Stump height effects on sprouting of mountain maple, paper birch and pin cherry — 10 year results

by Robert Jobidon[1]

Stump sprouting of mountain maple, paper birch and pin cherry was studied in relation to residual stump height. The three-year-old stems were cut at stump heights of 0, 15, 45 and 75 cm in a completely randomized plot design. Two growing seasons after cutting, the percent of stumps with live sprouts was lower for the low stump heights. Two years after cutting, the mean number of sprouts per stump of the three species significantly increased with stump height but the effect was no more significant after 10 years. Initially, total height of the sprouts was significantly greater for the higher stump heights of the three species, which is explained by the point of origin of the sprouts along the stump. After 10 years, this effect was no more significant. Except for pin cherry after the first growing season, the three species produced sprouts of similar vigor during the first 10 years, expressed in terms of both diameter and height growth, among the four stump heights. In view of the increasing stump mortality of these three species after manual or mechanical release treatments of a conifer regeneration, a cut height of 15 cm is recommended. Conversely, increasing stump height will likely favor sprout production, which could be advantageous in wildlife habitat management for browse consumption.

Key words: stump height, vegetation management, sprout production, vegetative reproduction, wildlife habitat

La production de rejets de souches chez le bouleau à papier, l'érable à épis et le cerisier de Pennsylvanie a été étudiée en fonction de la hauteur de coupe. Quatre hauteurs de coupe (0 (niveau du sol), 15, 45 et 75 cm au-dessus du sol) ont été testées sur de jeunes tiges âgées de 3 ans, à l'intérieur d'un dispositif à parcelles complètement aléatoires. Après deux saisons de croissance, les souches supportant le moins de rejets vivants sont associées aux plus petites hauteurs de coupe. Après deux ans, et pour les trois espèces, le nombre moyen de rejets par souche augmente significativement avec la hauteur de coupe; toutefois cet effet n'est plus significatif à la dixième année. Peu après la coupe, la hauteur totale des rejets était significativement plus grande pour les hautes souches, ce qui s'explique par le point d'origine des rejets le long de la souche. Après 10 ans, cet effet n'est plus significatif. À l'exception du cerisier de Pennsylvanie après une saison de croissance, les trois espèces ont produit des rejets de vigueur semblable entre les traitements, tel qu'évalué par les croissances en hauteur et en diamètre. Pour les trois espèces à l'étude, une coupe à une hauteur de 15 cm est recommandée lorsqu'il s'agit de dégager manuellement ou mécaniquement une régénération de conifères de la compétition, en raison d'une proportion plus grande de mortalité des souches, comparativement aux autres hauteurs de coupe. Par contre, des hauteurs de coupe plus élevées sont recommandées lorsqu'il s'agit de favoriser la production de rejets, notamment en aménagement faunique pour la production de brout.

Mots clés: habitat faunique, gestion de la végétation, hauteur de coupe, production de rejets, reproduction végétative

Introduction

Mountain maple (*Acer spicatum* Lam.), paper birch (*Betula papyrifera* Marsh.) and pin cherry (*Prunus pensylvanica* L.f.) are frequently found species on coniferous regenerating sites in eastern North America (Newton et al. 1987). These species are known to flourish following major disturbances such as fire or clear-cutting, which stimulate their seed germination or vegetative reproduction (see Bell [1991] and Jobidon [1995] for reviews of the autecology of those species). Young conifers associated with these species are unable to compete successfully for light, water or nutrients, leading to a failure in the establishment of coniferous regeneration. The competitive advantage of broadleaved species over conifers is well documented, notably for mountain maple (Vincent 1965; Batzer and Popp 1985), paper birch (Gregory 1966; Ahlgren and Ahlgren 1981; Piene 1981; Simard 1990; Ruel 1992) and pin cherry (Ruel 1992; White and Elliott 1992).

Although chemical herbicides are efficient in controlling these competing species (e.g., Sutton 1984; Pitt et al. 1993), their use is decreasing; manual or mechanical release treatments are used increasingly. The efficacy of these treatments, expressed in terms of improved survival and growth of both black spruce and white spruce seedlings, was studied in Quebec in relation to time and repetition of cutting competing hardwood tree species (Jobidon and Charrette 1992). These authors clearly indicated that the abundant and vigorous vegetative reproduction of the competing species, including mountain maple, paper birch, and pin cherry creates conditions unfavorable for the conifers to reach a free-to-grow stage five years after the first manual release treatment. The season of cutting hardwood tree species was also studied to help minimize sprout or root sucker growth, with a view to better control vegetation height along rights-of-way or for reducing competition between undesirable hardwoods and crop species (Wendel 1975; Kays and Canham 1991; Babeux and Maufette 1994). Alternatively, management of wildlife habitat requires sustainable production of available browsing material which could be achieved through vegetative reproduction and growth of preferred species, such as those in this study, considered as commonly browsed by white-tailed deer and moose (Crête and Bédard 1975; Brusnyk and Gilbert 1983; Newton et al. 1989).

Factors other than season of treatment and repeated cuttings can affect vegetative reproduction of the three species under study. For example, stump height affects stump sprouting of hardwood tree species. High stumps have a relatively large surface area available for dormant buds (Crist et al. 1983), but the produced sprouts are associated with a higher incidence of butt rot (Roth and Hepting 1943, 1969; Roth and Sleeth 1939) which

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could impair long-term sprout vigor. In their review of factors influencing coppicing of a large number of species, Blake and Raitanen (1981) pointed out that the high level of variability in sprouting characteristics of different species was notably affected by stump height. For example, increasing stump height in red alder (*Alnus rubra* Bong.) (Harrington 1984) and blue oak (*Quercus douglasii* Hook. & Arn.) (McCreary et al. 1991) significantly decreased stump mortality and led to a greater number of sprouts growing on the higher stumps. Similarly, total number of live sprouts stump^{-1} of American sycamore (*Platanus occidentalis* L.) (Belanger 1979) and swamp tupelo (*Nyssa sylvatica* var. *biflora* (Walt) Sarg.) (DeBell 1971) increased with higher stump height. On the other hand, white birch in the Russian taiga showed more numerous and vigorous sprouts 10 years after cutting at ca. 10 cm from the ground compared to cutting at ca. 1.0 m (Desinov and Desinov 1985). For other species, sprouting is not likely affected by stump height, e.g., sweet chesnut (*Castanea sativa* Mill.) (Cabanettes and Pages (1986) and black cottonwood (*Populus trichocarpa* Torr. & Gray) (De Bell and Alford 1972).

Little or no information is available on the effect of stump height on subsequent sprout growth and development of mountain maple, paper birch, and pin cherry. Such information could help improve: (a) the efficacy of manual or mechanical release treatments of a coniferous regeneration; (b) the maintenance of utility rights-of-way; and (c) vegetation management for wildlife habitat. The objective of this 10-year study was to evaluate the effect of four stump heights (0, 15, 45 and 75 cm) of mountain maple, paper birch, and pin cherry on : 1) the proportion of stumps with sprouts; 2) the number of sprouts per stump; and 3) height and diameter growth of the sprouts.

Methods

The experiment was conducted in eastern Quebec, near the village of Squatec about 120 km east of Rivière-du-Loup. The site is within the sugar-maple –balsam-fir ecological region. The number of degree-days available for growth, estimated at a 5.6°C level, ranged between 1220 and 1440 for the area (Thibault and Hotte 1985). Total annual rainfall averaged 766 mm (Canadian Climate Program 1993). The soil is classified as a humo-ferric podzol (Canadian Soil Survey Committee 1978). The site has the following general characteristics: slope: <10%; aspect: N–W; elevation: 335 m. The site was prepared in fall 1982 with barrels and chains and planted with black spruce in spring 1983. The site was then covered by red raspberry (*Rubus idaeus* L.) and fireweed (*Epilobium angustifolium* L.) in association with a growing cover of mountain maple, paper birch and pin cherry.

In 1985, a completely randomized plot design was established. It included four treatments, each replicated three times. Each of the 15 × 20 m plots represented a stump height of 0 cm (saplings cut at ground level), 15, 45 or 75 cm above ground level. For a given plot, 10 to 15 randomly selected saplings of mountain maple, paper birch and pin cherry were measured. In 1985 (end of growing season), height of these tree species ranged from 68 to 85 cm with a stem diameter measured at 30 cm, varying from 1 to 4 cm. The selected saplings were numbered and identified with a metal tag fixed in the soil at the base of the stump. The manual cutting treatment was completed between 17 and 26 June, 1986.

Table 1. Effect of stump height on the percentage of mountain maple, paper birch and pin cherry stumps with sprouts after two growing seasons, and the *P*-value of the χ^2 statistic.

	Stump height (cm)				
Species	**0**	**15**	**45**	**75**	***P*-value**
Mountain maple	31	22	37	71	< 0.001
Paper birch	35	18	33	73	< 0.001
Pin cherry	69	38	79	89	< 0.001

The numbered stumps were examined in the fall of 1986 (one growing season after treatment), 1987 (two growing seasons after treatment) and 1995 (10 growing seasons after treatment). The percentage of stumps that sprouted, based on the presence of living sprouts, was determined. The number of sprouts originating from each stump was counted. The definition of a stump sprout, as given by Stroempl (1983), was followed in this determination. The three tallest sprouts per stump were measured for length, total height above ground and diameter. Sprout length and diameter were measured 5 cm above the point of origin. Height and diameter growth rates were approximated by dividing the values of length and diameter obtained after 10 growing seasons, by 10. The result was compared to the first and second growing season measurements, as an estimation of reliability. When required to respect the homogeneity of variances, logarithmic or angular transformations of data were applied. The effect of stump height on the percentage of stumps with live sprouts was analyzed by a Chi-square test of independence. Data for sprout number, height and diameter were analyzed using an analysis of variance (ANOVA) to detect significant effects of stump height. When the treatment was significant at $P < 0.05$, treatment means were separated using the Student-Newman-Keuls (SNK) multiple range test.

Results and Discussion

Mountain Maple

Two growing seasons after cutting, low stump heights were significantly associated with a low percentage of stumps with sprouts (Table 1). The proportion of stumps with sprouts ranged from 31 (0 cm cut height) to 71% (75 cm cut height). During the first two growing seasons, the mean number of sprouts per stump significantly increased with the height of the cut (Table 2). This effect was not significant 10 years after treatment. Between the second and the tenth growing season, sprout mortality occurred for the 75-cm cut height; the mean number of sprouts per stump remained almost constant for the three other treatments.

Both length and diameter of mountain maple sprouts were not significantly affected by stump height up to 10 years after cutting (Table 2), which indicates that growth rate was similar among the sprouts regardless of the height of the cut. After two growing seasons, the number of sprouts produced, their diameter and their length were not significantly ($P > 0.14$) correlated with the diameter of the parent stem. After one growing season, the total height of the sprouts on the 75-cm cut stumps was more than twice the total height of those on the 0-cm cut stumps as a result of the height of the point of origin on the stumps. However, total height of the sprouts was not significantly different among treatments, 10 years after cutting. One growing season after treatment, the mean difference between the total height and the length of the sprouts on the 75 cm cut stumps reached 62 cm, which corresponds to the

Table 2. Effect of stump height on selected characteristics of mountain maple sprouts, one, two, and ten growing seasons after cutting, and the *P*-value of the *F* statistic

Growing seasons after cutting	Sprout characteristics	Stump height (cm) 0	15	45	75	*P*-value
1	Number	1.9*a*	1.4*a*	3.4*a*	4.0*a*	0.047
	Diameter[1] (mm)	3.3	3.2	3.5	3.4	0.571
	Length[2] (cm)	27.4	27.4	30.8	30.3	0.341
	Total height[3] (cm)	28.2*a*	32.6*a*	49.8*b*	65.4*c*	< 0.001
2	Number	2.0*a*	1.8*a*	2.8*b*	4.5*c*	0.003
	Diameter[1] (mm)	5.2	4.7	5.1	6.8	0.369
	Length[2] (cm)	62.6	69.0	55.9	77.9	0.428
	Total height[3] (cm)	65.1*a*	74.6*a*	81.7*a*	112.9*b*	0.027
10	Number	1.4	1.9	2.5	2.0	0.185
	Diameter[1] (mm)	21.7	25.2	20.9	25.0	0.609
	Length[2] (cm)	245.5	228.7	235.9	287.2	0.379
	Total height[3] (cm)	247.2	237.0	253.7	329.4	0.101

[1]Stem diameter measured 5 cm above the point of origin.
[2]Length was measured from 5 cm above the point of origin.
[3]Total height was measured from the ground level.
*a–c*For a given growing season after cutting and sprouting characteristic, means followed by the same letter are not significantly different according to the SNK multiple comparison test.

mean height of the point of origin of the sprouts (see Table 2). This indicates that sprouts originated at higher locations on high cut stumps.

Paper Birch

Two growing seasons after treatment, low stump heights were significantly associated with a low percentage of stumps with sprouts (Table 1). The proportion of stumps with sprouts ranged from 35 (0-cm cut height) to 73% (75-cm cut height). During the first two growing seasons, the mean number of sprouts per stump was significantly higher for the high cut stumps, compared to the 0-cm cut height, but the effect of stump height was not significant after 10 years (Table 3). Mean number of sprouts per stump increased during the first two years after cutting and then decreased, indicating that recruitment occurs during the first years followed by a relatively high mortality rate. As suggested by Crist et al. (1983), the fewer number of sprouts observed on the shortest stumps could be attributed to a limited surface area for originating sprouts. Nevertheless, this could not be considered the rule, because a reverse pattern has been noted for species such as *Betula populifolia* (Schrierbeck and Clarke 1940) and white birch in the Russian taiga (Desinov and Desinov 1985). After two growing seasons, only the number of sprouts produced was significantly correlated ($r = 0.39$; $P = 0.011$) with the diameter of the parent stem. This is in accordance with results reported by Perala (1974) who pointed out that the number of paper birch sprouts increased with tree diameter.

Both length and diameter of birch sprouts were not affected by stump height during the first 10 years after cutting (Table 3), which indicates that growth rate of the sprouts was similar among stump heights. A mean annual growth rate of 44 cm was noted in this study, which is comparable to the average of 39 cm reported by Bjorkbom (1972) in Maine, also after ten growing seasons. By the first year, total height of the sprouts on the 75-cm cut stumps is more than twice the total height of those on the 0-cm cut stumps. After the first growing season, the difference between total height and length of the sprouts clearly indicates that sprouts originated at higher locations on high cut stumps.

Pin Cherry

Among the three species studied, pin cherry had the highest percentage of stumps with sprouts two years after cutting (Table 1). At that time, the lowest percentage of stumps with sprouts was found on the 15-cm cut stumps. Although not significant ($P = 0.058$) after the first growing season, the mean number of sprouts per stump increased with stump height during the first two years and was similar among the four treatments by the tenth year after cutting (Table 4). Between the first and the second growing seasons, the mean number of sprouts per stump decreased, but in a greater proportion for the 0-cm and 15-cm stump heights than for the two others.

For the three years of evaluation, sprout diameter growth was not affected by stump height. However, sprout height growth was significantly higher for the 0-cm cut stump than for the 75-cm ones after the first growing season. This effect was no more significant by the end of the second year. After two growing seasons, the number of sprouts produced ($r = 0.30$; $P < 0.01$), their diameter ($r = 0.36$; $P < 0.01$) and their length ($r = 0.26$; $P < 0.01$) were significantly correlated with the diameter of the parent stem. A gross mean annual height growth of 40 cm and diameter growth of 4.4 mm were recorded in this study. According to growth rates reported by Leak (1979) for pin cherry seedings, it appears that growth rates of sprouts is greater by a factor of two. These differences in growth rates between seedlings and sprouts could be of major significance in the timing of application of a manual or mechanical release treatment of a coniferous regeneration with respect to the relative height of the conifers to pin cherry seedlings. Vegetative re-growth of pin cherry will likely be much more vigorous than the previous competing cover of seedling origin, which is susceptible of impairing the efficacy of a manual or mechanical release treatment notably in cases where the conifers are relatively small.

During the first two growing seasons, total height of the sprouts was significantly higher for the 75-cm cut pin cherry stump, compared to the three other treatments, and was similar among the four treatments by the tenth year. As for the two other species studied, the origin of sprouts along the stump is frequently relatively high (Fig. 1), so the mean difference between

Table 3. Effect of stump height on selected characteristics of paper birch sprouts, one, two, and ten growing seasons after cutting, and the *P*-value of the *F* statistic

Growing seasons after cutting	Sprout characteristics	Stump height (cm) 0	15	45	75	*P*-value
1	Number	1.5*a*	1.9*b*	3.6*b*	3.4*b*	0.016
	Diameter[1] (mm)	2.9	2.8	2.8	3.1	0.645
	Length[2] (cm)	30.4	28.2	28.7	29.6	0.985
	Total height[3] (cm)	33.2*a*	34.8*a*	53.7*b*	78.9*c*	< 0.001
2	Number	3.1*ab*	4.5*ab*	2.1*a*	5.0*b*	0.005
	Diameter[1] (mm)	5.5	6.1	6.8	6.5	0.811
	Length[2] (cm)	79.1	76.7	71.5	75.8	0.987
	Total height[3] (cm)	85.5	81.7	106.8	121.3	0.231
10	Number	1.5	2.4	1.1	2.1	0.380
	Diameter[1] (mm)	39.1	42.6	46.3	44.9	0.945
	Length[2] (cm)	484.8	385.4	464.1	414.7	0.604
	Total height[3] (cm)	484.8	388.7	486.3	473.9	0.545

[1]Stem diameter measured 5 cm above the point of origin.
[2]Length was measured from 5 cm above the point of origin.
[3]Total height was measured from the ground level.
*a–c*For a given growing season after cutting and sprouting characteristic, means followed by the same letter are not significantly different according to the SNK multiple comparison test.

Table 4. Effect of stump height on selected characteristics of pin cherry sprouts, one, two, and ten growing seasons after cutting, and the *P*-value of the *F* statistic

Growing seasons after cutting	Sprout characteristics	Stump height (cm) 0	15	45	75	*P*-value
1	Number	5.8	5.3	7.8	8.2	0.058
	Diameter[1] (mm)	3.8	3.9	3.8	3.6	0.568
	Length[2] (cm)	43.3*b*	39.2*ab*	38.1*ab*	34.4*a*	0.032
	Total height[3] (cm)	43.3*a*	47.9*a*	69.2*b*	89.1*c*	< 0.001
2	Number	2.4*ab*	1.9*a*	3.5*bc*	4.4*c*	0.006
	Diameter[1] (mm)	6.7	7.6	7.1	7.6	0.328
	Length[2] (cm)	91.0	99.3	84.7	87.3	0.061
	Total height[3] (cm)	91.1*a*	107.5*ab*	115.2*b*	136.8*c*	< 0.001
10	Number	1.5	1.4	1.2	1.3	0.633
	Diameter[1] (mm)	43.1	49.5	38.4	44.1	0.128
	Length[2] (cm)	417.2	412.5	361.1	413.3	0.256
	Total height[3] (cm)	417.6	424.8	392.1	471.4	0.142

[1]Stem diameter measured 5 cm above the point of origin.
[2]Length was measured from 5 cm above the point of origin.
[3]Total height was measured from the ground level.
*a–c*For a given growing season after cutting and sprouting characteristic, means followed by the same letter are not significantly different according to the SNK multiple comparison test.

total height and length of the sprouts is important and proportional to stump height.

Conclusions and Recommendations

In cases where mountain maple, paper birch, and pin cherry are cut to release a coniferous regeneration from a competitive effect, it is recommended that stems be cut at 15 cm from the ground. At such a height, the occurrence of stumps without sprouts is at a maximum during a 10-year period; for paper birch, a stump height of 0-cm is also recommended. Such a practice will help decrease total production of sprouts and potentially increase the probability of the conifers to form a dominant stand. Nevertheless, care should be taken in manual release treatments of a coniferous regeneration regarding the frequently reported higher growth rates of sprouts and root suckers of many species, compared to their seedlings, leading to the formation of a new competing vegetation cover shortly after the release treatment. In a study conducted in western U.S., Harrington (1984) reported a high level of stump mortality of red alder at low cut stumps heights. At higher stump heights, the point of origin of the sprout along the stump became an important factor, considering total height of the sprouts. During the first two years after cutting, at least, the three species studied showed an increase in the total height of sprouts with an increase in stump height. In any manual release treatment of a conifer regeneration, residual high stumps of the three studied species are likely to provide a competitive advantage to their sprouts over the conifers.

Although the stumps or the sprouts were not dissected to detect the presence of pathogens or any wood decay microorganisms, results obtained in the present study do not support the hypothesis that increasing stump height will favor stump invasion by decay organisms, leading to poor sprout vigor and increased sprout mortality. After two growing seasons, low stump heights had the lowest percentage of stumps with sprouts. After 10 years, no significant differences were found in both diam-

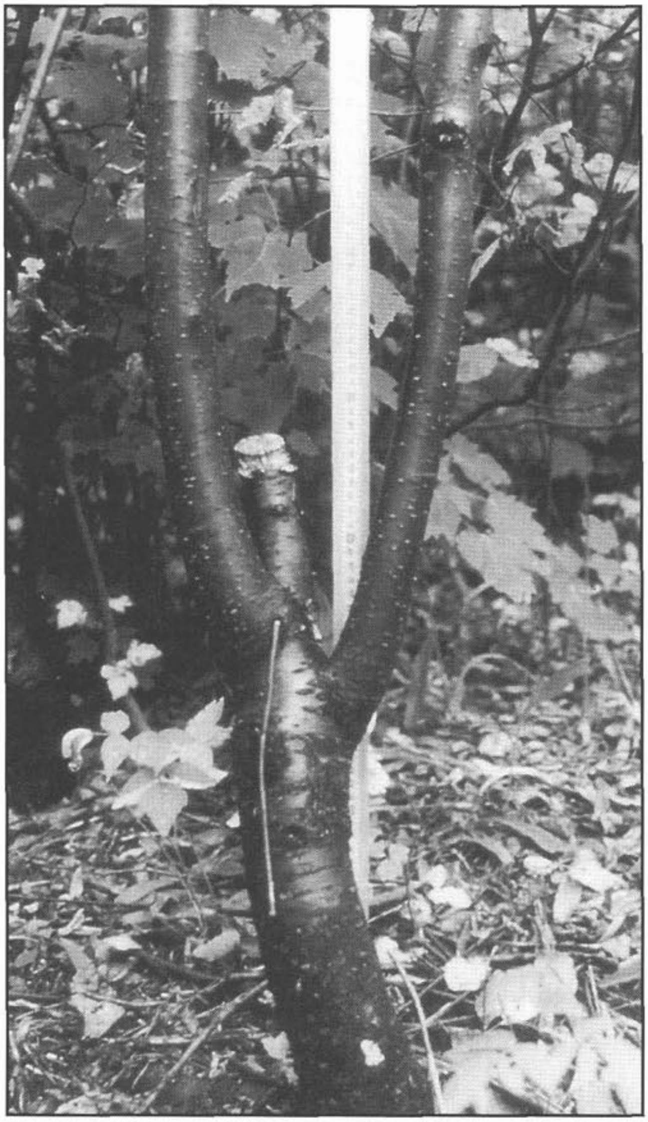

Fig. 1. For high stump heights, the origin of the sprouts is relatively high, giving a competitive advantage to the sprouts over newly released coniferous regeneration.

eter and height growth of the sprouts among the four treatments, indicating that sprout vigor was unaffected by stump height, at least during the time period of this study.

In view of producing browsing material, higher cut stumps permitted the occurrence of a greater proportion of stumps with live sprouts during the first two years, where accessibility is not likely a restricting factor. For example, increasing the height of cut of mountain maple will decrease the time period of browse availability to fawns of white-tailed deer. However, it will increase total vegetation biomass, considering the greater mean number of sprouts per stump, which could be advantageous for adult deer (Rogers and McRoberts 1992).

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