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Dendroecological Potential of *Juniperus virginiana* L. Growing on Cliffs in Western Virginia

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[**Note**: The following is an abridged version of a report by the same title prepared during the Fourth Annual North American Dendroecological Fieldweek, 4-11 June, 1993, Mountain Lake Biological Station, Pembroke, Virginia. The work was performed by a group of participants led by Dr. Doug Larson and comprised of Sylvain Archambault, Jaroslav Dobry, Bob Keeland, Jeff Matheson, Kiyomi Morino, David Williams, and Diana Wolfram, all of whom are authors of the original report. This version, condensed by Thomas F. Wieboldt (Massey Herbarium, VPI & SU, Blacksburg, Va.), adheres very closely to the original text. It is abridged with the intent of conveying life history and ecological information of interest to **Banisteria** readers while omitting other details of interest principally to dendrochronologists.]

Exposed limestone cliffs in western Virginia support a sparse forest composed of *Juniperus virginiana* L. (eastern red cedar), a few shrubby angiosperm species and a rich array of pteridophytes, bryophytes and other cryptogams. The structure of this forest superficially resembles that of exposed limestone cliffs of the Niagara Escarpment, southern Ontario, Canada (Larson et al., 1989), where a presettlement forest of stunted *Thuja occidentalis* (arbor-vitae) has been shown to occur (Larson & Kelly, 1992). Kelly et al. (1992) successfully crossdated the slow growing and deformed stems of *T. occidentalis* and demonstrated the dendroecological potential for this cliff species. Given the ecological similarity between cliff habitats in Ontario and Virginia, and the largely mutually exclusive continental distributions of *J. virginiana* and *T. occidentalis*, we decided to explore the dendroecological potential of *Juniperus virginiana* growing on cliffs in the southeastern United States.

Juniperus virginiana has a broad ecological amplitude (Burns & Honkala, 1990); on good sites, growth to 1.0 m diameter at breast height (DBH) and 25 m height can occur in 60 years, while on poor sites, trees ca. 400 years old with DBH < 20 cm and 'height' of 2 m have been found (Butler & Walsh, 1988; Guyette et al., 1980; Guyette et al., 1982). This broad range of growth rate and a generally inverse relationship between longevity and growth rate is similar to that of *T. occidentalis* (Burns & Honkala, 1990; Larson & Kelly, 1992; Archambault & Bergeron, 1992). Maximum longevity of 1032 years in *Thuja* trees less than 20 cm basal diameter and 2 m height has been described, but all such old trees show pronounced strip-bark growth. Mature (>100 yr.) *Thuja* trees occur at a very low density on cliff faces

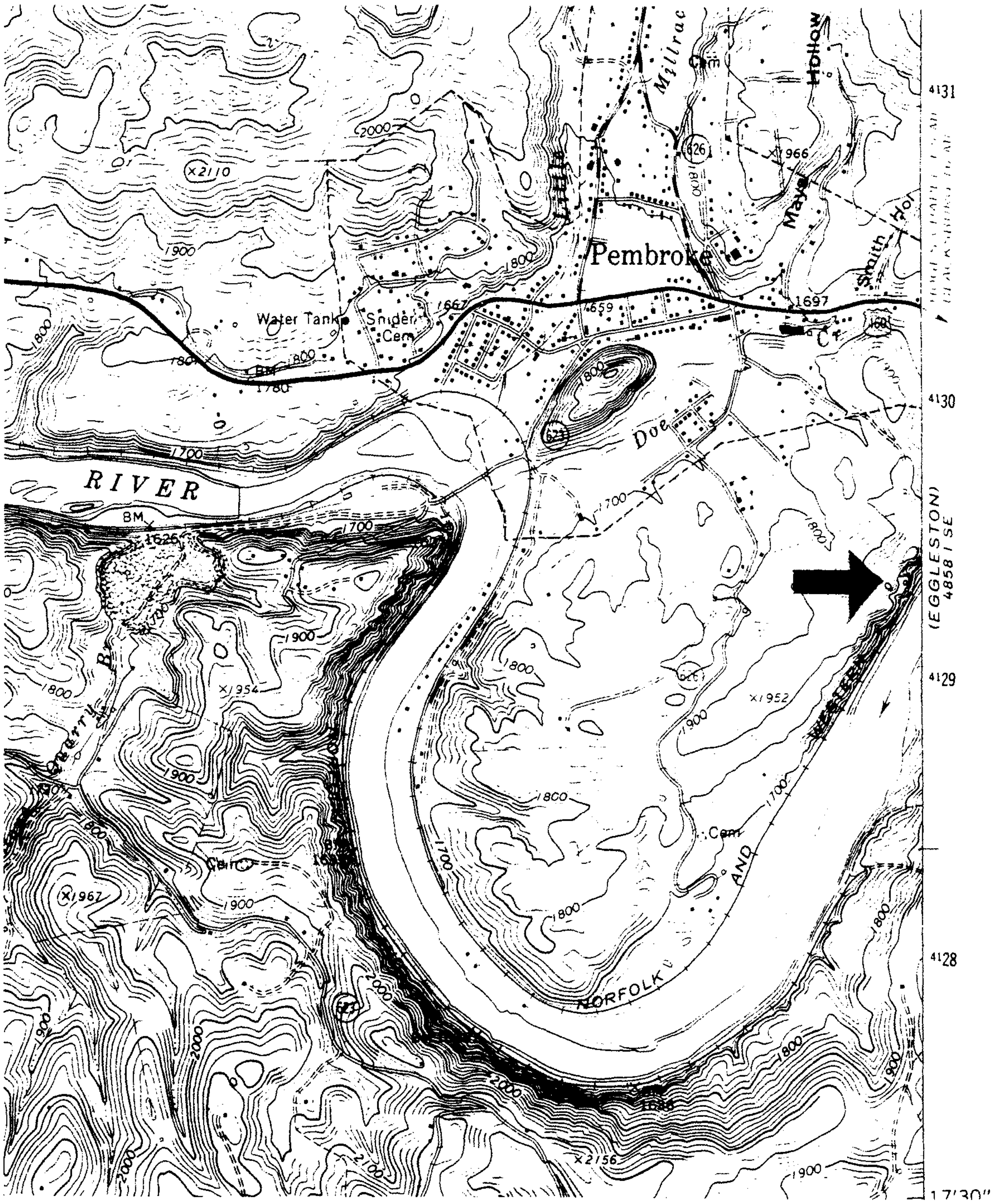

Fig. 1. A portion of the USGS topographic map (7½'), Pearisburg Quadrangle, showing location of the study site.

(ca. 100-150 trees per 100 m of cliff edge, or 200 trees per ha), and most of these trees occur towards the upper sections of cliff-faces and along the edge where the cliff-face borders the level-ground forest. Nothing is known, however, about the density, growth rate, or developmental architecture of *J. virginiana* on cliff habitats.

Past dendroecological studies on *J. virginiana* have been few in number and difficult to execute because of a high frequency of intra-annual rings (Guyette et al., 1980; Kuo & McGinnes, 1973) that complicate the search for annual increments of growth. Such false rings complicate the precise dating of growth increments required for accurate crossdating and subsequent climate reconstructions (Fritts, 1976). The dendroecological potential of this species, therefore, must include a direct examination of the form of the intrusion of false rings and the patterns of intra-ring width variability. In contrast to *J. virginiana*, the frequency of false rings in *T. occidentalis* is exceptionally low. Still, few dendro-ecological studies using *T. occidentalis* have been conducted due to its northeastern distribution in mesic parts of North America and a widespread belief that its maximum age was too low to be of interest to dendrochronologists.

The objective of this research was to evaluate the dendroecological potential of *J. virginiana* growing on limestone cliffs in western Virginia, and to compare this potential with that of *T. occidentalis* occurring on similar cliffs in southern Ontario, Canada.

Eight persons sampled cliff edges and faces during 4-11 June 1993. An area approximately 100 m long was sampled, but workers did not descend further than 15 m down the cliff face. Few trees were present below this zone. Safety harnesses, climbing rope and webbing were worn by workers to help guarantee the safety of personnel.

The total number of living and dead stems of *J. virginiana* was used as an approximate measure of the density of trees on the cliff. The location, diameter at increment coring height, and stem height were recorded for each tree. Paired core samples were taken from living trees and cross-sections were taken from dead trees found during the survey. Cores and cross sections were prepared using standard methods (Cook & Kairiukstis, 1990) and examined under dissecting microscopes to permit ring-counts.

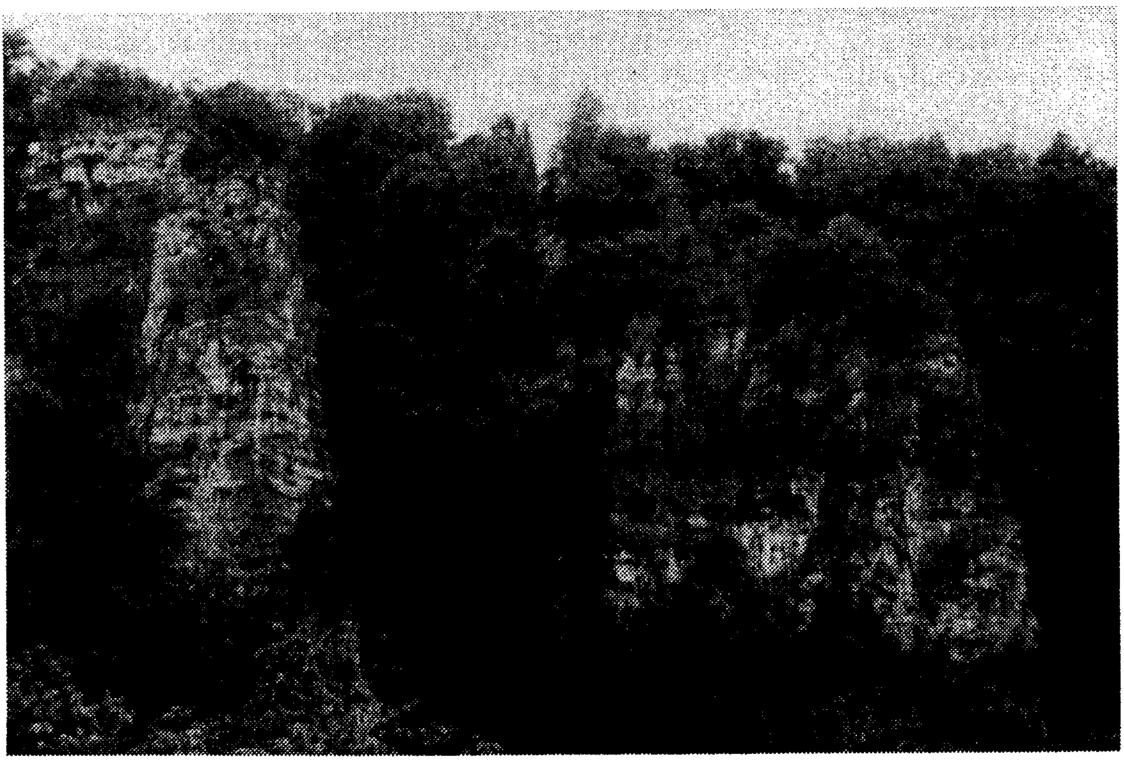

Fig. 2. Limestone cliff along New River, Giles County, Virginia, the site of the present study.

METHODS

The study site was a southeast-facing cliff near the town of Pembroke, Giles County, Virginia. (Lat. 37°18'30", Long. 80°37'30") (Fig. 1 & 2). Little evidence of disturbance was seen on the cliff face, although several fire scars on *J. virginiana* and hardwood species present in the level-ground forest at the top of the cliff were observed.

Chronology development

False rings were common in rapidly growing *J. virginiana* collected from the top of the cliffs. Although not as common in slower growing material, they posed a sizable dating problem. Since false rings occurred with high frequency only on precise years, they could be used as complementary information (Stokes & Smiley, 1968). Tree-rings were compared to the regional climatic data for divisions 05 and 06 to assess the strength of the species growth/climate response at this site. Two climatic divisions were used because the study site was located exactly at the boundary between the two divisions.

RESULTS

Tree density was very low. Given that 100 m of cliff edge were surveyed, the average mature tree density was less than one per linear meter for 15 m of vertical cliff edge.

The largest stems found in the survey were approximately 41 cm in diameter and showed 398 growth rings. Both dead and living trees with over 400 rings were found. Stems, which averaged about 6 m in height, showed a mean diameter of 20 cm and varied in ring count from approximately 120 years to 450 years. Stem V1C22 and V1A22 had the greatest number of growth rings at 469 and 473, respectively, and were 24 and 14 cm in diameter, respectively. The entire stem of V1A22 was harvested and had an air dried wood mass of 3.18 kg yielding an increment of 6.9 g $yr.^{-1}$. Evidence for such low growth rates applied to younger as well as older trees. Saplings 20-30 cm high frequently showed 20 growth rings and several samples of this age had a diameter of 4 mm. Constrained growth is clearly displayed by *Juniperus virginiana* growing on cliffs.

Crossdating was possible because of the synchronous occurrence of false rings in the majority of the samples. Since both climatic divisions yielded basically the same results, only those for division 06 will be discussed. Comparison of the residual chronology with climatic data showed a clear precipitation signal for current summer, with significant correlations for May (R=0.52), June (R=0.23) and July (R=0.30) precipitation (Fig. 3). A positive significant signal was also found with previous August precipitation (R=0.33). A strong relationship exists between the residual chronology and total precipitation for the May - June period (R=0.31). Temperature is not significantly related to growth although a slight negative influence of current summer temperature is observable.

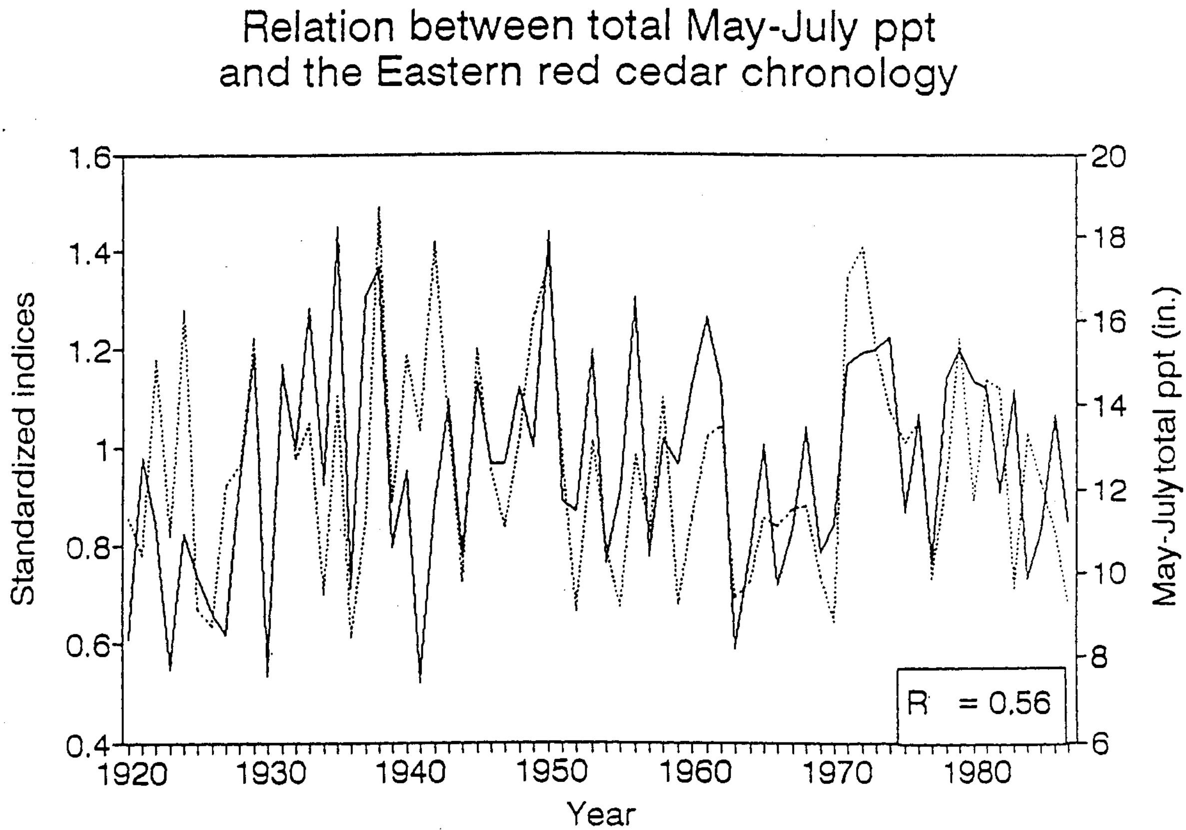

Fig. 3. Simultaneous plot of the annual tree-ring chronology of *Juniperus virginiana* (solid), and the May to July total precipitation for climate division 5 (Central Mountain) western Virginia (dotted). The simple correlation value is 0.56 indicating that portion of a substantial three growth can be explained by these climate data.

DISCUSSION

Limestone cliffs along the New River in western Virginia appear to support a presettlement forest of *Juniperus virginiana* of broadly similar structure and function to the *Thuja occidentalis* forests on the exposed limestone cliffs of the Niagara Escarpment (Larson & Kelly, 1991; Kelly et al., 1992). Tree population density, individual tree growth rates, longevity, and associated properties such as stem and canopy symmetry are very similar to *T. occidentalis* when growing on vertical limestone cliffs. Arbor-vitae most often shows stem asymmetry for trees greater than 300 years of age but this was not observed for *J. virginiana* on cliffs in Virginia. Maximum known tree age appears to be 475 years, but when one considers that only one cliff was sampled, and that only 101 adult trees were sampled, it is highly probable that much older trees will be found when other cliffs are explored. Given more time to carefully analyze the large collection of cores and cross-section of living and dead material, it is likely that this chronology can be extended beyond the pith date of the living trees (1517 AD). Since many of the trees that were harvested in Virginia had a similar weathered appearance to the *Thuja occidentalis* that occur on the Niagara Escarpment (Kelly et al., 1992), and since the latter trees have been shown to resist decay for many hundreds of years following death, it is entirely possible that a chronology could eventually be prepared from these trees that extends to ca. 1200 A.D.

Monthly precipitation and temperature records for regions adjacent to the study site were examined for trends since 1910. Early seasonal precipitation (May) showed a positive relationship to growth and there was an interesting but non-significant inverse relationship to temperature. In other words, *J. virginiana* displays increases in growth during cool and wet springs, and displays slow growth in May if conditions are dry and warm. This pattern of thermal and moisture relations is identical to *T. occidentalis* growing on rocky islands in boreal Quebec (Archambault & Bergeron, 1992) and similar to that found for *T. occidentalis* growing on cliffs of the Niagara Escarpment (Kelly et al., 1994).

Considering the magnitude of these correlations and the opportunities for extending the tree-ring chronology back several centuries, it appears that *Juniperus virginiana* has considerable dendroecological potential and research effort should be undertaken to exploit this species to the to the fullest extent possible.

SUMMARY

The dendroecological potential of *Juniperus virginiana* growing on vertical limestone cliffs in western Virginia was explored and compared to *Thuja occidentalis* growing on cliffs of the Niagara Escarpment, Ontario, Canada. One hundred and one core samples and cross sections of adult trees were obtained from ca. 100 m of cliff edge and face, and from these samples estimates were made of population density, tree growth rate, longevity, and xylem architecture. The results showed a high degree of similarity between forest and tree structure on New River cliffs and those of the Niagara Escarpment. False rings did not represent an impediment to chronology preparation. A tree-ring index was prepared for the period 1920-1992, and this chronology showed a high degree of correlation with May precipitation and a lesser negative correlation with summer air temperature. This chronology is the only one available for low elevation sites in Virginia, but by expanding it to include both living and dead tree-ring series, it could become a significant source for paleoclimatic reconstructions.

ACKNOWLEDGMENTS

The cooperation of Dr. Larson and fieldweek co-organizer Paul J. Krusic (TRL Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY) for signing-off on this version is gratefully acknowledged. The photograph used for Figure 2 was taken by Dr. Larson and made available through the assistance of Dr. Uta Matthes-Sears whose help is gratefully acknowledged. In addition, this abridged version was improved by reviews by Drs. Joseph C. Mitchell and Thomas J. Rawinski who suggested a number of minor textual changes.

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Two Orthopteroid Insects New to the Virginia Fauna (Saltatoria: Conocephalidae; Blattaria: Blattidae)

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Although there are no published lists of the various insects groups formerly included in the order Orthoptera known to occur in Virginia, a number of fairly compre-hensive accounts for the state fauna (e.g., Fox, 1917; Rehn & Hebard, 1916) or specific regions (e.g, Davis, 1926; Hebard, 1945) collectively give an impression of these insects in the Commonwealth. It is clear, however, that a considerable number remain to be collected and recorded, a good example being the camel crickets, genus *Ceuthophilus* as evident from the distribution maps in Hubbell's 1936 revision of that group. The extreme southeastern and southwestern parts of the state seem most likely to yield overlooked resident hexapods, and I provide here some documentation on two species inhabiting the former area. One is large but apparently not common, the other is small but widepsread and actually extremely abundant at most of its known localities.

Order Saltatoria (Orthoptera)

Family Conocephalidae

Pyrgocorypha uncinata (Harris)

Blatchley (1926: 511) stated that "...the species is known to range from Clarksville, Tenn., and Raleigh, N. Car., west and south to Arkansas, Texas, Cuba, Mexico, and Central America, though very few records of its occurrence in the United States