Effects of Crown Release on Growth and Quality of Even-Aged Red Maple Stands

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ABSTRACT: *The effects of six crown-release treatments on growth and bole quality of 54 dominant, codominant, and intermediate red maples* (Acer rubrum L.) *were examined in an even-aged stand in upper Michigan. Treatments included an unreleased control, a single-tree and a two-tree crown release, and a full crown-to-crown release of 5, 10, and 15 ft. Twenty-two years after treatment, all trees showed a decrease in number of defects. Trees released to 15 ft lost twice as many defects as unreleased trees. Codominants and intermediates lost twice as many defects as dominants. Overgrown knots were the most common defects and showed the greatest decrease over time. The number of epicormic branches also declined; dominants had no epicormic branches after 22 years. Growth was greater for all released trees than for unreleased trees. Twice as much growth occurred in the 15-ft treatment as in the control, but this result was not significantly greater than those of the 5- or 10-ft crown release treatments. Dominant trees grew significantly more than the intermediate trees. Twenty-two years after treatment, dominants appeared to be least affected by crown-release but had the fewest defects and largest diameters. Crown-release treatment had the greatest effect on intermediates. To maximize growth and maintain bole quality, a crown release of between 5 and 10 ft is recommended for red maple pole-size trees in the Lake States. North. J. Appl. For. 23(4): 229–233.*

Key Words: Crown release, tree quality, defects, red maple.

Red maple (*Acer rubrum* L.) is one of the most common species in the Lake States. According to recent surveys, red maple accounted for the largest increase in growing stock in Wisconsin and the second largest increase in Michigan (Leatherberry and Spencer 1996, Schmidt 1997). Few studies, however, have examined the effects of management on red maple growth and quality, perhaps due to its reputation as an inferior sawlog species. On poor sites, red maple is susceptible to poor form, defect, and decay, but on good sites, it can grow with good form and quality (Burns and Honkala 1990).

Red maple is intermediate in shade tolerance and can grow on a variety of sites, from droughty upland sands to lowland swamps (Erdmann et al. 1985). Its wood is softer than that of sugar maple but can be substituted in most situations. Thus, if its quality can be maintained, red maple can be a valuable timber species.

Heavy cutting can increase the amount of red maple growth but can also degrade the quality of a stand if epicormic branching occurs. Quality can also be degraded as a result of sprouting, which red maple does prolifically. Alternatively, red maple has responded positively to thinning (Sonderman 1987, Burns and Honkala 1990). Erdmann et al. (1985) found that crown-released red maples had growth increases of up to 70% after 7 years with only small increases in the number of epicormic branches. Studies in West Virginia (Trimble 1974) and in New Hampshire (Marquis 1969) showed that crown-released red maples had almost double the growth rate of nonreleased red maples.

In 1976, a study was established to determine the effects of six crown-release treatments on growth and quality of potential red maple crop trees. Trees were also examined based on crown class: dominant, codominant, or intermediate. In this paper, 22-year results are reported.

Study Area

The study was established in an even-aged northern hardwood stand on the Escanaba River State Forest near Sands, MI. Stem analysis of five dominant red maple trees indicated that the age of the stand was 54 years and that the site index was 63 ft at 50 years. The stand became established after commercial clearcutting and wildfire, which likely eliminated most advance sugar maple regeneration and left huge charred pine stumps. The soil is a Rousseau fine sand (Entic Haplorthod), a weakly developed spodosol, that developed on outwash plains. It transitions to a

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Kalkaska variant (Typic Haplorthod) that is deep and well drained.

Before treatment, the stand contained 530 trees/ac averaging 6.5 in. diameter at breast height (dbh) (4.6 in. dbh and larger) and had 120 ft^2/ac of basal area. The stand was composed primarily of seedling-origin trees with a few sprout clumps. Species composition, obtained from 108 circular 0.05-ac plots, showed that the stand was dominated by red maple, sugar maple (*Acer saccharum* Marsh.), and paper birch (*Betula papyrifera* Marsh.), accounting for 64, 24, and 7% of the basal area, respectively. Other species present included yellow birch (*Betula alleghaniensis* Britton), balsam fir (*Abies balsamea* [L.] Mill.), black cherry (*Prunus serotina* Ehrh.), eastern hemlock (*Tsuga canadensis* [L.] Carr.), aspen (*Populus grandidentata* Michx. and *Populus tremuloides* Michx.), white spruce (*Picea glauca* [Moench] Voss), pin cherry (*Prunus pensylvanica* L.f.), American mountain-ash (*Sorbus americana* Marsh.), and northern red oak (*Quercus rubra* L.).

Methods

Treatments

Crown-thinning treatments were randomly applied to groups of six well-matched trees within each of three crown classes. The six treatments were i) unreleased control, ii) single-tree release, iii) two-tree release, iv) 5-ft release, v) 10-ft release, and vi) 15-ft release. In the single-tree and two-tree treatments, only the most important crown competitor or competitors were cut. In the 5-, 10-, and 15-ft crown-release treatments, all surrounding trees, including intermediate and suppressed trees, whose crowns were within the specified distance of the study tree's crown perimeter were cut. Each treatment was applied to nine red maple crop trees of potential to produce a grade 1 or better sawlog. Within each treatment group, three trees were classified as dominant, three as codominant, and three as intermediate. The crown-release treatments were applied in May 1976 before leaf out. No thinning occurred in the matrix beyond the treatment crown releases.

Quality

As a measure of quality, all stem defects from 1 to 33 ft above ground were located on the north and south faces of each study tree in 1976 and 1998. For greater accuracy each tree was divided into four 8-ft (log) sections. Each defect was identified and mapped to provide a comparison between the two years. The identified defects were as follows: live branch, epicormic branch, dead branch, open knot, closed knot, overgrown knot, bump, open wound, overgrown wound, canker, crack, open seam, healed-over seam, rotten stub, and bird peck.

Diameter

Stem diameters were measured in 1976 and 1998 at breast height (4.5 ft), 17 ft, and 33 ft above ground to the nearest 0.1 in.

Data Analysis

Analysis of variance (ANOVA) was used to compare effects of treatment, crown class, and aspect. Duncan's multiple range test was used to test for significant differences between treatment effects.

Table 1. Average initial (1976), final (1998), and decrease in number of defects per tree of dominant, codominant, and intermediate red maple trees.

Crown class	1976	1998	Decrease
Dominant	55(31)a	33(19)a	22(15)a
Codominant	103(27)b	61(22)b	42(20)b
Intermediate	104(28)b	64(18)b	40(23)b

Number in parentheses is the standard error ($n = 18$). Means followed by the same letter in a column are not significantly different ($P < 0.05$).

Results

Defects

The number of defects per tree before release varied among crown classes, with dominants having about half as many defects as codominants or intermediates (Table 1). Over the 22-year period, codominant and intermediate trees both lost about 40 defects per tree, whereas dominant trees lost only 22 defects per tree. However, all three crown classes lost approximately 40% of their initial number of defects.

Aspect had some effect on the number of defects. Overall, there was about a one-third greater number of defects on the southern half of each tree (Table 2). However, the effect of aspect on number of defects was only significant in the intermediate trees. There was no difference between the north and south halves when treatments were compared, and there were very few differences by type of defect. A greater number of overgrown knots were found on the south half in both 1976 and 1998, and a greater number of live branches were on the south half in 1998.

In both 1976 and 1998, the butt 8-ft log had the fewest number of defects, accounting for about 10% of the defects, whereas the upper two logs (17–25 ft and 25–33 ft above ground) each contained about one-third of the defects (Table 3). The butt log also had the smallest decrease in number of defects, but it still lost half of its prerelease defects. The third log (17–25 ft) had the largest decrease, but it was not significantly larger than either the second (9–17 ft) or top (25–33 ft) logs ($P < 0.05$).

After 22 years, there was a decrease in the number of defects for all crown-release treatments and the control. The 15-ft crown release had the greatest decrease in defects (55%), but that decrease was significantly larger than only the control (Figure 1).

Crown-release treatment had the greatest effect on intermediate trees, where the 15-ft crown release led to an average decrease of 72 defects per tree (Table 4). This was

Table 2. Decrease in the number of defects of red maple trees over a 22-year period by crown class and aspect.

Aspect	Dominant	Codominant	Intermediate
North	9(7)a	19(10)a	15(10)a
South	13(8)a	23(11)a	24(15)b

Number in parentheses is the standard error ($n = 18$). Means followed by the same letter in a column are not significantly different ($P < 0.05$).

Table 3. Average initial (1976), final (1998), and decrease in number of defects of red maple trees by location on tree.

Location	1976	1998	Decrease
Log 1	8(8)a	4(5)a	4(6)a
Log 2	22(12)b	12(8)b	10(8)b
Log 3	30(13)c	18(9)c	11(12)b
Log 4	27(11)c	18(8)c	9(7)b

Log 1, 1–9 ft above ground; Log 2, 9–17 ft; Log 3, 17–25 ft; Log 4, 25–33 ft. Number in parentheses is the standard error (n = 54). Means followed by the same letter in a column are not significantly different (P < 0.05).

not significantly greater than the two-tree release, which had an average decrease of 44 defects per tree. Treatment had little or no effect on codominant and dominant trees.

All 15 defects were observed. However, most defects averaged less than one occurrence per tree (e.g., among the 54 trees, only one canker and one bird peck were found). Before release, overgrown knots were the most common defects, followed by closed knots and epicormic branches (Table 5). Very few of the remaining defects were present. After 22 years of growth, overgrown knots were still the predominant defects, followed by closed knots. Again, few of the other defects were present. In absolute numbers, overgrown knots decreased the most. In terms of percentages, though, the largest decreases were of epicormic branches, dead branches, and open knots, with 87, 89, and 84%, respectively. There were increases in some of the defects, but these were small enough to result in a change of less than one defect per tree.

No pattern emerged when specific types of defects were compared by treatment. All trees had a similar number of overgrown knots, the most common defect. Trees in the control and two-tree release had less than one live branch each, which was significantly less than the three live branches found on trees released to 5 ft. In addition, the number of live branches decreased in the control and single-tree release but increased in the remaining, more-intensive treatments. The 5- and 15-ft releases had fewer open knots than the single-tree release and 10-ft release. The control gained one closed knot per tree, whereas the 10-ft release lost more than five knots per tree.

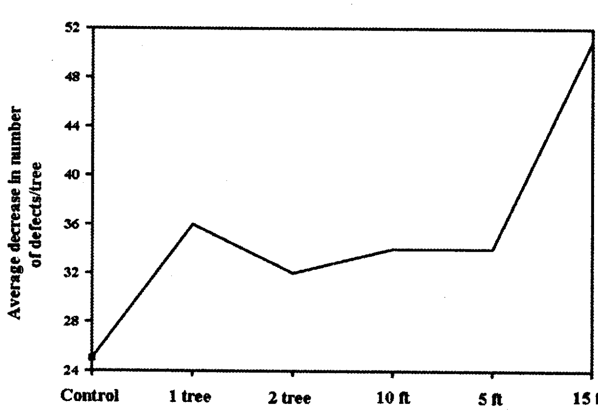

Figure 1. Average decrease in the number of defects per tree by crown release treatment.

Table 4. Average decrease in the number of defects of red maple trees over a 22-year period by crown class and crown release treatment.

Treatment	Intermediate	Codominant	Dominant	Mean
Control	33 (13)a	26 (9)a	17 (19)a	25 (14)
1 tree	28 (17)a	53 (35)a	22 (10)a	34 (25)
2 tree	44 (8)a,b	24 (16)a	24 (21)a	31 (17)
5 ft	34 (24)a	41 (3)a	24 (26)a	33 (19)
10 ft	28 (17)a	49 (14)a	27 (7)a	34 (16)
15 ft	72 (31)b	59 (6)a	22 (10)a	51 (28)
Mean	40 (23)	42 (20)	23 (13)	

Number in parentheses is the standard error (n = 3). Means followed by the same letter in a column are not significantly different (P < 0.05).

Dominants started and ended with significantly fewer overgrown knots, although each crown class lost about one-third of its overgrown knots. By the end of the 22-year period, the dominants had lost all their epicormic branches, but this amount was not significantly different from the amount lost by the codominants or intermediates. However, all three crown classes showed a small increase in the number of live branches, due mainly to the development of epicormic branches into live branches, not new defects. Intermediates did lose significantly more open knots than dominants and more dead branches than codominants.

Diameter Growth

Over the 22-year period, treatment had a significant effect on diameter growth of codominant and intermediate trees but no effect on the diameter growth of dominant trees. At dbh, the control had significantly less growth than any of the crown-release treatments (Figure 2). In fact, the growth in the control treatment was, on average, half that of the 15-ft crown release. For codominants, the 5-, 10-, and 15-ft crown releases showed significantly greater growth than the control at dbh and 17 ft above ground, whereas for the intermediates the 15-ft crown release had significantly greater growth than the control.

Initial diameters differed significantly by crown class (Table 6). Diameters of dominant, codominant, and intermediate trees averaged 10.2, 7.2, and 5.6 in., respectively. Dominant trees grew significantly more in diameter than the

Table 5. Average initial (1976), final (1998), and decrease in number of defects per tree by type of defect.

Defect	1976	1998	Change
Knot-overgrown	59.8a	39.6a	20.2a
Knot-closed	7.8b	6.7b	1.1d,e
Epicormic branch	7.8b	1.0c	6.8b
Dead branch	5.0b,c	0.5c	4.4b,c
Knot-open	3.6c,d	0.6c	3.0c,d
Seam-healed over	1.1d	1.3c	−0.2e
Live branch	1.0d	1.5c	−0.5e
Bump	0.8d	0.9c	0.0e
Wound-overgrown	0.5d	0.5c	0.0e
Crack	0.2d	0.1c	0.1e
Seam-open	0.1d	0.1c	0.0e
Wound-open	0.1d	0.2c	−0.1e
Rotten stub	0.1d	0.0c	0.0e
Canker	0.0d	0.0c	0.0e
Bird peck	0.0d	0.0c	0.0e

Means followed by the same letter in a column are not significantly different (P < 0.05).

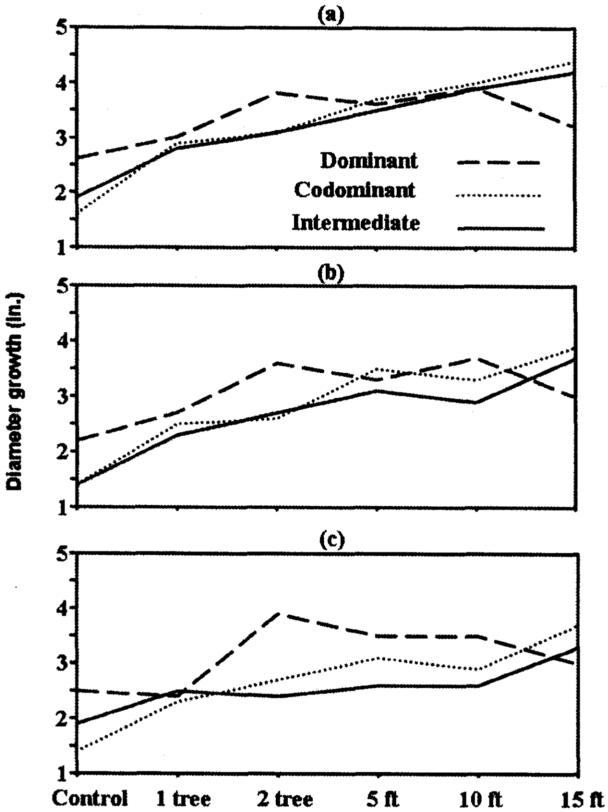

Figure 2. Average diameter growth (in.) by treatment of dominant, codominant, and intermediate red maple trees at diameter at breast height (a), 17 ft (b), and 33 ft (c) over a 22-year period after release.

Table 6. Average initial (1976), final (1998), and 22-year diameter growth of dominant, codominant, and intermediate red maple trees.

Crown class	1976 (dbh)	1998 (dbh)	Growth (in.)
Dominant	10.2(1.2)a	13.8(1.7)a	3.5(1.2)a
Codominant	7.2(0.5)b	10.3(1.3)b	3.1(1.1)a,b
Intermediate	5.6(0.3)c	8.6(1.1)c	3.0(1.1)b

Number in parentheses is the standard error ($n = 30$). Means followed by the same letter in a column are not significantly different ($P < 0.05$). Abbreviation: dbh, diameter at breast height (4.5 ft above ground).

intermediate trees (3.5 in. compared with 3.0 in., respectively). The codominant trees grew 3.1 in. Intermediates grew 53%, codominants grew 44%, and dominants grew 35%. However, the actual diameters of dominants were significantly larger than that of either codominants or intermediates, and codominants were significantly larger than intermediates. The amount of growth measured at the three vertical sampling points (breast height, 17 ft, and 33 ft above ground) was not significantly different; the amount of growth at 17 and 33 ft was almost identical to the amount of growth measured at breast height.

Conclusions

The red maples in this study showed varied responses to the crown-release treatments that were applied to them. After 22 years, all trees had fewer defects than before release, and 69% of the defects were on the upper halves of the trees. Trees released to 15 ft lost almost twice as many defects as the controls, but the remaining treatments were equally effective in reducing defects. When treatments were compared by crown class and 8-ft log sections, there were very few differences. Crown class had a larger influence on reduction of defects than treatment. Dominants started with and lost significantly fewer defects than codominants or intermediates but still ended up with about half as many defects as the other crown classes. There were significantly more defects on the southern halves of the trees, mostly epicormic branches.

Overgrown knots were the most common defects, accounting for 68% of the initial defects and 75% of the ending defects. Most of the initial epicormic branches had been lost after 22 years and few had been gained, regardless of treatment. In fact, there were no epicormic branches on any dominants. This finding concurs with earlier results on this site, which showed a decrease in epicormic branches for dominants and small increases for codominants and intermediates 3 years after release (Erdmann et al. 1985). Trimble and Seegrist (1973) also found that red maple had a low susceptibility to epicormic branching and that dominants had fewer epicormic branches than intermediates. However, Strong and Erdmann (2000) found significant epicormic branching in more heavily cut treatments of a stocking level study of red maple. They reported a loss of up to 11.8 ft of clear bole length due to epicormic branching in plots cut to 40 ft^2/ac of residual basal area.

Erdmann (1986) suggested crown releasing 60 crop trees/ac to maximize value growth for even-aged northern hardwoods in the Lake States. A 15-ft crown release of 60 crop trees/ac would essentially cut all trees but the crop trees. The resulting basal area of trees with an average dbh of 6.5 in. and larger, as in this study, would be 14 ft^2/ac, a much lower basal area than the 40 ft^2/ac that Strong and Erdmann (2000) found produced heavy epicormic branching in red maple. This implies that the 15-ft crown release would likely result in heavy epicormic branching.

When diameter growth was compared at three vertical points on each tree, there was twice as much growth in the 15-ft treatment as in the control at breast height and at 17 ft above ground. At 33 ft, the difference was not quite as large but still significantly larger than in the control. These differences were evident only in codominant and intermediate trees. Dominants did not show any response to treatment.

Earlier results, after 7 years, showed that diameter growth of red maple poles at breast height varied by initial tree crown class and by degree of release (Erdmann et al. 1985). Diameter growth rates for dominant, codominant, and intermediate trees averaged 0.20, 0.18, and 0.16 in./year, respectively. For 7 years after release, dominants maintained their greater diameter growth over intermediates and codominants. Trees in the one- and two-tree crown release treatments increased growth over trees in the control treatment by 35% for dominant, 28% for codominant, and

Table 7. Even-aged stocking levels for red maple stands by mean stand diameter for tree of average basal area, basal area, and number of trees/ac for specified crown covers after thinning.

			Crown cover (percentage of 43,560 ft²/ac)					
			80%		90%		100%	
Mean stand diameter	Crown area/tree (ft^2)	Basal area/ tree (ft^2)	Trees/ac	Basal area/ ac (ft^2/ac)	Trees/ac	Basal area/ ac (ft^2/ac)	Trees/ac	Basal area/ ac (ft^2/ac)
5	68	0.136	512	69.9	577	78.6	641	87.4
6	95	0.196	367	72.0	413	81.0	459	90.0
7	126	0.267	277	73.9	311	83.2	346	92.4
8	161	0.349	216	75.6	244	85.0	271	94.4
9	200	0.442	174	77.0	196	86.6	218	96.2
10	243	0.545	143	78.2	161	88.0	179	97.8
11	290	0.660	120	79.3	135	89.2	150	99.1
12	340	0.785	102	80.5	115	90.6	128	100.6
13	394	0.922	88	81.5	100	91.7	111	101.9
14	452	1.069	77	82.4	87	92.7	96	103.0
15	513	1.227	68	83.4	76	93.8	85	104.2
16	578	1.396	60	84.2	68	94.7	75	105.2
17	646	1.576	54	85.0	61	95.7	67	106.3
18	718	1.767	49	85.8	55	96.5	61	107.2
19	793	1.969	44	86.5	49	97.3	55	108.2
20	872	2.182	40	87.2	45	98.1	50	109.0
21	954	2.405	36	87.9	41	98.8	46	109.8
22	1,039	2.640	34	88.5	38	99.6	42	110.7
23	1,128	31	89.1	35	100.3	39	111.4	
24	1,220	29	89.7	32	101.0		36	112.2

70% for intermediate trees. The heavier 5–15-ft crown-release treatments resulted in significant average growth increases over the one- and two-tree crown-release treatments for the dominants and codominants but not for the intermediates. Although these growth relations continued through seven growing seasons, the significance of the differences in diameter growth between the two-tree competitor treatment and the more heavily released treatments was diminishing. After 7 years, crowns of some of the released crop trees were closing, and treatment effects were beginning to disappear. After 22 years, dominants were no longer affected by crown-release treatments, but the codominants and intermediates still showed some response. Similar responses to crown release were reported by Webster and Lorimer (2003) in a hemlock-hardwood forest.

This suggests that after 10–12 years, dominant and codominant red maple trees need to be released again following crown closure and lower branch mortality to maintain improved growth rates and bole quality. This study indicates that properly releasing about 60 pole-size crop trees/ac by removing competing crowns to about 5–10 ft will not only increase growth of the crop trees but also improve bole quality over time while minimizing the potential for epicormic branching.

Maintaining the proper residual overstory density is also very important in stem quality control in the second 16-ft stem section. Related unpublished research on desirable stocking levels for producing high quality crop trees was developed from crown area/diameter relations of potential two-log (33 ft) trees in different average diameter even-aged red maple stands (Table 7). For a given mean stand diameter, the number of trees and basal area/ac required for 80, 90, and 100% crown cover of dominant and codominant red maple crop trees are shown. The most important point to remember when making the first thinning in pole-size (5–8 in.) red maple stands is to crown release 60 crop trees/ac 5–10 ft and leave 80% crown cover. Subsequent thinnings after 10–15 years and thinnings in larger diameter stands should be to 90% crown cover for the best growth and bole quality development. The final red maple stand should average 18 in. in diameter and have 61 trees/ac, with 107 ft^2/ac of basal area to fully occupy the site at 100% crown cover.

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