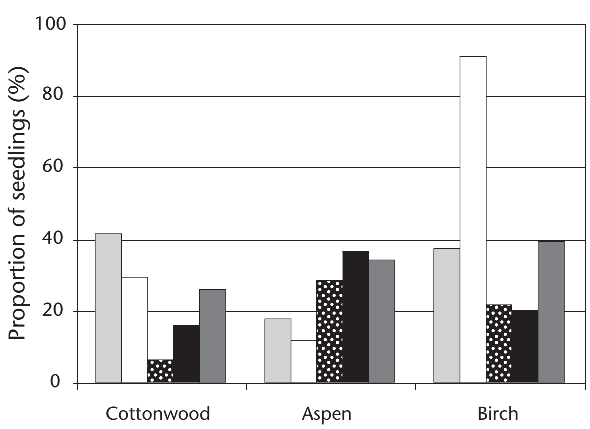

FIGURE 4 *Proportion of broadleaf seedlings having browsed foliage or branch tips in the tenth-year assessment.*

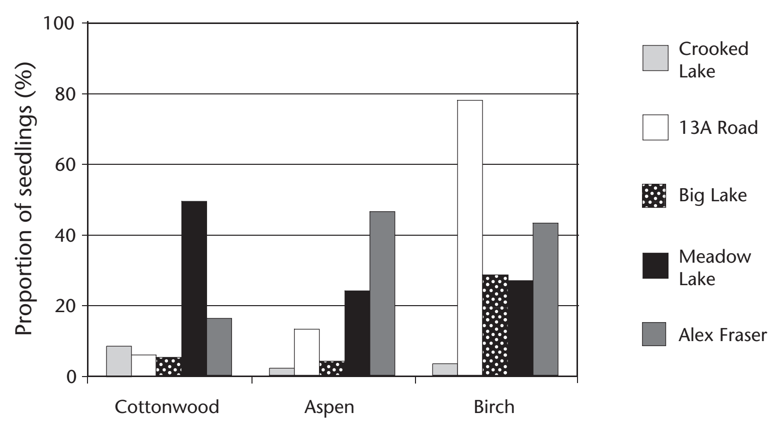

FIGURE 5 *Proportion of broadleaf seedlings having forked stems in the tenth-year assessment.*

that age, spacing, and density could be regulated. It was not anticipated that performance of planted broadleaves would differ substantially from that of naturally regenerated seedlings. However, the survival of planted broadleaves was generally so poor that it became impossible to address long-term objectives related to broadleaf damaging agents, effects on root disease and soil nutrient status, and spacing effects. A range of factors, not the same at each site, is thought to be responsible for the poor survival. These include: a) wildlife browsing, b) grass competition as a result of seeding, c) cattle and horse grazing, and d) herbicide damage.

In our study, birch tended to sustain more damage from wildlife browse than aspen or black cottonwood, which is consistent with observations made during provincial provenance trials. In those trials, the severity of browse hazard decreased in the order of birch>aspen>black cottonwood. It was also observed that birch seedlings that had been browsed repeatedly and then guarded from browse for 1–2 years were able to progress from saplings to trees within an additional 5–6 years.[1] Wildlife browsing is a common phenomenon in naturally regenerated broadleaf stands, but the effects are diluted by high stem densities. Grass competition was probably also critical to survival and performance of broadleaf seedlings on some sites in our study. Birch, aspen, and black cottonwood are all very sensitive to herbaceous competition, especially from grasses.[2] It is also possible that shoot and root characteristics of the broadleaf container stock influenced their performance after outplanting. Growers had very little experience producing broadleaf stock in 1993; and much more is currently known. Although seed and/or cuttings from non-local sources were used to grow the stock that was planted in 1993, British Columbia provenance trial results suggest that this is unlikely to have been a factor in the poor performance following outplanting.[3]

This study produced survival and growth results for planted broadleaf seedlings that are clearly not representative of the potential that has been observed among naturally regenerated aspen, birch, and cottonwood. In their juvenile forms, these species commonly overtop most conifers under full light conditions, and are recognized competitors in British Columbia (Kimmins and Comeau 1990; Simard et al. 2001; Newsome et al. 2003). In naturally regenerated SBSdw and IDFdk stands of the Cariboo, aspen generally overtop lodgepole pine in juvenile stands (Newsome et al. 2003, 2004). In contrast, 10-year-old pine in all ecosystems of our study were as tall as or taller than aspen, and much taller than cottonwood and birch. Spruce tended to be taller than cottonwood and birch, except at the Crooked Lake site, where surviving broadleaf trees exhibited their best growth. Informal observations made in this study suggest that the only microsites where broadleaves outperformed conifers occurred on compacted skid trails, but these observations are contradicted by another Cariboo study, in which aspen planted on landings in similar climates performed poorly.[4]

Lodgepole pine and interior spruce had moderate to good survival in this study, and, in keeping with the results of other studies (e.g., Newsome et al. 2003), had greater height and diameter growth on sites in moist climates. Douglas-fir survival and growth at the Meadow Lake site (IDFdk3) were poor as a result of heavy frost damage, which is also a common problem in many Cariboo ecosystems. In contrast to spruce and pine, broadleaf survival was highly variable across the five study sites. We attribute this to differences in growing environment, as well as to the confounding effects described above. Aspen tended to survive well in the drier ecosystems and poorly in the wetter ecosystems, whereas birch and cottonwood survived poorly everywhere except the 13A Road site (SBSwk1). By year 10, broadleaf survivors, in a manner similar to that of spruce and pine, tended to have the greatest height and diameter growth on the sites with greatest moisture availability.

At present, although the management of mixedwood and pure broadleaf tree stands is of interest, there is little potential or need for planted broadleaves to contribute to timber production in British Columbia's interior. Broadleaf volume currently harvested is obtained from natural regeneration. Planting of broadleaf tree species can be successful, but it is currently a more costly and risky option than planting conifers. At present, broadleaf seedlings are most commonly grown for site restoration projects.

Despite the poor survival of planted broadleaf trees in this study, some conclusions and recommendations can be made:

1 M. Carlson, Kalamalka Forestry Centre, B.C. Ministry of Forests, Vernon, B.C., pers. comm., Feb. 2005.

2 Ibid.

3 Ibid.

4 B. Chapman, unpublished data, 2003, B.C. Ministry of Forests, Williams Lake, B.C.

1. Planted trembling aspen is more likely to survive in dry ecosystems such as the SBSdw1 and IDFdk3 than in wetter ecosystems such as the SBSwk1 and ICHwk2. All broadleaf species require adequate growing-season soil moisture in order to perform well, but aspen is more tolerant of late-season drought than either birch or cottonwood.[5] Aspen naturally regenerates with ease in most dry Cariboo ecosystems, however, resulting in little need to plant this species.
2. Planted paper birch and black cottonwood are likely to have better survival and growth in wetter ecosystems such as the SBSwk1 and ICHwk2 than in dry ecosystems such as the SBSdw1 and IDFdk3. However, both these species appear to be highly susceptible to various damaging agents. In particular, juvenile birch sustained heavy damage from ungulate browsing throughout the 10-year study period.
3. If the need to plant birch, aspen, or black cottonwood seedlings on particular site types arises in the Cariboo, further outplanting trials should be conducted. Nursery practices and experience regarding the production of broadleaf plug stock have improved during the last 12 years, which, coupled with appropriate species selection and management of various damaging agents, could result in better survival and performance than were obtained in this study.
4. Hybrid poplar strains are known to have the potential for rapid growth, but they are unsuitable to Cariboo ecosystems because of their low frost tolerance. For Cariboo sites, native cottonwoods are a better choice than hybrid poplars.

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