Dendrochronological Analysis of Cottonwoods at Bent's Old Fort National Historic Site

Final Report
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1. Introduction

Bent's Old Fort National Historic Site (BEOL), in southeastern Colorado, has riparian cottonwood forests with significant resource values. In March 2002, a fire burned about 200 ha at BEOL, including a portion of the riparian forest along the Arkansas River. Park personnel noted that some of the dead trees appeared to have fire scars. Photos of these trees sent to us by Fran Pannebaker did appear to show fire scars. At our direction, NPS personnel cut six cross-sections, across the scars, from five trees. The orientation of the tree when standing was marked on the cross-section. The dating of these scars would add to the knowledge of the area's fire history for BEOL's Fire Management Plan and perhaps impact the use of fire as a management tool.

Park personnel also wanted us to sample several large cottonwoods in the riparian forest to get a better sense of the ages of the larger trees at BEOL.

This work was done concurrently with a larger project, "Riparian Forest Age Structure and Hydroclimatic Variability, Sand Creek Massacre National Historic Site". BEOL is approximately 100 km southwest of Sand Creek Massacre NHS (SAND).

2. Description of the study area

The study area is a section of the floodplain of the Arkansas River within BEOL. The cross-sections (BEX samples) were collected east of the fort along the south side of the river. The cores (BEO samples) were collected south of the fort on the south side of the river.

3. General timeline of work completed

In October 2005, one of us (Lukas), along with Henry Adams of INSTAAR, traveled to BEOL to pick up cross-sections collected previously by BEOL staff, and to sample six trees there. Fran Pannebaker accompanied us in the field. In June 2006, we prepared and analyzed the BEOL samples.

Below we describe in detail the methods and results for this work.

4. Methods

4.1. Cores from Trees

In the bottomland south of the Arkansas River, we sampled five large living plains cottonwoods and one dead standing cottonwood with an increment borer for age determination, measured their DBH, and recorded their location with a GPS. In the lab, we mounted, surfaced, and crossdated the cores.

4.2. Scarred Cross-Sections

The six cross-sections from the presumably fire-scarred plains cottonwood trees, collected by BEOL staff, were taken back to INSTAAR. However, closer inspection of the scars showed that the only visible charring is on wood grown after the formation of the scars and is almost certainly associated with the 2002 fire that killed the trees. We then determined the year of formation of the scars from observing when the scar and/or post-scarring growth intercepted the crossdated annual rings.

5. Results and Discussion

(The Excel file **BEOL Tree Data.xls**, contains the full data from the BEOL trees described below.)

5.1. Cores from trees (BEO)

The DBH of these trees (80-130+ cm) was comparable with those of trees in the older age classes (A1 and A2) at SAND.

The crossdating among the cores from the six cottonwoods was much poorer than that among the SAND trees, indicating that the growth of the BEOL trees was less affected by hydroclimatic fluctuations. This would be expected, given their location near a large perennial stream. In four trees, the cores came close enough to pith to estimate the pith date from ring curvature. As in the SAND study, a correction of one year was used for the time the tree takes from germination to reach sampling height. The estimated germination dates for these four trees were 1932, 1935, 1943, and 1948. Another core (BEO5) did not reach the pith because of heartrot, although the rings that were present included the earliest date (1922) from all six trees. From this partial core and the DBH of the tree, we estimated a germination date of 1898. Finally, even though the core from the largest tree (BEO6) was collected with our longest (70 cm) borer, it did not come close enough to pith to show ring curvature. Because the tree forked just above the sampling height, we did not attempt to estimate the pith date from the DBH, and so we can only say that germination date predates 1937.

The results show that four of the trees are between about 60 and 75 years old, another is at least 70 years old, and the last is approximately 110 years old. All but the oldest of these trees are growing much faster than their counterparts at SAND. Again, this is to be expected, given the likely greater availability of moisture in the floodplain of the Arkansas River. Because of the very small sample size, we did not attempt to link these germination dates with specific flood events.

5.2. Scarred cross-sections (BEX)

The crossdating on these trees was much better than with the other group from BEOL; that is, their growth was more responsive to changes in moisture availability. Two cross-sections contained pith; BEX2 had a pith date of 1929, and while the innermost wood of BEX4 was rotten, precluding reliable dating, the estimated pith date is 1933. Germination dates were not estimated since the sampling heights were unknown. The inside dates of the other cross-sections ranged from 1938 to 1971; no attempt was made to estimate pith dates.

The scars on all of the trees had very similar morphology: some injury had led to the death of the cambium (the active growth layer of the wood) across roughly one-third to one-half of circumference of the tree. The growth since the injury, at the point that the section was cut, partially covered over the scar. In the time since the scar, the death of bark and cambium had led to rot in the underlying wood, and it appears that the 2002 fire readily consumed this rotten wood on several of the trees, hollowing them out. Photos taken in the field by BEOL staff showed that on at least two of the trees, the scar extended to the base of the tree (basal scars).

The formation of the scars was dated to 1978 (BEX1), 1981 (BEX2), 1981 (BEX3), 1975 (BEX4), and 1969 (BEX5). BEX4 also had what appeared to be an older scar, in about 1946, though its nature and exact date were obscured by the rotten inner wood and the subsequent scarring. Similarly, the inner rot and charring on the other cross-sections may hide earlier scars.

With four different years over a 13-year period represented by the five scars, the mechanism of injury must be fairly frequent. This high frequency is not consistent with a natural fire regime in riparian cottonwood ecosystems, which typically have much longer fire intervals. However, the scars could represent high-frequency intentional burning of the study area to control weeds and/or improve forage. Even if some or all of the scars were caused by fire, they are unlikely to provide information about the natural fire regime.

Another potential cause of the scars is impact from flood-rafted debris, which is common in floodplain forests. Many studies (Yanosky and Jarrett 2002 and references therein) have used such scars to reconstruct the frequency and magnitude of past flood events. The orientation of the scars on the trees only supports this mechanism, for one or two of the trees, however. On three of the five trees, the scar faced south; on the fourth, southwest; on the fifth, west. The trees are located on a reach where the Arkansas River flows to the east. Therefore, injury caused by flood-rafted debris would be expected to occur on the west side of the tree. Furthermore, scars caused by flood-rafted debris tend not to extend to the base of the tree.

If these are in fact flood-debris scars, we might expect the four scar years to be among the larger flood events in recent decades. The gaged flow record for the Arkansas River at La Junta can be used to assess this expectation. In 1969 and 1978 the peak instantaneous discharges were 380 m^3/s (13,400 cfs) and 420 m^3/s (14,800 cfs), respectively. These were the two highest peak discharges between 1967 and 1984, and the fifth and sixth highest from 1960-2005. But the 1975 and 1981 peak discharges were not exceptional, at 126 m^3/s (4,460 cfs) and 190 m^3/s (6,690 cfs), respectively.

Another potential cause of basal scars on cottonwoods is browsing by the American beaver *(Castor canadensis)*. Beavers are known to occur at BEOL, and so some or all of the scarred trees may have been partially girdled by browsing. Further examination of other scarred cottonwoods in the study area would be needed to determine whether scars were more likely to be caused by fire, flood debris, browsing by beavers, or another mechanism.

6. Reference

Yanosky, T. M., and Jarrett, R. D. 2002. Dendrochronologic evidence for the frequency and magnitude of paleofloods. Pp. 77-89 in P. K. House, D. R. Levish, R. H. Webb and V. R. Baker, eds., Paleoflood Hydrology. American Geophysical Union Monograph, Washington, 385 p.