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Growth dynamics of crowns of eastern redcedar at 3 locations in Oklahoma

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Abstract

Eastern redcedar (*Juniperus virginiana* L.) trees from a location in western, central, and eastern Oklahoma were aged by tree ring analysis to assess the relationship of tree age to tree height and crown area. The relationship of tree age to crown size differed with location. Trees in the oldest age class, 28 to 29 years, ranged in height from 6.2 m on the western Oklahoma location to 8.3 m on the eastern Oklahoma location. The oldest trees at all locations were still actively growing. Height growth rate of the oldest class of trees averaged 0.5 to 0.6 m yr^{-1} on the western and eastern study locations, respectively. Eastern redcedar reached 2.0 m in height at about 8 years of age on the eastern Oklahoma location. Trees reached 2.0 m in height in 10 to 14 years at the other locations. This suggests that burning intervals should be more frequent on the eastern Oklahoma location than on the central and western Oklahoma locations. Crown area as a function of tree age was not as similar as tree height among the 3 locations. Not only did the relationship differ among locations, but it differed also between 2 central Oklahoma range sites. Crown area of 28-year-old trees ranged from only 15 m^2 on the central Oklahoma Loamy Prairie to 40 m^2 at the eastern Oklahoma location. These data suggest that the smaller crown area of trees at the central Oklahoma location may be a result of an influence other than environment, such as an introduction of plants of a different race with an inherent columnar growth habit. The reduction in forage production associated with eastern redcedar and the efficacy of prescribed burning for controlling eastern redcedar would change more rapidly as trees age on the eastern Oklahoma location than on the other locations.

Key Words: *Juniperus virginiana*, growth analysis, brush control, prescribed burning

Encroachment of eastern redcedar (*Juniperus virginiana* L.) is extensive in the tallgrass prairie and adjacent vegetation types of the central United States in the absence of fire (Bragg and Hulbert 1976, Wright 1978). Eastern redcedar populations have increased exponentially in recent years, modifying the physiognomy of these ecosystems and reducing their value for most uses (Wright and Bailey 1980, Snook 1985). As a result, eastern redcedar has become a major management concern of range managers in the region.

The growth dynamics of crowns of invading eastern redcedar could be useful for managing rangelands susceptible to invasion by eastern redcedar. Unlike junipers of the western United States, the zone of interference with herbaceous plant production is primarily inside the drip line of the eastern redcedar crown (Engle et al. 1987). This simple relationship would make information on the crown area growth of eastern redcedar useful in predicting the effects of eastern redcedar invasion on herbage production and subsequent livestock and wildlife production. Furthermore, the effectiveness of burning on eastern redcedar is inversely proportional to tree height (Owensby et al. 1973, Engle et al. 1988). Guidelines could be developed for the frequency of burning necessary to control invading eastern redcedar based on the height growth patterns of eastern redcedar.

Unfortunately, growth of eastern redcedar is unlikely to be represented by generalized growth functions because the range-wide distribution of eastern redcedar contains a broad delineation of races, some of which are influenced by other juniper species (Van Haverbeke and Read 1976). The genetic base of eastern redcedar in Oklahoma may be influenced by introgressive hybridization from the west by Rocky Mountain juniper (*J. scopulorum* Sarg.) and by Ashe juniper (*J. ashei* Buckh.) from the south (Hall 1952, Flake et al. 1978). The influx of plant materials of other races brought in with settlement also may serve to complicate the gene pool within a region. Tree form and many other characteristics vary widely as a consequence, even though populations of junipers in the Great Plains are characterized generally by regional races adapted to variable environments (Van Haverbeke and King 1990). Considering the uncertainties surrounding the potential growth forms of eastern redcedar invading rangelands in the central United States, our objective was to compare the relationship of tree crown area and tree height to tree age among populations occupying different range sites at 3 distant locations within the state of Oklahoma.

Methods

Locations in western, central, and eastern Oklahoma were selected that contained a variation in size classes of eastern redcedar. The western Oklahoma study area was located in Major County on a Dill fine sandy loam (coarse, loamy, mixed Typic Ustochrept) and is classified as a Sandy Prairie range site. The central Oklahoma study area was located in Payne County. Two areas at this location were only the Coyle loam soil (fine-loamy, siliceous, thermic Udic Argiustoll) that is classified as a Loamy Prairie range site. Two other study areas at this location were on a complex of the Grainola (fine, mixed, thermic Vertic Haplustalf) and the Lucien (loamy, mixed, thermic, shallow Typic Haplustoll) soils, both classified as a Shallow Prairie range site. The eastern Oklahoma study area was located in McIntosh County on a Taloka silt loam (fine, mixed, thermic Mollic Albaqualf) and is classified as a Loamy Prairie range site. Average annual precipitation is 70, 83, and 107 cm in Major County, Payne County, and McIntosh County, respectively. The potential vegetation at all locations is dominated by perennial grasses, and the understory vegetation at all locations was dominated by perennial grasses at the time of the study.

Eastern redcedar trees were sampled for age and crown dimensions in June 1987 in Payne County (Loamy Prairie N = 23, Shallow Prairie N = 27) and June 1988 in Major County (N = 33) and McIntosh County (N = 41). Only those trees separated from other trees by a minimum distance of 3 m were included in the sample to minimize overlapping of spheres of influence. Trees with

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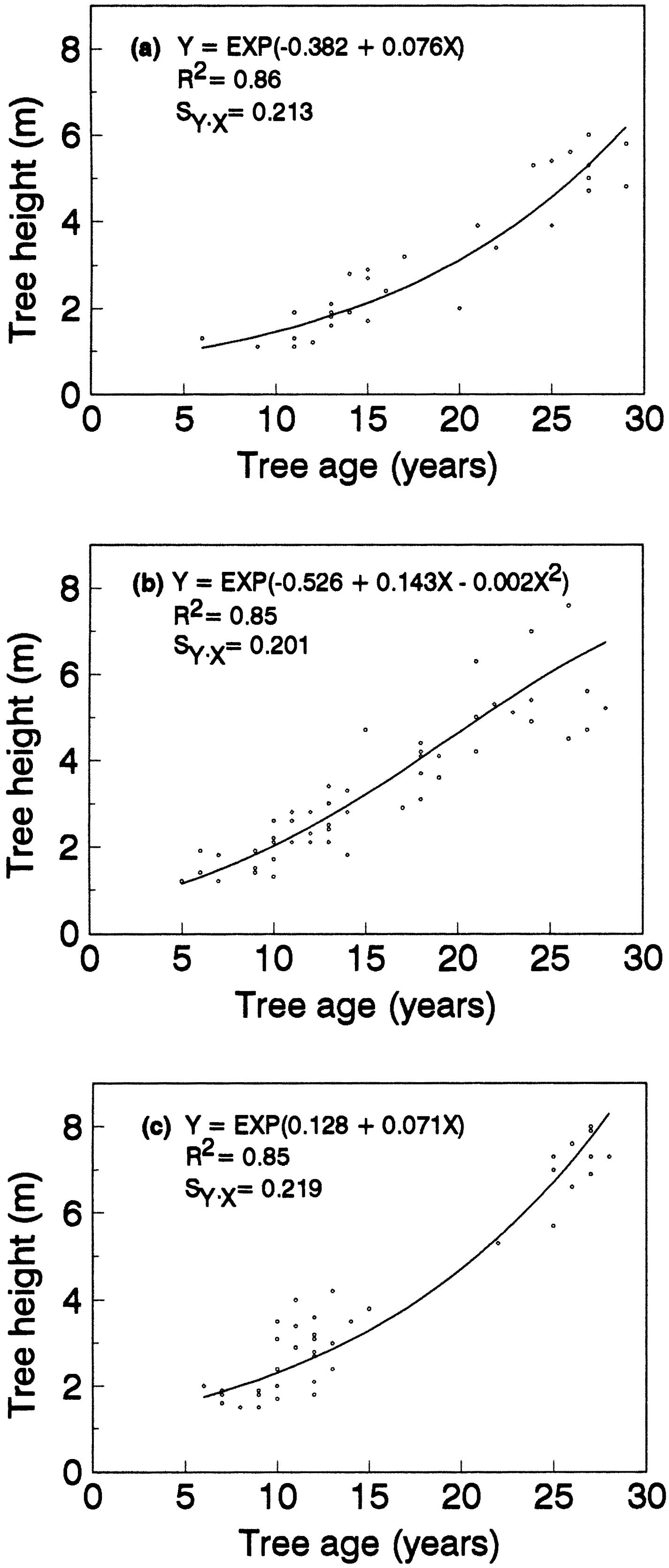

Fig. 1. Eastern redcedar crown height as a function of tree age at 3 locations in Oklahoma, (a) western Oklahoma, (b) central Oklahoma, and (c) eastern Oklahoma.

abnormally shaped crowns resulting from grazing injury or other influences were not sampled. The crown of each tree was measured for its longest diameter and the diameter perpendicular to the

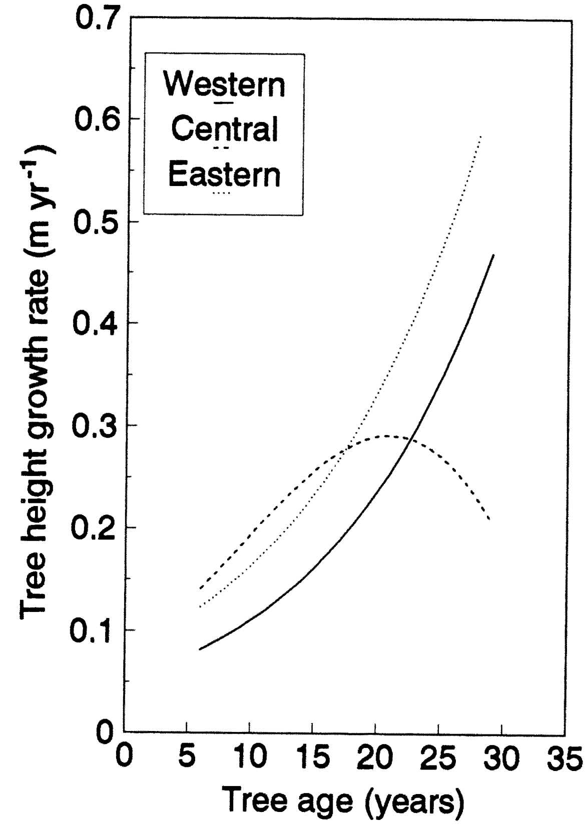

Fig. 2. Growth rate of eastern redcedar crown height at 3 locations in Oklahoma.

longest diameter. Differences in the 2 diameter axes were rarely greater than 5%, so the average of the 2 measurements was used in computing crown area as a circle. Trees were cut 2 cm above the soil surface, and crown height of the cut tree was measured from the bottom of the cut trunk of the apex. A full cross-section was removed from the trunk of each tree and a radius of each cross section was sanded and polished to facilitate identification of annual growth rings. Tree age was determined from ring counts as described for eastern redcedar by Kuo and McGinnes (1973) to avoid counting false rings.

The crown size variables were transformed to natural logarithms to produce homoscedasticity in the variance (Hunt 1978). The transformed variables were expressed as polynomial functions of time, with the functions fit to the third order by least squares regression analysis. Best fit was determined from analysis of variance to minimize overfitting with a 5% level of probability for entry level of individual parameters. Same order polynomials for different locations and sites were compared using indicator variables for locations and sites (Draper and Smith 1966). Absolute rate of growth of crown height and of crown area were determined from the derivative of the respective function with respect to age (Hunt 1978). Crown size and crown growth rate data were plotted in the original units of measurement by retransforming the regression models.

Results

The relationship of tree age to tree height differed with respect to location ($P<0.03$), but not between the 2 range sites in central Oklahoma ($P>0.80$) (Fig. 1). Trees in the 28 to 29 year-old age class ranged in height from 6.2 m on the western study site to 8.3 m on the eastern study site, but the oldest trees at all locations were still actively growing (Fig. 2).

Height growth rates of the oldest class of trees continued at 0.5 to 0.6 m yr^{-1} on the average on the western and eastern study locations. Trees on the central study location, which grew faster than trees on either the eastern or western study sites for the first 20 years, slowed their growth to about 0.2 m yr^{-1} at 28 years of age.

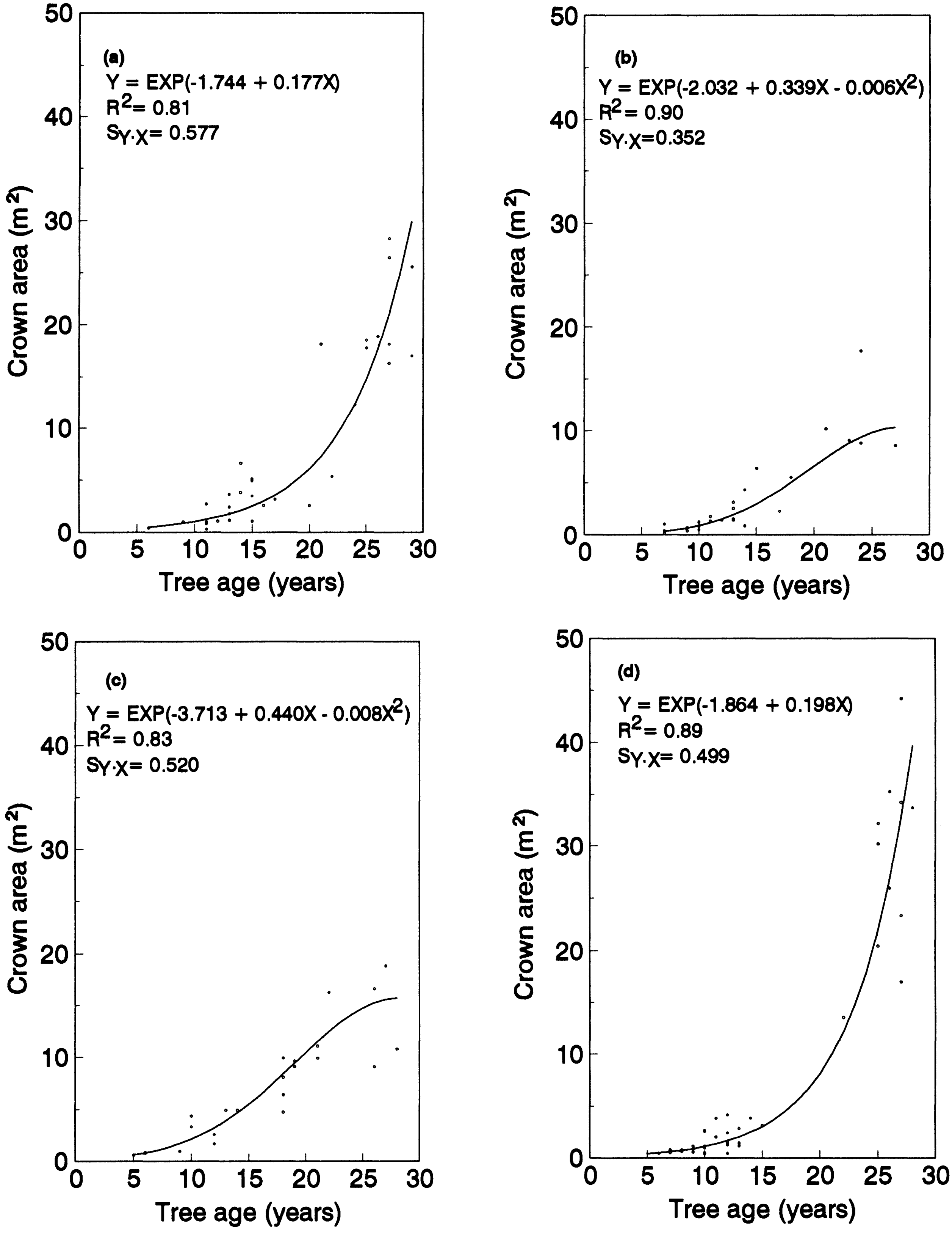

Fig. 3. Eastern redcedar crown area as a function of tree age at 3 locations in Oklahoma, (a) western Oklahoma, (b) central Oklahoma Shallow Prairie, (c) central Oklahoma Loamy Prairie and (d) eastern Oklahoma.

The average increase in height over all age classes was 0.33, 0.24, and 0.22 m yr^{-1} at the eastern, central, and western Oklahoma study locations, respectively.

Crown area as a function of tree age was not as similar as tree height among the 3 locations. Not only did the relationship differ among locations, but the relationship differed between the 2 central Oklahoma range sites ($P<0.03$) (Fig. 3). Crowns of 28 year-old trees on the eastern Oklahoma location occupied 40 m^2, whereas crowns of 28 year-old trees on the central Oklahoma Loamy Prairie occupied only 15 m^2. Crown area of eastern redcedar increased at a similar rate at all locations to about age 20, after which trees grew at a greater rate at the eastern Oklahoma and western Oklahoma locations than at the central Oklahoma location (Fig. 4).

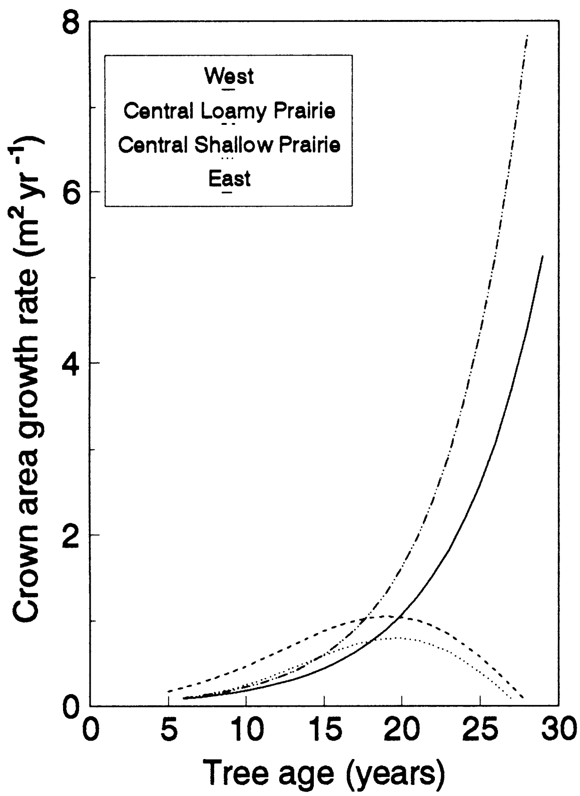

Fig. 4. Growth rate of eastern redcedar crown area at 3 locations in Oklahoma.

Discussion

Eastern redcedar grow considerably taller than juniper species of the western United States (Jameson 1965, Van Pelt et al. 1990). Redberry juniper (*Juniperus pinchotii* Sudw.), for example, averaged only 2 m in height at 30 years on a mesic lowland site in western Texas (McPherson and Wright 1987). Eastern redcedar may reach a height of 17 to 18 m on well-drained alluvial sites in the eastern United States (Ferguson et al. 1968). From observations of eastern redcedar in the Ozarks of Arkansas, Arend (1950) concluded that growth averages about 14 m in 50 years on well-drained alluvial soils and upland soils that exceed 0.6 m in depth. Trees on soils less than 0.3 m in depth seldom grow taller than 6 to 9 m in the Ozarks, whereas trees average about 11 m on soils between 0.3 and 0.6 m in depth. Site index curves for eastern redcedar in the eastern U.S. predict tree height from less than 5 m to over 12 m for 30 year-old trees (Carmean et al. 1989). The trees on our study locations, all of which had soils of 1.0 m or more in depth, fit well within the normal range of height for the eastern U.S.

The effectiveness of burning, an economically favorable method of controlling eastern redcedar (Bernardo et al. 1988), is primarily a function of tree height. Almost all trees in the <1.0 m height class are killed by any fire that carries through a grass fuel bed, but tree kill declines rapidly as tree height increases from 1.0 to 2.0 m (Martin and Crosby 1955, Buehring et al. 1971, Owensby et al. 1973). The eastern redcedar invasion rate and the demography of future eastern redcedar populations on grassland sites susceptible to encroachment will likely be determined by an interaction of the fire return interval and the rate of height growth of eastern redcedar. To kill invading eastern redcedar, prescribed burning intervals should be more frequent on the eastern Oklahoma Loamy Prairie than on the central and western Oklahoma locations. Trees reached the 2.0-m height class at 8 years of age on the eastern Oklahoma location and trees reached 2.0 m at 10 and 14 years of age at the central and western locations, respectively. Trees 2.0-m tall averaged 12 years of age on a variety of Kansas tallgrass prairie range sites with similar site potential as the range sites at the central Oklahoma location (Owensby et al. 1973). This provides some evidence for uniformity in height growth functions among sites of similar potential.

The potential for crown closure appears very high at the eastern and western Oklahoma locations in particular. Only 250, 28-year-old trees ha^{-1} on the eastern Oklahoma study location would create complete canopy closure, assuming individual tree growth characteristics were similar to those of this study. Competition between trees at higher densities might significantly alter their individual growth characteristics. It is revealing, however, that canopy closure has become more common on grasslands throughout Oklahoma in the past 30 years. According to our observations in central Oklahoma (unpublished data), most of these stands are occupied by trees in the size and age classes represented in this study.

Crown area of 28-year-old trees was increasing at a rate of nearly 8 m^2 yr^{-1} on the eastern Oklahoma location. This suggests that the efficacy of prescribed burning for controlling eastern redcedar would be further reduced as trees age because fine fuel necessary to sustain an effective fire will be reduced in an amount approximately equal to the crown area of eastern redcedar (Engle et al. 1987).

Conclusions

Eastern redcedar tree height and crown area as a function of age were different at 3 locations in Oklahoma. Trees in the 28- to 29-year-old age class ranged in height from 6.2 m on the western Oklahoma location to 8.3 m on the eastern Oklahoma location. The trees on the eastern location were younger when they grew beyond the height at which they are effectively killed by fire. This implies that burning return intervals would need to be more frequent in the east to provide similar protection from eastern redcedar invasion under the same rate of invasion.

Crown area growth rate was also greatest on older trees on the eastern Oklahoma location, but crown area on older trees on the central Oklahoma location was less than that of trees on the eastern or western Oklahoma locations. These data suggest that the smaller crown area of trees at the central Oklahoma location, which is intermediate in site potential to the western and eastern locations, might be reflecting a genetic influence, such as an introduction of a different race having more of a columnar growth habit. A distinct variety having a columnar crown form has been described for eastern redcedar (Van Haverbeke and Read 1976).

The reduction in forage production associated with eastern redcedar would change more rapidly as trees age beyond 20 years on the eastern Oklahoma location than at the other locations. The efficacy of prescribed burning for controlling eastern redcedar would also change more rapidly in this age class of trees on the eastern Oklahoma location. The annual rate of forage loss beneath the crowns of 20 year-old and older trees is substantial at all 3 locations, and it is very high for older trees at the eastern and western locations.

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