Impact of Pruning Eastern Redcedar (*Juniperus virginiana*)

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ABSTRACT: *In recent years, eastern redcedar has been the most rapidly expanding tree resource in the Great Plains from Oklahoma to South Dakota, primarily in rangelands and pastures. Based on these increases and potential management-related problems, eastern redcedar is perceived as a threat to the rangeland resource. Pruning eastern redcedar can allow for increased herbaceous growth under the eastern redcedar's crown, improve livestock handling, maintain the species for diversity and habitat contributions, and improve wood quality for potential future utilization by forest industries. To determine the effect of pruning to different heights on tree growth, we compared unpruned trees' total height and diameter to trees pruned from ground level to heights of 60, 90, 120, and 150 cm. No significant differences in the total height were found for all pruning treatments over all time periods. After more than 10 yr, trees pruned to 60, 90, and 120 cm had smaller diameters at ground level than unpruned trees. There were no differences in ground diameters for trees pruned to 150 cm compared to unpruned trees after 4 yr of growth. There were no significant differences in dbh for eastern redcedar trees pruned to all heights. Management of eastern redcedar, including pruning, is recommended as an alternative to control measures. West. J. Appl. For. 17(4):189–193.*

Key Words: Eastern redcedar, pruning, height growth, diameter growth.

Eastern redcedar (*Juniperus virginiana*) is the most widely distributed conifer of tree size in the eastern United States and is indigenous in every state east of the 100th meridian (Van Haverbeke and Read 1976). It grows under a wide range of climatic and soil conditions and can be found on almost any site and in conjunction with almost any plant community.

The primary factors limiting the presence of eastern redcedar are fire, cultivation (Owensby et al. 1973), and site characteristics. With the control of fire and the changes in land-use and ownership patterns, eastern redcedar has been increasing in acreage and locations (Wilson and Schmidt 1990, Schmidt and Wardle 1998). It has been the most rapidly expanding tree resource in the Great Plains from Oklahoma to South Dakota. Expansion has primarily occurred in rangelands and pastures due to the control of wildfires, the physiological adaptability of eastern redcedar, and expanded seed source availability. Its encroachment on rangeland may cause loss of forage production, change of grassland species composition, livestock handling problems, and loss of wildlife species dependent on grassland habitat. Based on these increases and potential problems, eastern redcedar is perceived as a threat to the rangeland resource. At the same time, the expansion of eastern redcedar is viewed as a growing economic opportunity by forest industries.

Except in some limited areas, eastern redcedar has historically been of minor economic importance because of its taper, large number of branches, and comparatively small growth habit. In addition, its tendency to be a minor component of most forest types, its tendency to occur on poor sites with low potential productivity, and its low utilization by forest industries have resulted in the species being considered of minor importance. However, the aromatic wood is believed to inhibit insects and is used for cedar chests and closet lining. Cedar shavings are used for animal bedding, and the wood is used for fence posts, paneling, and a wide variety of specialty products. Eastern redcedar markets have been expanding in recent years; some logs are now exported to Asian markets (Hoefer and Bratton 1988). Eastern redcedar is a source of cedarwood oil, which is used in a variety of fragrance compounds (Lawson 1990). These compounds are used in making soaps, inhalants, liniments, insecticides, polishes, perfumes, and cosmetics (Bailey 1948, VanHaverbeke and Read 1976).

Information on the growth and potential utilization of eastern redcedar is of particular interest to public land managers and private landowners where eastern redcedar has experienced rapid expansion over the past 25 yr. Re-

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search related to eastern redcedar has been conducted on physiological aspects, methods and effectiveness of control, species establishment, and factors that impact the species expansion. However, little research has been conducted on pruning eastern redcedar. Jelly (1937) did address pruning eastern redcedar but thought that in general eastern redcedar should not be pruned. He recommended that if pruning was necessary, stubs of 8 to 10 in. in length should be left because if the limbs were cut too close to the trunk they would not heal over. We disagree with this early reference and feel that pruning is an appropriate silvicultural treatment and that pruning can be done close to the trunk, minimizing the branch stub. Results for ponderosa pine (*Pinus ponderosa*) by O'Hara and Buckland (1996) were similar to our conclusions.

An increased understanding of the impact of pruning eastern redcedar is important because pruning can allow for increased herbaceous growth under the eastern redcedar's crown, improved livestock handling, an economic incentive to retain the species for diversity and habitat contributions, and improved wood quality for potential utilization by forest industries. These potential contributions can increase and diversify landowner income and the related rural community's economic base.

Research on pruning effects on other conifers has been widespread. Research on pruning conifers reached a peak in the 1950s, declined until the 1980s (O'Hara 1989), and has again emerged as pruning has become a possibly desirable silvicultural operation (Cahill et al. 1986). Pearson (1950) included an in-depth discussion on pruning of ponderosa pine finding that pruning did not have a major impact on the overall growth and health and that the time required for healing of the pruning wounds depended on rate of diameter growth, diameter of limb removed, and length of stub left. Pruning can be attractive to forest management: for species with persistent dead branches, in stands with wide spacing (and thus potentially branches of large diameter), to reduce potential fire hazards, to produce a greater percentage of clear wood, and to maintain the stand in a "stand initiation" structure (Oliver et al. 1995). These potential benefits of pruning should also apply to native stands of eastern redcedar.

When mature, eastern redcedar has a height ranging from 8 to 30 m and a mature crown spread of 4 to 12 m (Dirr 1983). Growth rates for eastern redcedar are extremely variable, depending on site and climate. Radial growth is often irregular, and the trunk may be fluted (Lawson 1986). Trees are variable in form; the crown may be columnar or pyramidal, with the branches ascending, wide spreading, or even pendulous. The grain is straight and knots are harder than surrounding wood.

The goal of this study was to determine the effect of different pruning intensities on growth of eastern redcedar. The method used was to measure and compare total height before and after treatment, and diameter after treatment, of pruned and unpruned trees.

Methods

In 1982, 1,250 eastern redcedar seedlings were machine-planted in a block design in a plantation 3.2 km southeast of Republican City (Harlan Co.), NE (south central portion of the state, T. 1N, R. 17W, Sec. 2), referred to as the Harlan Co. Site. Spacing was 3.7 m between rows and 2.4 m within rows. In total, 30 rows were planted with an average of 45 trees/row. The total number of trees in each row varied because of minor differences in spacing between trees within each row, initial mortality following planting, and the occurrence of trees that did not have a distinct leader (such trees were excluded from the study since we were not able to make viable comparisons with the vast majority of trees with typical growth form). Rows were established with an approximate east to west orientation.

Within the plantation, two border rows were left on all but the southern side, which had one row. Treatment blocks of six trees were randomly designated for either treatment or control. The purpose for the six-tree group design was to eliminate any variance in growth of the two outside trees within the six-tree group due to either treatment or control on the adjacent trees. Thus, this design left four trees within each six-tree block that had similar treatment on both sides.

We recognized that with only one location, results would have a limited scope of application; however, additional treatment locations were not developed at the time of initial installation and treatment due to time and funding limitations. To address the limitations imposed by the single location, a second set of measurements was taken during the 1999–2000 dormant season on a pruning study implemented in July 1995 in a natural stand of eastern redcedar about 12 mi SE of North Platte (Lincoln Co.), NE (west central portion of the state, T. 12 N, R. 29 W, Sec. 14) referred to as the Lincoln Co. Site.

Because the second site was naturally established, spacing among trees was random. However, average stocking rates were consistent throughout the majority of the stand. The natural stand was dominated by eastern redcedar with a small component (<5%) of green ash (*Fraxinus pennsylvanica*). Although we included the second site to expand the scope of results of this study, we recognize that comparisons between the two study sites are limited because of the differences between times of treatment, natural versus planted stand origins, and different treatment levels.

Pruning Treatments

Harlan Co. Site

We decided to initiate pruning once an average tree height of 200 cm was attained. By the winter of 1987–1988 (age 5), the plantation averaged the target height, and the six-tree blocks designated for treatment were pruned from ground level to a height of 60 cm. In total, 14 six-tree blocks were pruned and 14 six-tree blocks were left unpruned as the control.

In the winter of 1988–1989, a second set of six-tree blocks was pruned from ground level to a height of 90 cm. In total, 12 six-tree blocks were pruned to a height of 90 cm, and 16 six-tree blocks were left unpruned as the control. In the winter of 1989–1990, a third set of six-tree blocks was pruned from ground level to a height of 120 cm in a third block within the overall plantation. In total, 21 six-tree blocks were pruned and 19 six-tree blocks were left unpruned.

In the winter of 1996–1997, a fourth set of six-tree blocks was designated for treatment and pruned from ground level to a height of 150 cm in a fourth block within the overall plantation. In total, 20 six-tree blocks were pruned and 14 six-tree blocks were left unpruned as the control. In addition, during this time, 5 of the 14 six-tree blocks that were initially pruned to 60 cm in the fall of 1987 were again pruned, this time to a total height of 150 cm (a total of 30 additional trees pruned).

Over time, individual tree mortality, loss of growth form, and removals reduced the total number of trees in the plantation. In the winter of 1996–1997, several trees were removed for a separate study related to closure of pruning wounds. As a result of tree losses and secondary pruning, the total number of trees within each block and the total number of blocks were reduced between the initial measurements in 1987–1988 and the final measurements in 1999.

Thus, treatment consisted of pruning eastern redcedar trees from ground level to a total height of 60, 90, 120, and 150 cm. The 60 cm pruning removed an average of 27% of the total live crown length while the 90, 120, and 150 cm pruning removed an average of 38% of the total live crown length at the time of treatment. Treatment is expressed as the mean of the four measurement trees within each block. Results are presented for the heights and diameters of 60, 90, 120, and 150 cm pruned blocks, comparing mean total height and diameter to that of untreated blocks.

Lincoln Co. Site

In July 1995, within a naturally established stand of eastern redcedar trees, blocks of trees were pruned from ground level to an average height of 150 cm, and blocks of trees were left unpruned. All pruned trees were pruned to the same height. A total of 51 pruned trees and 62 unpruned trees were selected for measurement. Within each block, all trees with a central leader and natural growth form were measured due to the similar size class, age class, and site conditions of both the pruned and unpruned tree blocks.

Measurements

Harlan Co. Site

Individual tree measurements included height and diameter. Only total height was measured initially. Diameter measurements were taken at ground level and at 137 cm (diameter at breast height, dbh). Once the trees had attained sufficient size, measurement was switched from a height to diameter. Total height (height pole) was taken annually during the dormant (winter) season from 1987 through 1991. Diameter (diameter tape) was taken at both ground level and at a height of 137 cm during the dormant season in 1996–1997 and 1999–2000.

Statistical analyses were completed using a heteroscedastic *t*-test comparison of two-sample means assuming unequal variances from groups of unequal sizes (Microsoft 1994, Snedecor and Cochran 1967, Steel and Torrie 1980). P ($T \leq t$) one-tail values were used to determine statistical significance based on the potential for pruning to decrease height and/or diameter (assumed that pruning would not increase height or diameter growth).

Groups of unequal sizes were used in the comparisons because of differences in the total number of pruned and unpruned blocks for each treatment. Comparisons were made between pruned and unpruned blocks for each treatment, but comparisons could not be made between treatments. For example, differences between blocks of trees pruned to 60 cm and blocks of trees not pruned were determined but comparisons between pruning to 60 or 90 cm were not made. Because of the measurements' unequal variances, every time we constructed another confidence interval to analyze the results for different years, we had to re-estimate the degrees of freedom (Milliken and Johnson 1984). Thus, reported degrees of freedom varied between the years of measurement within the same treatment.

Lincoln Co. Site

Diameter measurements were taken at ground level and at 137 cm (dbh) during the 1999–2000 dormant season. With pruning treatments in July 1995, results represent four-plus growing seasons since treatment. No height measurements were taken based on the findings from the Harlan Co. Site 1996–1997 dormant season measurements that indicated no differences in total heights among trees within the same stand. The comparison of diameters at ground level and at dbh allowed us to determine the differences between treated and untreated trees. The same null hypothesis and statistical analyses were completed as those used for the Harlan Co. Site except that trees were not combined into blocks. Thus, each individual tree contributed to the overall mean and comparisons of pruned and unpruned trees.

Results and Discussion

Harlan Co. Site

In general, height growth for most tree species is a reflection of site quality. Thus, it would be expected that pruning treatments would not affect height growth unless the treatment was so severe that the tree's vigor was reduced to the point where it did not grow. There were no significant differences in the total height between blocks of pruned and unpruned eastern redcedar trees at the time of treatment and for all pruning treatments over all time periods (Table 1). This implies that pruning approximately 30% of the live crown does not negatively impact height growth of eastern redcedar trees.

With no difference in total height between blocks of pruned and unpruned trees, all blocks were combined to determine average total height. Ten growing seasons after planting, the eastern redcedar trees averaged 399 cm in total height. With an initial average top height of 23 cm, total growth over 10 growing seasons was 376 cm or an average height growth of 37.6 cm/yr. This growth rate indicates that the plantation was located on a good to excellent site.

Unlike height growth, diameter growth is generally a reflection of tree spacing and the condition and vigor of the

Table 1. Total height comparison of blocks of eastern redcedar trees pruned to 60 cm (in 1987–1988), 90 cm (1988–1989), and 120 cm (1989–1990) and unpruned trees over time at the Harlan Co. Site.

Pruning height	1988		1989		1990		1991	
(time of pruning)	Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned
60 cm								
Mean (cm)	242.7ns	245.7	297.2ns	303.1	357.2ns	367.8	407.7ns	409.3
Standard error	4.4	4.8	4.5	5.9	4.9	6.8	7.3	9.3
Observations	14	14	14	14	14	14	11	11
90 cm								
Mean (cm)			303.7ns	300.0	367.1ns	361.7	405.0ns	399.7
Standard error			6.5	6.7	7.6	8.3	7.4	9.6
Observations			12	16	12	16	12	16
120 cm								
Mean (cm)					361.1ns	358.6	395.7ns	390.0
Standard error					4.6	6.3	4.7	6.3
Observations					21	19	21	19

NOTE: ns: not significant; *: significant at $\alpha = 0.05$; **: significant at $\alpha = 0.01$

tree. Pruning reduces the total photosynthetic potential of the tree by removing a portion of the leaf area, which could potentially reduce diameter growth. In addition, our results show that pruning can lessen the natural taper of trees.

By the end of the 1996–1997 and 1999–2000 growing seasons, trees pruned from ground level to a height of 60 cm in the 1987–1988 dormant season had smaller diameters at ground level than unpruned trees (Table 2). Seventeen years after establishment and 12 yr after treatment (in dormant season of 1999–2000), pruned eastern redcedar trees had diameters 2.3 cm smaller at ground level (an approximate reduction in diameter growth of 10%). Diameters at breast height were similar for trees pruned to 60 cm and unpruned trees. Between 1996–1997 and 1999–2000, average annual diameter growth at ground level was about 1 cm, and dbh growth was about 0.75 cm for both pruned and unpruned trees.

In the 1996–1997 dormant season, there were no differences in the diameter at both ground level and at 137 cm for eastern redcedar trees pruned from ground level to a height of 90 cm in the 1988–1989 dormant season and those unpruned. However, by the 1999–2000 dormant season, trees pruned to 90 cm had smaller ground diameters than unpruned trees. As with trees pruned to 60 cm, there was no difference between pruned and unpruned trees at 137 cm in both measurement periods.

Eastern redcedar trees pruned in the 1989–1990 dormant season from ground level to a height of 120 cm had smaller ground-level diameters by the end of the 1996 and 1999 growing seasons (8 and 10 yr after treatment). There were no differences in dbh during the same time period. Since initial establishment, unpruned trees averaged a ground-level diameter increment of 1.4 cm/yr (1982 through 1999). Pruned trees averaged a ground-level diameter increment of 1.3 cm/yr over the same time period. Both unpruned trees and trees pruned to 120 cm in height averaged a dbh increment of almost 1.0 cm/yr over the 17 yr from establishment to final measurements (1982 through 1999).

Eastern redcedar trees pruned during the 1996–1997 dormant season from ground level to a height of 150 cm were measured only in the 1999–2000 dormant season. With the first set of measurements, there were no differences in diameters at ground level and at breast height. With no differences detected between diameters at breast height of pruned and unpruned trees across all treatments, all trees were combined to determine an average dbh of 15.7 cm after 17 yr of growth, or an average increment of 0.9 cm/yr. This average dbh growth rate is considered to be good to excellent.

Table 2. Comparison of mean diameter at ground level and dbh of blocks of eastern redcedar trees pruned to 60 cm (in 1987–1988), 90 cm (1988–1989), 120 cm (1989–1990), and 150 cm (1996–1997) and unpruned trees in 1996 and 1999 at the Harlan Co. Site.

Pruning height	1996 ground		1999 ground		1996 dbh		1999 dbh	
(time of pruning)	Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned
60 cm								
Mean (cm)	19.0**	20.6	21.0**	23.3	13.5ns	14.3	15.2ns	15.7
Standard error	0.4	0.3	0.6	0.4	0.5	0.4	0.4	0.4
Observations	14	14	10	11	14	14	10	11
90 cm								
Mean (cm)	19.3ns	20.0	21.7*	22.8	14.5ns	14.2	16.0ns	15.8
Standard error	0.4	0.6	0.4	0.4	0.3	0.5	0.3	0.3
Observations	12	16	12	12	12	16	12	12
120 cm								
Mean (cm)	18.5**	20.7	21.6**	23.7	14.0ns	14.3	16.6ns	16.4
Standard error	0.3	0.3	0.4	0.4	0.2	0.3	0.3	0.3
Observations	21	19	21	14	21	19	21	14
150 cm								
Mean (cm)			22.4ns	21.6			15.1ns	15.0
Standard error			0.3	0.5			0.3	0.4
Observations			20	14			20	14

NOTE: ns: not significant; *: significant at $\alpha = 0.05$; **: significant at $\alpha = 0.01$

Table 3. Comparison of mean-diameter at ground level and dbh of eastern redcedar trees pruned to a height of 150 cm in July 1995 and unpruned trees 4 yr after treatment at the Lincoln Co. Site.

	1999 ground		1999 dbh	
	Pruned	Unpruned	Pruned	Unpruned
60 cm (1987–1988)				
Mean (cm)	17.2ns	17.6	12.6ns	13.6
Standard error	0.7	0.7	0.5	0.6
Observations	51	62	51	62

NOTE: ns: not significant; *: significant at $\alpha = 0.05$; **: significant at $\alpha = 0.01$

Lincoln Co. Site

In the 1999–2000 dormant season, there were no differences in diameters at both ground level and 137 cm between eastern redcedar trees pruned from ground level to an average height of 150 cm in 1995 and unpruned trees. While the average diameters were lower than those for the Harlan Co. Site, results in Lincoln Co. were similar for trees pruned to 150 cm and unpruned trees (Table 3).

Summary and Conclusions

It is predicted that eastern redcedar will continue its expansion into rangelands, pastures, and other forest types (Schmidt and Wardle 1998). Since birds are the primary dispersal mechanism for eastern redcedar (Smith 1985), its continued expansion will be difficult to limit, and control measures and management of the resource will become of increased importance. While control can be accomplished through mechanical, chemical, or prescribed burning means (Wilson and Schmidt 1990), it generally is an expensive option for the landowner. Thus, management of the resource to increase its economic value through means such as pruning may be a desired alternative.

The importance of a reduced ground-level diameter for pruned eastern redcedar trees needs to be considered with the potential benefits of increased understory growth and improved quality of the main bole for future commercial utilization. With a reduced ground-level diameter and similar diameters at breast height, the tree's bole will tend to be more cylindrical (less taper), which has harvesting and processing advantages.

Clear (knot-free) eastern redcedar logs bring higher stumpage prices. To obtain clear logs, landowners must make initial investments in pruning and risk this investment over a period of years. However, in many cases landowners are making a similar investment by applying control measures or by accepting a loss of forage production, without the potential future return. An advantage for pruning eastern redcedar is that it can be done at any time of the year, especially when landowners have fewer demands on their time.

We encourage economic analysis of pruning costs and benefits compared to removal. Analyses should be considered regarding the time necessary for the pruning wounds to close, the relative increase in clear wood and stumpage value, and the incidence of rot or other defects caused by pruning. We recommend that different degrees of pruning—i.e., pruning 40, 60, and 80% of the live crown—be investigated to determine at what point height and diameter growth can be influenced by pruning. The importance of determining the greatest degree of pruning that can be implemented without negatively impacting growth is that, with increased pruning, we would expect to get increased understory herbaceous growth, increased accessibility into the stand, and increased final economic value. Many landowners with eastern redcedar present would view these responses to increased pruning heights as positive.

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