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A River Transformed: Historic Geomorphic Changes of the Lower Rio Grande in the Big Bend Region of Texas, Chihuahua, and Coahuila

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A RIVER TRANSFORMED: HISTORIC GEOMORPHIC CHANGES OF THE
LOWER RIO GRANDE IN THE BIG BEND REGION OF TEXAS,
CHIHUAHUA, AND COAHUILA

by

David James Dean

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Watershed Science

Approved:

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UTAH STATE UNIVERSITY
Logan, Utah
2009
ABSTRACT

A River Transformed: Historic Geomorphic Changes of the Lower Rio Grande in the Big Bend Region of Texas, Chihuahua, And Coahuila

by

David James Dean, Master of Science
Utah State University, 2009

Major Professor: Dr. John C. Schmidt
Department: Watershed Sciences

Over the last century, the construction and management of large dams and streamflow diversions, and periodic drought have resulted in significant declines in stream flow of the lower Rio Grande in the Big Bend region. Reductions in mean annual flow and peak discharge have resulted in channel narrowing by the formation of vertically accreting inset floodplains. Narrowing has been temporarily interrupted by infrequent large dam releases greater than 1000 m$^3$/s that have temporarily widened the channel; however, after each of these events, narrowing has resumed. Prior to 1942, floods of this magnitude occurred approximately once every 4 years and maintained a wide sandy channel. Since 1942, they have occurred 4 times. The decline in frequency of these large floods has resulted in a channel approximately 50% narrower than in the 1940s. Since the most recent channel widening floods in 1991, the channel has narrowed between 35 and 50%. In two large floodplain trenches, we observed between 2.75 and 3.5 m of vertical accretion during the same period. Additionally, nearly 90% of bare active channel bars have been converted to vegetated floodplains. Since 1991, the cross section
channel area at the Johnson Ranch gage has decreased by approximately 30%. The reduction in cross section area and the invasion of non-native vegetation have resulted in higher flood stages, flooding at lower discharges, and continued vertical accretion.

Channel narrowing has negatively impacted the native and endemic aquatic ecosystem through the loss of ecologically important habitats such as backwaters, side channels, and low velocity portions of the channel. Reductions in cross section area and resultant increased flood stages have also endangered historic cultural sites within the Big Bend region. Restoration efforts are currently underway within the region without a clear understanding of these historical channel changes and why they occurred.

Our reconstruction of historical channel changes shows that the most significant periods of channel narrowing occurred during drought and increased stream-flow management. Management practices also appear to have enabled the invasion of non-native riparian species, which promoted sedimentation, bank stabilization, and additional channel narrowing. In order to restore historical measures of channel width, management options include non-native vegetation removal, common low magnitude dam releases that provide flood disturbance and prevent vegetation establishment, and large dam releases in excess of 1000 m$^3$/s that create and maintain a wide channel. Vegetation management is expensive and time consuming, and managed dam releases are politically unpopular and expensive, however, without the management of non-native riparian species and reinstatement of portions of the historical flood regime, ecological restoration will be difficult.

(346 pages)
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David J. Dean
CONTENTS

Page

ABSTRACT .............................................................................................................. ii

LIST OF TABLES.................................................................................................. viii

LIST OF FIGURES................................................................................................. ix

CHAPTER

1. INTRODUCTION............................................................................................... 1

References Cited................................................................................................. 4

2. THE TIMING AND MAGNITUDE OF HISTORIC CHANNEL CHANGES IN THE
BIG BEND REGION OF TEXAS, CHIHUAHUA, AND COAHUILA........................ 7

Abstract............................................................................................................... 7

1. Introduction..................................................................................................... 8

2. Study Area..................................................................................................... 9

3. Hydrology...................................................................................................... 11

4. Previous Studies of Channel Change of the Rio Grande Along and Near the
International Boundary...................................................................................... 13

5. Methods........................................................................................................ 16

5.1 Hydrologic Data............................................................................................ 16

5.2 Repeat Photography of Historic Oblique Photographs............................... 17

5.3 Analysis of Discharge Measurement Notes and Stage Plate
Measurements....................................................................................................... 18

5.4 Stratigraphic and Dendrogeomorphic Analysis of Inset Floodplain
Deposits.............................................................................................................. 19

5.5 Aerial Photograph Interpretation and Analysis............................................ 19

5.6 Water Surface/Channel Bed Slope.................................................................. 21

6. Results............................................................................................................. 21

6.1 Hydrology..................................................................................................... 21

6.2 Historic Oblique Photograph Comparison................................................. 22

6.3 Changes in Channel Width Based on Historic Oblique Photograph
Comparison......................................................................................................... 23

6.4 Analyses of Discharge Measurement Notes............................................... 24

6.5 Dendrogeomorphologic Analyses of Inset Floodplain Deposits............... 26
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.6 Aerial Photograph Analysis</td>
<td>27</td>
</tr>
<tr>
<td>6.7 Changes in the Longitudinal Profile</td>
<td>28</td>
</tr>
<tr>
<td>7. Synthesis of Historical Channel Changes</td>
<td>29</td>
</tr>
<tr>
<td>7.1 1900-1942: Channel Maintenance</td>
<td>29</td>
</tr>
<tr>
<td>7.2 Post-1942: Narrowing and Resetting</td>
<td>30</td>
</tr>
<tr>
<td>8. Geomorphic Effects of Flooding</td>
<td>31</td>
</tr>
<tr>
<td>9. Forcing Mechanisms of Change</td>
<td>33</td>
</tr>
<tr>
<td>10. Conclusions</td>
<td>37</td>
</tr>
<tr>
<td>11. References Cited</td>
<td>38</td>
</tr>
<tr>
<td>3. FLOODPLAIN ANATOMY OF A NARROWING RIVER: STRATIGRAPHIC AND SEDIMENTOLOGICAL ANALYSIS OF FLOODPLAIN FORMATION IN BIG BEND NATIONAL PARK, TX</td>
<td>72</td>
</tr>
<tr>
<td>Abstract</td>
<td>72</td>
</tr>
<tr>
<td>1. Introduction</td>
<td>73</td>
</tr>
<tr>
<td>2. Study Area</td>
<td>74</td>
</tr>
<tr>
<td>3. Geomorphic Background</td>
<td>75</td>
</tr>
<tr>
<td>4. Floodplain Formation and Stratigraphy</td>
<td>76</td>
</tr>
<tr>
<td>5. Methods</td>
<td>77</td>
</tr>
<tr>
<td>6. Results</td>
<td>78</td>
</tr>
<tr>
<td>6.1 Stratigraphy and Sedimentology</td>
<td>80</td>
</tr>
<tr>
<td>6.2 Active Channel Component</td>
<td>80</td>
</tr>
<tr>
<td>6.3 Floodplain Conversion Component</td>
<td>81</td>
</tr>
<tr>
<td>6.4 Floodplain Component</td>
<td>82</td>
</tr>
<tr>
<td>6.5 Grain Size</td>
<td>83</td>
</tr>
<tr>
<td>7. Discussion</td>
<td>83</td>
</tr>
<tr>
<td>8. Conclusions</td>
<td>85</td>
</tr>
<tr>
<td>9. References Cited</td>
<td>86</td>
</tr>
<tr>
<td>4. CONCLUSIONS</td>
<td>98</td>
</tr>
<tr>
<td>4.1 Management Options</td>
<td>99</td>
</tr>
<tr>
<td>4.2 References Cited</td>
<td>102</td>
</tr>
<tr>
<td>APPENDIX – SUPPLEMENTAL STRATIGRAPHIC AND DENDROGEOMORPHIC DATA</td>
<td>104</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Flight dates for aerial photographs</td>
<td>41</td>
</tr>
<tr>
<td>2.2</td>
<td>Hydrologic characteristics at the Rio Grande below Rio Conchos gage and at the Rio Grande at Johnson Ranch gage</td>
<td>42</td>
</tr>
<tr>
<td>2.3</td>
<td>Summary of oblique historical photograph data</td>
<td>43</td>
</tr>
<tr>
<td>2.4</td>
<td>Changes in channel width based on historical oblique photograph comparison</td>
<td>44</td>
</tr>
<tr>
<td>2.5</td>
<td>Hydraulic geometry of the Rio Grande at the Johnson Ranch gage</td>
<td>45</td>
</tr>
<tr>
<td>2.6</td>
<td>Active channel width of Rio Grande for Castolon, Johnson Ranch, and Boquillas Reaches</td>
<td>46</td>
</tr>
<tr>
<td>2.7</td>
<td>Percent conversion of active channel surfaces</td>
<td>47</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Map of the Big Bend region</td>
<td>48</td>
</tr>
<tr>
<td>2.2</td>
<td>Reach Location Map</td>
<td>49</td>
</tr>
<tr>
<td>2.3</td>
<td>Median annual hydrographs prior to 1915 at IBWC gages Rio Grande above Rio Conchos and Rio Grande below Rio Conchos near Presidio, TX and Ojinaga, Chih</td>
<td>50</td>
</tr>
<tr>
<td>2.4</td>
<td>Cumulative reservoir storage of upper Rio Grande and Rio Conchos</td>
<td>51</td>
</tr>
<tr>
<td>2.5</td>
<td>Mean annual flow of segments of the Rio Grande</td>
<td>52</td>
</tr>
<tr>
<td>2.6</td>
<td>Methods for delineating changes in active channel width and calculating the conversion of active channel bars to vegetated floodplain</td>
<td>53</td>
</tr>
<tr>
<td>2.7</td>
<td>Annual peak flow characteristics at the Rio Grande below Rio Conchos gage and the Rio Grande at the Johnson Ranch gage</td>
<td>54</td>
</tr>
<tr>
<td>2.8</td>
<td>Flow duration curves at the Rio Grande Below Rio Conchos gage and at the Rio Grande at Johnson Ranch gage</td>
<td>55</td>
</tr>
<tr>
<td>2.9</td>
<td>Annual hydrographs of the Johnson Ranch gage from 1992 to 1995</td>
<td>56</td>
</tr>
<tr>
<td>2.10</td>
<td>Historical oblique photo match in Hot Springs Canyon looking upstream toward Tornillo Creek</td>
<td>57</td>
</tr>
<tr>
<td>2.11</td>
<td>Historical oblique photo match looking downstream from the outlet of Hot Springs Canyon</td>
<td>58</td>
</tr>
<tr>
<td>2.12</td>
<td>Historical oblique photo match looking downstream toward Black Dike</td>
<td>59</td>
</tr>
<tr>
<td>2.13</td>
<td>Historical oblique photo match taken above the “rock slide” looking downstream in Santa Elena Canyon</td>
<td>60</td>
</tr>
<tr>
<td>2.14</td>
<td>Historical oblique photo match looking upstream from the Johnson Ranch stream gage</td>
<td>61</td>
</tr>
<tr>
<td>2.15</td>
<td>Hydraulic geometry relations at the Johnson Ranch gage</td>
<td>62</td>
</tr>
</tbody>
</table>
2.16 Channel cross sections measured at the Johnson Ranch cableway ............63
2.17 Stage-discharge rating relations for flows measured at JR and the Castolon stage plate..........................64
2.18 Stratigraphy and burial dates observed in the Castolon trench.............65
2.19 Best estimate of the active channel width for the Castolon, Johnson Ranch, and Boquillas reaches..........................66
2.20 Sediment accumulation and reductions in active channel width between 1991 and 1996..................................................67
2.21 Longitudinal profile of the water surface from Santa Elena Canyon to the Castolon trench site..................................................68
2.22 Peak discharge and duration in cms days greater than 300 m³/s..................69
2.23 General model of historic channel changes..................................................70
2.24 Synthesis of historic channel change and its drivers...............................71
3.1 Map of the Big Bend region.................................................................91
3.2 Locations of the Castolon and Boquillas trench sites.............................92
3.3 Stratigraphy and sedimentology observed in the Castolon trench.............93
3.4 Stratigraphy and sedimentology observed in the Boquillas trench.............94
3.5 Sedimentological characteristics of the active channel facies.....................95
3.6 Sedimentological characteristics of the floodplain conversion facies..........96
3.7 Sedimentological characterizes of floodplain facies................................97
3.8 Vegetation induced sedimentary structures..........................................98
3.9 Average grain size distribution of active channel facies, floodplain conversion facies, and floodplain facies.................................99
CHAPTER 1
INTRODUCTION

Rivers adjust their morphologies in response to changes in their flow regime, sediment supply, and size of the supplied sediment, and the style of response is partly determined by the surrounding vegetation and the width of the alluvial valley (Leopold and Maddock, 1953; Lane, 1955; Schumm, 1977; Brierley and Fryirs, 2005). In natural systems, watershed characteristics such as geology, relief, and climate control the water and sediment supply as well as the valley topography (Schumm and Lichty, 1965). Humans, however, have altered the runoff and sediment supply regime through dam construction, stream-flow diversion, ground-water pumping, and land use practices resulting in widespread changes to stream channel form (Haff, 2001). Climate change and non-native riparian vegetation invasions have exacerbated the transformation of many of the Earth’s rivers. Additionally, positive feedbacks may result in a cascade of changes resulting in a river system completely transformed from its natural state.

Dam construction and management disrupts the mass balance of water and sediment by trapping sediment in reservoirs and altering the hydrograph downstream. The resulting geomorphic effects depend upon the overall magnitude of alteration as well as the changes to the relative ratio of water and sediment supplies (Schmidt and Wilcock, 2008). In cases where the reduction in stream flow is greater than the reduction in sediment supply, the result is often channel narrowing which occurs through the formation of floodplains inset within the previously wider channel margins (Everitt, 1993; Friedman et al., 1996; Friedman et al., 1998; Allred and Schmidt, 1999). Narrowing often occurs at the expense of ecologically important habitats through bank
attachment of channel bars and the accretion of sediment within side channels and backwaters.

On many western rivers, the reduction in flood frequency and magnitude, and the shift of flood timing have favored the establishment and proliferation of non-native vegetation including tamarisk (*Tamarix* spp.), a shrub that is a federally designated noxious weed. In many areas, dense monocultures of tamarisk exist along rivers that previously had little vegetation along their margins. Vegetation effectively stabilizes once mobile surfaces (Thorne, 1990; Simon and Collison, 2002), reduces channel-margin flow velocities (Carollo et al., 2002), and induces sedimentation (Schultz et al., 2003) thereby creating a positive feedback between vegetation establishment and channel narrowing. Some studies show that vegetation effectively results in secondary channel abandonment and the conversion of a multi-thread river to a single thread (Tal et al., 2003; Tal and Paola, 2007).

The lower Rio Grande in the Big Bend region of Texas, Chihuahua, and Coahuila has experienced tremendous changes in stream flow, sediment supply, and vegetation cover. During the 20th century, the construction of dams, stream flow diversions, and levees on the upper Rio Grande and its largest tributary, the Rio Conchos, completely altered the hydrologic and sediment regime. On the upper Rio Grande, the operation of dams in New Mexico, and the diversion of their releases for agriculture in the El Paso-Juarez Valley, resulted in a severe depletion of stream flow downstream in the Big Bend region (Everitt, 1993; Schmidt et al., 2003). Thus, although the lower Rio Grande historically received more than two-thirds of its water from the Rio Conchos, the present flow regime is now completely dependant upon the Rio Conchos. However, consumptive
water use of the Rio Conchos has also increased during the 20th century resulting in an 86% decrease in mean annual flow since 1915 (Schmidt et al., 2003).

Channel changes immediately upstream of the Rio Conchos are relatively well understood. Stream flow reductions and unaltered sediment inputs from ephemeral tributaries caused the channel to narrow by approximately 90% between 1902 and 1970 (Everitt, 1993). Channel narrowing and vertical aggradation of the channel bed and floodplains occurred until channel capacity was so greatly reduced that overbank flooding resumed. Thus, the channel established a new balance between its altered stream flow and sediment supply. As the channel narrowed, thick stands of tamarisk colonized these new floodplain surfaces which now dominate the riparian corridor.

Downstream of the Rio Conchos, geomorphic changes are widely recognized by river users yet remain largely un-quantified. In this region, the lower Rio Grande is not confined within levees, nor is it channelized. Six protected areas exist within the United States and Mexico along this reach and all have the common goal of wilderness and ecosystem preservation. Additionally, managers are currently implementing restoration projects along the river corridor without a clear understanding of the historical geomorphic changes and/or the forcing mechanisms of those changes. Thus, the quantification of the rate, magnitude, and mechanisms of historical channel change on the lower Rio Grande will help guide reasonable targets for restoration efforts currently underway in the region.

Chapter 2 describes channel changes of the lower Rio Grande using methods applied at several spatial and temporal scales. At large spatial but temporally limited scales, I conducted aerial photograph analyses of 3 study reaches within Big Bend
National Park (BBNP), TX, and adjacent portions of Chihuahua and Coahuila, MX, to determine changes in channel width. I matched 18 historic oblique photos within the 3 study reaches, and matched 9 photos elsewhere in BBNP to describe channel changes prior the first aerial photographs. At spatially limited but temporally precise scales, I analyzed discharge measurement notes and stage plate measurements at the Johnson Ranch gage and Castolon stage plate to determine changes in the channel cross section, hydraulic geometry, and stage-discharge relationships. Additionally, I conducted stratigraphic and dendrogeomorphic analyses of inset floodplain deposits in two large floodplain trenches to determine the rate and magnitude of recent floodplain formation. The integration of these methods provides a comprehensive synthesis of channel change during the last century.

Chapter 3 specifically addresses floodplain stratigraphy and sedimentology, and I describe the mechanisms of channel narrowing and floodplain formation in BBNP. Using a high resolution tree ring dating technique (Friedman et al., 2005), I constrained the timing and magnitude of floodplain formation. I analyzed primary sedimentary structures, secondary sedimentary structures, and grain size to determine the dominant mechanisms responsible for recent floodplain formation.

The thesis concludes in Chapter 4 with a discussion of management recommendations that arise from this study.

REFERENCES CITED


CHAPTER 2

FROM CHANNEL TO FLOODPLAIN: GEOMORPHIC TRANSFORMATION OF THE LOWER RIO GRANDE IN THE BIG BEND REGION OF TEXAS, CHIHUAHUA, AND COAHUILA¹

ABSTRACT

Large-scale water development of the upper Rio Grande in the U.S. and Mexico, and of the Rio Conchos in Mexico, has resulted in channel narrowing, vertical floodplain accretion, and loss of channel capacity of the lower Rio Grande in the Big Bend region of Texas, Chihuahua, and Coahuila. Although general channel narrowing has occurred since the 1940s, the active channel width of the Rio Grande in Big Bend National Park has narrowed by 35-50% since 1991. This recent phase of narrowing occurred following a channel widening flood in 1991. Narrowing has occurred by vertical accretion of fine-grained deposits inset within natural levees. Vertical accretion has occurred on top of alternate bars of sand and gravel. In two floodplain trenches, 2.75 and 3.5m of vertical accretion were measured, all of which occurred during the past 17 years. In some localities, nearly 90% of bare, active channel bars were converted to vegetated floodplain during the same period. Channel narrowing by vertical accretion coincided with a rapid invasion of non-native riparian vegetation (Tamarix chinensis, Arundo donax). Upward shifts of stage-discharge relations occurred resulting in over-bank flooding at lower discharges, and continued vertical accretion despite a progressive reduction in stream flow. Thus, although peak flows were reduced by 48% and the duration of the 2-year

¹ Coauthored by John C. Schmidt
flood declined during the past 17 years, over-bank flooding has continued. The loss of channel capacity and subsequent elevated flood stages have threatened historical sites throughout the park. Our results are based on methods that operate at multiple spatial and temporal scales including: hydrologic analysis of historic stream gage data, analysis of discharge measurement notes, historic oblique and aerial photograph analysis, field mapping of geomorphic surfaces, and stratigraphic and dendrogeomorphic analysis of inset floodplain deposits. These changes reflect a shift in the geomorphic nature of the Rio Grande from a laterally unstable, multi-thread, wide river with transient channel bars to a laterally stable, single-thread, channel with cohesive, vertical banks and few active in-channel bars.

1. INTRODUCTION

Climate change, dams, stream flow diversions, alluvial ground-water pumping, non-native riparian vegetation invasion, and watershed-scale land use change have altered the stream flow regime and sediment supply of many of the world’s rivers and thereby caused channel change (Hooke, 1994; Haff, 2001). Many of these channel changes are undesirable and are now the focus of river restoration efforts. Thus, it is axiomatic that restoration goals and techniques associated with these efforts be guided by sound understanding of the history of channel change and why that change occurred (Kondolf, 1995).

The Rio Grande in the Big Bend region of Texas, Chihuahua, and Coahuila has experienced tremendous changes in stream flow and sediment supply. The associated transformation of channel and floodplain geomorphology is widely recognized but has
never been well described or quantified. Restoration efforts are currently underway within the region without a clear understanding of these historical channel changes and why they occurred.

In this paper, we integrate methods applied at multiple temporal and spatial scales to develop a robust history of channel change and determine the causes of that change. We conducted detailed studies in parts of Big Bend National Park (BBNP) in the United States and in adjacent parts of Mexico. We demonstrate that due to a decrease in total stream flow and flood flow, the width of the Rio Grande is approximately half of what it was a century ago. We also describe the relative importance of various forcing mechanisms that caused the channel change and show how the trajectory of channel change was affected by non-native riparian vegetation invasion.

2. STUDY AREA

Channel change was analyzed at a few discrete locations within bedrock canyons, and in 3 alluvial reaches that comprise 14% of the 205-km length of the Rio Grande in BBNP (Fig. 2.1). All field work was conducted in BBNP, but we report remotely-sensed attributes of channel change in adjacent parts of Chihuahua and Coahuila where the Rio Grande is called the Rio Bravo.

The Big Bend region extends from the confluence of the Rio Grande and Rio Conchos 490 km downstream to Amistad Reservoir. Because stream flow from the Rio Conchos significantly augments the hydrology of the Rio Grande, we refer to the Rio Grande upstream from the Rio Conchos as the upper Rio Grande and downstream from the Rio Conchos as the lower Rio Grande.
There are five other protected areas besides BBNP in the Big Bend region: Big Bend Ranch State Park, Cañon de Santa Elena Protected Area, Maderas del Carmen Protected Area, Black Gap Wildlife Management Area, and the Rio Grande Wild and Scenic River. The proposed Ocampo Protected Area would link Cañon de Santa Elena and Maderas del Carmen in Mexico and thereby create the one of the largest bi-national conservation areas in North America.

Today, the Rio Grande in the Big Bend region is single-threaded and flows through wide alluvial valleys in structural basins and narrow canyons cut through intervening ranges. Some of the canyons are very narrow, and the channel banks are bedrock. In wider canyons, alluvium forms the channel banks. Channel slope is approximately 0.0013 in the alluvial valleys and 0.002 in the canyons. The bed of the Rio Grande is predominately sand, although alternate gravel bars form at the mouths and downstream from ephemeral tributaries.

Main-stem floods have high suspended loads of fine sediment. Sources of sediment are the Rio Conchos downstream from Luis Leon Dam (Fig. 2.1) and ephemeral tributaries that drain parts of the sparsely vegetated Chihuahuan Desert that are underlain by fine grained sedimentary and volcanic rocks. The largest ephemeral tributaries are Alamito, San Carlos, Terlingua, and Tornillo Creeks (Fig. 2.1b). Floods on these tributaries sometimes exceed the magnitude of the long-term average 2-yr flood of the lower Rio Grande, yet their combined mean annual flow is a small fraction of the total flow.

The 3 alluvial study reaches include: (1) 14.5 km between the mouth of Terlingua Creek and Castolon, TX, referred to as the Castolon reach, (2) 12.5 km in the vicinity of
the Johnson Ranch gage, referred to as the Johnson Ranch reach, and (3) 12.1 km near Boquillas, Coah, referred to as the Boquillas reach (Fig. 2.2). A stage plate near Castolon has been read daily since 1984, and is located approximately 100 m downstream from a trench that we excavated to analyze floodplain stratigraphy. The Johnson Ranch reach includes the Johnson Ranch stream gage operated by the International Boundary and Water Commission (IBWC) (gage number 08375500; Rio Grande at Johnson Ranch). Discharge at the Johnson Ranch gage has been measured since 1936. In the Boquillas reach, we excavated a trench in the floodplain approximately 2 km upstream from Boquillas, MX. At the Castolon stage plates, there are brief periods from a few days to a month when there is no record.

We also analyzed hydrologic records collected at an IBWC gage 8 km downstream from the Rio Conchos (gage number 08374200; Rio Grande below Rio Conchos). We also matched 18 historic photos within the 3 alluvial study reaches, and matched 9 photos elsewhere in BBNP.

3. HYDROLOGY

Stream flow of the lower Rio Grande has long been altered by humans, and it is impossible to reconstruct the pre-disturbance condition of the river. Irrigation diversions in northern New Mexico date to at least the late 1500s (Wozniak, 1998), irrigated agriculture supported by diversions began in the El Paso - Juarez Valley in 1659 (Stotz, 2000), and irrigated agriculture has been practiced near Presidio since the mid-1700s (Schmidt et al., 2003). In the 1890s, Mexico lodged formal complaints to the United
States on behalf of irrigators near Juarez whose water supplies were greatly diminished by upstream depletions.

Stream flow measurements in the Big Bend region began at the beginning of the 20th century. Between 1901 and 1913, prior to the construction of large dams, most of the stream flow of the lower Rio Grande came from the Rio Conchos (Schmidt et al., 2003). This occurred despite the fact that the 165,000 km² area of the upper Rio Grande is more than twice as large as the 70,000 km² drainage basin area of the Rio Conchos.

The flood regime of lower Rio Grande in the early 20th century was composed of two peaks: a small, snowmelt peak from the upper Rio Grande, and a much larger peak from monsoon rains and tropical storms in the Rio Conchos watershed (Fig. 2.3). Between August and February, more than 65% of the lower Rio Grande’s mean monthly stream flow came from the Rio Conchos, and the annual flood typically peaked in September (Schmidt et al., 2003). In contrast, between April and June, more than 80% of the lower Rio Grande’s stream flow came from the upper Rio Grande’s snow melt flood (Fig. 2.3), when there was little precipitation in the Rio Conchos watershed.

The stream flow regime of the lower Rio Grande was profoundly changed by La Boquilla Dam, completed in 1913 on the Rio Conchos, and by Elephant Butte Dam in southern New Mexico completed in 1915. Together, reservoir storage created by these dams and other dams was nearly 3 times the pre-1915 mean annual flow of the lower Rio Grande (Fig. 2.4). Reservoir storage has more than doubled since then, including two dams on the Rio Conchos downstream from La Boquilla Dam (Francesco I. Madera in 1947 and Luis L. Leon in 1967) and one downstream from Elephant Butte (Caballo in 1938). Operations of Elephant Butte and Caballo Dams eliminated the natural spring
snowmelt flood and created a high base flow that is completely diverted in the El Paso - Juarez valley (Schmidt et al., 2003). Virtually no flow now passes beyond Fort Quitman, TX, at the southern end of the El Paso - Juarez Valley (Everitt, 1998). Thus, greater than 90 percent of the present stream flow of the lower Rio Grande comes from the Rio Conchos.

Consumptive water use in the Rio Conchos watershed has increased during the 20th century, causing an 86% decrease in mean annual flow of the lower Rio Grande measured near Presidio. Mean annual flow was 72.1 m$^3$/s prior to 1915 and was 9.8 m$^3$/s between 1995 and 2005 (Fig. 2.5).

4. PREVIOUS STUDIES OF CHANNEL CHANGE OF THE RIO GRANDE ALONG AND NEAR THE INTERNATIONAL BOUNDARY

Prior to dam construction, the Rio Grande was wide, meandering, multi-threaded, and prone to avulsion (Mueller, 1975; Stotz, 2000). In the wide alluvial valleys of southern New Mexico, the channel bed often approached 1 km in width (Ainsworth and Brown, 1933). In the El Paso – Juarez Valley, the channel was narrower and more sinuous, and the adjacent floodplains were constructed of natural levees, oxbow lakes, marshes, swamps, salt pans, and sloughs (Hill, 1901; Everitt, 1998; Stotz, 2000). Vegetation communities were heterogeneous with sparse, flood tolerant patches of seepwillow (*Baccharis glutinosa*) established on sand bars, discontinuous stands of willow (*Salix exigua*) and cottonwood (*Populus* spp.) at the channel margins, and dense thickets of mesquite (*Prosopis glandulosa, Prosopis pubescens*) set back from the channel margins (Ainsworth and Brown, 1933; Everitt, 1998; Stotz, 2000). The complex
structure of the channel, adjacent floodplains, and vegetation assemblages apparently
reflected the variable hydrology which included short periods of large magnitude floods
and longer periods of little or no flow within the river.

With the onset of dam construction in New Mexico, widespread channel changes
occurred. Channel incision began immediately after completion of Elephant Butte Dam
(Lawson, 1925) and ultimately extended approximately 260 km to El Paso. The average
magnitude of bed incision was about 0.9 m within 125 km from the dam and was about
0.3 m as far as 210 km from the dam (Stevens, 1938). The eroded sediment caused bed
and floodplain aggradation further downstream, and the bed was higher than the adjacent
streets of El Paso and Juarez in the 1930s (Lawson, 1936). In response to the threat from
floods and diplomatic issues associated with an aggrading, ever-changing channel that
defined the international border, the entire channel between Caballo Dam and Fort
Quitman was straightened and confined by levees by 1938.

Stevens (1938, table 1) estimated that the annual suspended sediment load of the
Rio Grande at El Paso decreased by more than 90% after completion of Elephant Butte
Dam. Between 1906 and 1909, the average annual suspended load was $16.0 \times 10^6$ Mg/yr,
and the load was $0.5 \times 10^6$ Mg/yr between 1916 and 1925. Today, the annual sediment
supply to the Rio Grande in the El Paso – Juarez Valley is $0.6 \times 10^6$ Mg, because this is
the amount annually removed to maintain channel capacity (Everitt, 1993). Although
dam construction undoubtedly caused changes to the sediment supply of the Rio
Conchos, no sediment transport data are available and changes to the sediment load are
unknown.
Everitt (1993) showed that the nearly complete depletion of stream flow and the continued delivery of sediment from ephemeral tributaries that enter the Rio Grande between Ft. Quitman and Presidio caused the Rio Grande immediately upstream from the Rio Conchos to narrow by approximately 90% between 1902 and 1970. These changes occurred by aggradation of the bed of more than 2 m, as well as vertical accretion of the floodplain. Reduced transport capacity of the river resulted in accumulation of coarse debris at tributary mouths that locally steepened the river profile. Everitt classified these geomorphic changes into 3 stages: (1) a period of channel shrinking when reductions in discharge led to in-channel aggradation, (2) a period when reduced channel capacity resulted in the resumption of over-bank flooding and valley-wide aggradation, and (3) a period of gravel accumulation at tributary mouths that has re-graded the river into a series of steps.

As the channel shrank, non-native vegetation dominated by tamarisk (*Tamirix* spp.) established along the river margins. Tamarisk was present in west Texas as early as 1912 (Everitt, 1998). Ainsworth and Brown (1933) reported dense growth of native willow and mesquite, and non-native tamarisk along the Rio Grande in the El Paso - Juarez valley in 1932. Aerial photographs depicted tamarisk and non-native giant cane (*Arundo donax*) along the Rio Grande in the Presidio Valley in 1938 (LeSeur, 1945) and abandoned farmland overgrown by tamarisk in 1967. Today, tamarisk occupies areas in the Presidio Valley once dominated by cottonwood and mesquite thickets (Everitt, 1998) and the density and extent of giant cane has drastically increased over the last 20 years.
5. METHODS

Temporally detailed data include discharge measurement notes at the Johnson Ranch gage, rating relations at the Castolon stage plate, and stratigraphic and dendrogeomorphic analysis of two large floodplain trenches. Spatially extensive data include matches of ground-level photographs originally taken in the early to mid 20th century and analysis of aerial photographs first taken in 1941.

5.1. Hydrologic Data

We analyzed mean daily discharge data collected at the Johnson Ranch gage and compared those data with the longer term record of the gage below the Rio Conchos (BRC) near Presidio. There is greater imprecision in the magnitude of floods at Johnson Ranch, because discharges are measured infrequently, and flood magnitudes are typically estimated by extrapolation of rating relations developed at lower flows. During large floods, access to Johnson Ranch is sometimes blocked.

We fit a Log Pearson Type III distribution to the annual maximum of the mean daily discharge data and calculated mean annual flow and flow duration statistics from the mean daily data. We divided the 20th century into 5 sub-periods based on trends in the record at BRC. These periods are: (1) 1900 to 1914, prior to the construction of Elephant Butte and La Boquilla Dams; (2) 1931 to 1942 when stream flows were large; (3) 1943 to 1969 during extended regional drought, (4) 1970 to 1991 when stream flow was high, and (5) 1992 to 2006 during drought. Stream flow measurements were not made between 1915 and 1930. Gaging did not begin at Johnson Ranch until 1936, so no data are available for the period from 1900 to 1914 and less data are available with which
to compute flow statistics for the second period. We compared hydrologic changes among adjacent periods.

5.2. Repeat Photography of Historic Oblique Photographs

We made historic photograph comparisons in 3 geomorphic environments: (1) bedrock confined canyons, (2) wider canyons where channel banks are alluvium, and (3) unconfined alluvial reaches. We classified each site according to the current geomorphic environment and grouped the photos for comparison by location within BBNP.

We compared changes between the historic and repeated photographs by describing relative changes in channel width, accumulation or evacuation of sediment, and relative changes in vegetation cover and type. We mapped the location of the channel in Hot Springs Canyon (Fig. 2.2) as depicted in 2 photos taken in 1901. In a GIS, we calculated the average channel width within the field of view of these two historic photos, and compared channel conditions to those depicted on the 2004 digitally ortho-rectified quarter quadrangles (DOQQs). These channel width measurements within Hot Springs Canyon offer a limited spatial perspective but are essential documentation of channel conditions over 100 years ago. We used the same technique to evaluate channel narrowing in an alluvial reach immediately downstream from Hot Springs Canyon using a matched photo originally taken in 1945. The latter photo match helped us extend the record of channel change at least a decade prior to the oldest aerial photographs of the Boquillas reach.
5.3. Analysis of Discharge Measurement Notes and Stage Plate Measurements

We analyzed discharge measurement notes and stage measurements for the Johnson Ranch gage and the Castolon stage plate. Although discharge measurements have been collected at the Johnson Ranch gage since 1936, we were only able to obtain measurements from 1970 and between 1979 and 2006. Each discharge measurement includes water depth and mean velocity at a minimum of 20 points across the channel which are referenced to permanent markings on the cableway. Because stage at the time of measurement is recorded in relation to a fixed reference mark, channel cross-section elevation can be compared throughout the period of available data. At the Castolon stage plate, National Park Service (NPS) rangers collect stage measurements every morning. Stage at both locations are reported in relation to arbitrary datums.

We created stage discharge rating relations for Johnson Ranch, because they are not available from the IBWC. We identified the timing and magnitude of shifts in the relations. After identifying shifts in the relation at Johnson Ranch, we created rating relations at the Castolon stage plate based on discharge measured at Johnson Ranch, because the NPS collects too few discharge measurements at Castolon to develop local stage discharge relations. Although uncertainty exists concerning the stage observations, the assumed travel times of flow between the stage plate and Johnson Ranch, and limited number of discharges measured at the gage, these relations still proved valuable for identifying channel changes. We plotted measurements of channel area, channel width, and mean flow velocity against discharge to investigate how changes in the rating relation are accommodated by changes in cross section form. We investigated changes in
channel cross section shape at the Johnson Ranch gage by comparing measurements collected at flows which were approximately the magnitude of the 2-yr flood of 300 m$^3$/s.

5.4. Stratigraphic and Dendrogeomorphic Analysis of Inset Floodplain Deposits

We excavated two trenches through the floodplain and mapped and interpreted the exposed alluvial stratigraphy. We excavated tamarisk and willow rootstock, determined the date and elevation of germination (Hereford, 1984), and analyzed changes in tree ring anatomy due to burial (Friedman et al., 2005) at the USGS labs in Ft. Collins, CO. We compared the location of the burial signals to the location of stratigraphic contacts in order to identify years in which individual stratigraphic units were deposited. We collected 8 tamarisk from the Boquillas trench site and 6 tamarisk and 1 sandbar willow from the Castolon trench site. In the Castolon trench, we found a beer can which helped constrain the dates of deposits that were older than the deposits dated by the trees.

5.5. Aerial Photograph Interpretation and Analysis

We stereoscopically analyzed aerial photographs of each study reach (Table 2.1). We electronically scanned one photo of each stereo pair and used a 3$^{rd}$ order polynomial correction model to georeference each of the scanned photographs to the 2004 DOQQs. The root mean square errors (RMSEs) were less than 1m for all 1980s, 1991, and 1996 photo corrections, less than 2m for the 1968 and late 1950s photo corrections, 3m for the 1941 photo corrections, and 4m for the 1948 photo corrections. The larger RMSEs for the older photographs reflect their smaller scale and poor quality.
We identified the boundaries of the active channel on each photo series. We distinguished between the active channel and floodplain by noting the differences in elevation of geomorphic surfaces above the river and the relative abundance of vegetation on near-channel deposits. We classified surfaces with abundant, mature vegetation as floodplains, and classified most of the bare surfaces as portions of the active channel. However, in many of the historic aerial photographs, delineating the active channel was difficult for two reasons: (1) dense stands of vegetation were not always present along the channel margins, and (2) there were a number of bare geomorphic surfaces at different elevations above the river. Thus, it appears that a wide range of flood discharges and frequencies removed vegetation and prevented vegetation establishment on many of the geomorphic surfaces, and there was no clear relationship between elevation and vegetation density discernable on the aerial photographs. To account for the uncertainty in delineating the active channel, we mapped our best estimate of the active channel boundary and made minimum and maximum estimates of the extent of the active channel. We considered the active channel boundary to define the extent of the area inundated by common floods. We divided the area of the active channel by the length of the channel centerline to estimate the reach average active channel width. The minimum estimated extent of the channel most likely includes surfaces inundated on an annual basis and the maximum estimated extent of the active channel most likely includes surfaces inundated by large, rare discharge events (Fig. 2.6).

To clarify the role that vegetation invasion had in causing recent change, we calculated the percentage of the active channel bars present in 1996 that had been colonized by vegetation in 2004. This was not possible for earlier photographs, because
elevated discharges obscured some of the active channel deposits. We estimated error for this metric in a similar manner to our active channel delineation by also estimating the minimum and maximum areas of the active channel bars.

5.6. Water Surface/Channel Bed Slope

We measured the longitudinal profile of the Castolon Reach in winter 2008 using a Real Time Kinematic Global Positioning System. We analyzed inflections in the water surface in relation to tributary confluences and other geographic features.

6. RESULTS

6.1. Hydrology

Peak and mean annual flows of the Rio Grande have steadily declined since 1900. Both the 2-yr flood and the mean annual flow for the period from 1931 – 1942 at the BRC and Johnson Ranch gages were higher than any other period (Table 2.2). The 3 largest floods recorded were 4,220, 2,090, and 2,500 m$^3$/s and occurred in 1904, 1932, and 1933, respectively, at the BRC gage. These all occurred before gaging began at Johnson Ranch.

The long-term 2-yr flood at the BRC and Johnson Ranch gages are 294 m$^3$/s and 305 m$^3$/s, respectively. The mean annual flows at the BRC and Johnson Ranch gages for the period 1936-2006 are 32.2 m$^3$/s and 34.6 m$^3$/s, respectively. Mean annual flow for the entire period of record at the BRC gage is approximately 20% larger at 39.1 m$^3$/s, because larger total stream flow occurred at the beginning of the 20$^{th}$ century (Table 2.2).

With the exception of the period between 1970 and 1991, the duration of floods has progressively declined during the 20$^{th}$ century. For the period between 1900 and
1914 at the BRC gage, the long-term duration of the 2-yr flow was 4.33%. Between 1992 and 2006, the duration of the same discharge was 0.12%. Similar changes occurred at Johnson Ranch (Fig. 2.7, Table 2.2).

Flow duration curves indicate that between 1992 and 2006 large floods did not occur, and common to intermediate floods occurred for shorter durations (Fig. 2.8). No flows exceeded 1000 m$^3$/s, and the duration of common and intermediate floods (200 - 1000 m$^3$/s) was reduced from approximately 5% to 1% compared to previous periods (Fig. 2.8).

Between 1992 and 1995, elevated baseflows greater than 10 m$^3$/s occurred during the winter months when flow is often much lower (Fig. 2.9). Many of the elevated baseflows have flat or ramped trajectories of rise and fall which indicate that they were caused by dam releases on the Rio Conchos.

6.2. Historic Oblique Photograph Comparison

Historic oblique photographs are the oldest data that depict early 20th century geomorphology of the lower Rio Grande. These photo comparisons provide some of the motivation for restoration efforts in the region, because the evidence for subsequent channel change is so obvious. Photograph comparisons showed substantial reductions in channel width, increases in riparian vegetation predominantly by tamarisk and giant cane, floodplain aggradation, accumulation of gravel within the channel, and in a few cases, aggradation of the channel bed (Table 2.3). Channel narrowing, increases in riparian vegetation, and vertical floodplain accretion most commonly occurred in alluvial reaches and alluvial canyon reaches (Figs. 2.10, 2.11, and 2.12). Gravel accumulation has
occurred in bedrock canyon and alluvial canyon reaches, especially downstream from large tributaries (Fig. 2.9). Fine sediment was deposited on top of gravel bars and has since been stabilized by dense stands of riparian vegetation. In some cases, narrowing has converted bedrock canyon reaches into alluvial canyon reaches, as observed in Hot Springs Canyon. Downstream from Hot Springs Canyon, in an alluvial reach, narrowing occurred through the development of inset floodplains within the historic alluvial channel margins (Fig. 2.11). These inset floodplains are overgrown by tamarisk and giant cane in contrast to the upland xeric species which are growing on the historic channel bank. In many of the alluvial reaches, changes to the river corridor have been so dramatic that the once wide sandy channel and low elevation floodplain visible in the historical photographs are now completely obscured by dense vegetation (Fig. 2.12). Channel width has been maintained in the bedrock canyon reaches such as within Santa Elena Canyon, yet substantial accumulation of gravel has occurred providing evidence for local bed aggradation (Fig. 2.13).

6.3. Changes in Channel Width Based on Historic Oblique Photograph Comparison

Channel width measurements from oblique photographs indicate that the 2004 active channel was approximately 50% narrower than in 1901. In 1901, the active channel width of the Rio Grande spanned the entire width of Hot Springs Canyon. The average channel width of the canyon was 82 m in one oblique photo and 103 m in the other. The active channel widths measured from the 2004 DOQQ were 39 m and 51 m for the same photos, respectively, which is equivalent to a 51% to 52% reduction in active channel width (Table 2.4). The active channel width calculated from the alluvial
reach at the outlet of Hot Springs Canyon in 1945 was 88 m compared to 51 m in 2004; a 42% reduction.

We observed that greater than 95% of the photos taken of alluvial and alluvial canyon reaches displayed channel narrowing (Table 2.3). Of 20 photographs of in-channel deposits, 60% had noticeable accumulations of gravel. We observed substantial increases in riparian vegetation in 81% of the photographs. We did not observe increases in vegetation in the upper portion of Santa Elena Canyon, presumably because regular high flows span the canyon width and prevent vegetation establishment.

6.4. Analyses of Discharge Measurement Notes

Historic oblique photo comparisons depict channel narrowing and vertical floodplain accretion at Johnson Ranch since 1945 (Fig. 2.14). Analysis of discharge measurements at the Johnson Ranch gage showed that progressive channel narrowing has been interrupted by two channel widening floods in excess of 1,000 m³/s. The first occurred on October 1, 1978, at 1,850 m³/s, and was the flood of record at Johnson Ranch. This flood widened the channel by 10 m, and increased channel cross-section area by approximately 50% (Fig. 2.15a and 2.15b). We illustrated these increases with at-a-station hydraulic geometry relations instead of cross-section data, because none of the acquired discharge measurements prior to this flood were collected at discharges greater than 150 m³/s and do not depict the geometry of the banks. Thus, the implications to channel form at the bank edge are extrapolated. Cross section measurements showed that within 7 years after this flood, the channel narrowed by approximately 10 m or 15% (Fig. 2.16a).
On October 3, 1990, the second channel widening flood of 1,410 m³/s occurred, and another high flow of 1,030 m³/s occurred 11 months later on September 27, 1991. Bank erosion by these floods widened the channel by 8 m (Figs. 2.15c and 2.16a) and scoured the bed of the channel cross section by 3 m (Fig. 2.16b). Following these floods, the channel began to narrow, and by June 1992, the scoured cross section form had filled in (Fig. 2.16b). By 2002, the channel narrowed by approximately 20% through the development of an inset floodplain (Fig. 2.16b), and by 2005, approximately 1 m of additional vertical floodplain accretion had occurred (Fig. 2.16b). Between 1991 and 2006, channel cross-section area declined by approximately 30%.

Each channel widening event resulted in subsequent increases of river stage. This is anti-intuitive because we would expect that erosion and increases in the width to depth ratio would result in decreases in river stage. We acknowledge that we don’t completely understand this phenomenon but believe these increases in stage are related to local aggradation downstream of the gage sites. Stage discharge relations showed a small, temporary increase in stage after the 1978 flood (Figs. 2.17a and 2.17c). By 1981, this shift in stage recovered to its previous position prior to flood. After the October 1990 flood, a much larger, permanent increase in stage occurred (Figs. 2.15a and 2.15d). The magnitude of this shift was approximately 0.5 m and occurred for discharges less than approximately 300 m³/s. This shift occurred at both the Johnson Ranch gage and the Castolon stage plate. At the Johnson Ranch gage, cross section data do not show any discernable pattern of aggradation at the gaging cross section. However, aerial photographs show that after the October, 1990 flood, sediment was deposited downstream of the gage which has since developed into a vegetated island. Thus, at the
gage, this shift appeared to be attributable to a downstream change in control. The cause of the shift at the Castolon stage plate is less clear and because no topographic data exist there, we lack to data to determine its true cause.

A third increase in stage occurred at the Johnson Ranch gage after 2001. This shift only affected stages at discharges greater than approximately 100 m³/s (Fig. 2.17c) and appears to be related to the loss of channel cross-section area that occurred as the channel narrowed and the floodplain vertically accreted.

Loss of channel capacity resulted in a reduced threshold discharge for floodplain inundation. Hydraulic geometry relationships show that the threshold discharge decreased from approximately 400 m³/s in the 1990s to approximately 200 m³/s in the 2000s (Fig. 2.15e). Additionally, the channel became more rectangular, shown by small increases in width for discharges below the threshold of 200 m³/s (Table 2.5, Fig. 2.15e).

6.4. Dendrogeomorphic Analyses of Inset Floodplain Deposits

Dendro-geomorphologic analyses illustrate that channel narrowing occurred by the formation of vertically accreting inset floodplains over relatively short time periods (Fig. 2.18). Vertical accretion occurred by the deposition of fine grained sediment on top of bars of sand and gravel. Vertically accreted deposits are inset within natural, sandy levees that were the channel banks after the recession of the 1990 and 1991 floods. Tamarisk germinated on fine grained deposits overlying the coarse-grained gravel bars that were exposed at the base of the trenches. We measured 3.5 and 2.75 m of vertical accretion since 1991. The rate of vertical accretion was 0.2 and 0.16 m/yr at the Castolon and Boquillas trench sites, respectively. Since 1991, the channel at the Castolon and
Boquillas trench sites has narrowed by 55 and 33%, respectively, 83% and 90% of which occurred on the U.S. side of the river and was observed in the trenches. Currently, thick groves of tamarisk exist within the floodplain trough. Giant cane has colonized both the sandy levee as well as the current channel bank. We observed an abundance of buried cane within the current channel bank of the Castolon trench reflecting rapid accretion of the floodplain such that nearly 2 m of buried cane had not yet decomposed. Stratigraphic and dendrogeomorphic analyses show that changes observed in the channel geometry, stage-discharge relations, and hydraulic geometry are reflected in the floodplain stratigraphy.

6.6. Aerial Photograph Analysis

The above analyses depicted channel narrowing, vertical floodplain accretion, and vegetation invasion at discrete locations of the lower Rio Grande. Aerial photograph analyses show that the processes described above have been widespread.

The lower Rio Grande has narrowed between 34 and 57% since the first aerial photographs were collected. In the 1940s and 1950s, the best estimates of active channel width ranged between 72 m and 102 m. In 2004, the best estimates of active channel width ranged between 43 and 48 m (Fig. 2.19, Table 2.6).

Since the most recent channel widening flows in 1990 and 1991, the channel has narrowed between 36 and 52%. Narrowing occurred at a rate of 3.53, 3.07, and 1.85 m/yr in the Castolon, Johnson Ranch, and Boquillas reaches, respectively. Since 1991, the reductions in active channel width have been greater than the reductions observed over the 50 years prior.
Vegetation invasion in the 1990s coincided with the rapid rates of recent narrowing. Aerial photographs of 1991, 1996, 1998, and 2004 show that substantial accumulation of sediment within the channel occurred through the growth of channel margin and mid-channel bars (Fig. 2.20). DOQQs show vegetation growth on these surfaces by 1998. In the Castolon, Johnson Ranch, and Boquillas reaches, vegetation colonized 77, 89, and 39% of the active channel surfaces observed in 1996, respectively, which effectively converted them to floodplains (Fig. 2.20, Table 2.7).

Many of the above measures include large uncertainty which appears to be related to the time since the last large flood (Table 2.6). In the 1940s, 1980s, and 1990s, vegetation was limited, the size and elevation of geomorphic surfaces was diverse, and error was large. All of these photos were taken less than 5 years after a flood greater than 1,000 m$^3$/s. However, in 1968 and 2004, nearly a decade had passed since the last large flood. In these photos, vegetation was plentiful, active channel delineation was simple, and error was small.

6.7. Longitudinal Profile

Since 1991, coarse-grained deposits have formed at the mouths and downstream from ephemeral tributaries. At each tributary mouth within the Castolon Reach, as well as at a gravel bar near station 3000 m, a step in the profile exists (Fig. 2.21). Aerial photographs show that gravel and cobble bars at tributary mouths, and the large gravel bar at station 3000 m were either much smaller or did not exist in the past. These deposits are acting as hydraulic controls of the river profile at these locations creating long pools upstream, and steep riffles downstream.
7. SYNTHESIS OF HISTORICAL CHANNEL CHANGES

Over the last century, hydrologic and geomorphic change of the lower Rio Grande can be divided into two periods: (1) maintenance of a wide, sandy active channel bed by large floods prior to 1942, and (2) progressive channel narrowing during drought punctuated by infrequent channel resetting floods that widened the channel. These channel resetting floods are similar to Nanson’s “catastrophic floodplain stripping” (Nanson, 1986), because they temporarily interrupted and reversed the progressive channel narrowing during the latter half of the 20th century. The timeline and trajectories of observed changes are described below.

7.1. 1900-1942: Channel Maintenance

Floods and large total stream flow (Fig. 2.7) characterized the beginning of the 20th century. Historic oblique photographs (Figs. 2.10 and 2.12) depict a wide, sandy channel with low elevation floodplains and sparse annual vegetation. The four largest floods of the 20th century, in 1904, 1932, 1933, and 1938, occurred during this period. Comparison of the earliest oblique photographs and the first aerial photographs indicate that progressive channel narrowing did not occur between 1900 and 1942.

During this period, large dams were built on the Rio Conchos and the upper Rio Grande. Dam construction and irrigation diversions on the upper Rio Grande resulted in the complete loss of floods from Rocky Mountain snowmelt. Dam construction on the Rio Conchos appears to have had little effect on flows within the Big Bend region.
7.2. Post-1942: Narrowing and Resetting

The onset of regional drought from the 1940s through the 1960s resulted in decreased mean annual flows, decreased flood peaks, and channel narrowing (Table 2.2, Figs. 2.6 and 2.19). Additional dams were constructed on the Rio Conchos during this time. Vegetation establishment coincided with channel narrowing between the early 1940s and 1968. One large, long duration flood of 1,520 m$^3$/s occurred on September 27, 1958, yet there are insufficient data to determine if this flood significantly widened the channel.

Stream flow increased in the 1970s (Fig. 2.7). Hydraulic geometry relationships show that the flood of record at Johnson Ranch on October 1, 1978 widened the channel by approximately 10 m, and increased cross section channel area by approximately 50% (Fig. 2.15b). In the 1980s, mean annual flow was relatively high, and floods in excess of the long-term 2-yr flow occurred every other year, however, channel width narrowed to dimensions predating the 1979 flood.

In 1991, aerial photographs and hydraulic geometry relationships showed that the floods of 1990 and 1991 widened the channel by nearly 25% (Table 2.6, Figs. 2.15c and 2.19). With the onset of drought in 1992 (Table 2.2, Fig. 2.7), channel narrowing resumed. Sediment accumulated within the widened channel by vertical accretion of fine sediment on top of previously active channel bars. Vegetation establishment on vertically accreting surfaces resulted in the conversion of these bars to floodplains (Figs. 2.18 and 2.20).
Additionally, the growth of coarse grained deposits at tributary mouths and on gravel bars occurred which appears to be altering the river profile. These deposits have created long pools upstream, and steep riffles downstream.

The changes observed within the Big Bend region reflect the changes Everitt (1993) identified on the upper Rio Grande. First, reductions in discharge led to channel narrowing as described by Everitt’s “Stage I: Shrinking.” Second, the resultant loss of channel capacity and continued floodplain accretion was similar to Everitt’s “Stage II,” which was typified by valley wide aggradation. And finally, the alteration of the river profile by the accumulation of coarse lag deposits at tributary mouths and on gravel bars reflect Everitt’s “Stage III,” regrading. Thus, even though the upper and lower Rio Grande have distinctively different hydrologic regimes and histories of alteration, the net result of mean and peak flow reductions without similar reductions in sediment supply have created analogous changes of narrowing, floodplain accretion, and adjustment of the river profile.

8. GEOMORPHIC EFFECTS OF FLOODING

We classify the floods of the lower Rio Grande into two types based on their different geomorphic implications. Small to moderate magnitude floods (~200 – 1,000 m$^3$/s) typically occur for short durations (< 1 x 10$^5$ m$^3$/s·days) and have contributed to channel narrowing and vertical floodplain accretion. Floods greater than 1000 m$^3$/s, such as those that occurred in 1978, 1990, and 1991, caused channel bank erosion and reset. Prior to 1942, these large magnitude floods were common. Of the 26 years of hydrologic data available between 1901 and 1942, floods in excess of 1,000 m$^3$/s occurred 7 times.
Many of these floods occurred for durations that exceeded $2 \times 10^5$ m$^3$/s-days. However, since 1942, only four floods in excess of 1,000 m$^3$/s have occurred (Fig. 2.22). Thus, the reduced frequency of these floods have resulted in a shift from floods that maintained a wide channel prior to 1942 to progressive channel narrowing and episodic reset events since 1942. The decline of large, long duration, erosive floods and an increase in the proportion of small, short, tributary floods have resulted in the narrow, rectangular shaped channel that we see today.

An additional consequence of channel narrowing appears to be the loss of reach-scale heterogeneity. Aerial photographs show that as the channel narrowed, the active channel width of all three study reaches converged to a common width between 43 and 48 m (Figure 2.19). This contrasts with observations taken from the 1940s and 1950s. During these periods, the difference between our maximum and minimum active channel delineations within a reach often exceeded 10 m, and the difference of active channel width among each reach was at times greater than 20 m. The loss of reach-scale heterogeneity that appears to be coupled to processes of channel narrowing may have important implications for habitat availability for the aquatic ecosystem.

To summarize the above discussion of flooding and related cross section morphology, we present a general model that illustrates the trends of channel narrowing caused by small and moderate magnitude floods, and channel reset events caused by large floods (Fig. 2.23). A wide channel was created and maintained by frequent floods greater than 1000 m$^3$/s in the early 20$^{th}$ century (Fig. 2.23a). Progressive channel narrowing began in the 1940s with the onset of drought and the construction and management of additional infrastructure in the Rio Conchos watershed. Progressive narrowing between
the early 1940s and the late 1970s, and again between 1979 and 1991, was characterized by small and moderate magnitude flood peaks between approximately 200 and 1000 m$^3$/s (Fig. 2.23b). Since 1942, two channel resetting floods in excess of 1000 m$^3$/s temporarily widened the channel in 1979 and 1991 (Fig. 2.23c). Narrowing resumed after 1991, and occurred through the development of vertically accreting inset floodplains on top of active channel bars. This period of narrowing was again characterized by a lack of floods exceeding 1000 m$^3$/s. Non-native vegetation established on fine grained deposits overlying coarse gravel bars and appears to have exacerbated channel narrowing by stabilizing these surfaces, and potentially reducing channel margin flow velocities, and trapping sediment (Fig. 2.23d).

9. FORCING MECHANISMS OF CHANGE

Three external, large scale processes are responsible for changes described above. The construction of infrastructure, i.e., dams and diversions, created large sediment sinks (Grams and Schmidt, 2005; Schmidt and Wilcock, 2008), attenuated runoff from upstream portions of the basin, and provided the potential for other alterations including the retention and diversion of large quantities of stream flow. Second, management of infrastructure affected the actual changes in stream flow, because the timing, magnitude, and duration of stream flow are determined by dam releases and diversion schedules. Third, natural processes such as climate affected the total amount of runoff available to be managed and the frequency of extreme precipitation events (i.e hurricanes) in the Rio Conchos watershed (Douglas et al., 1993; Kim et al., 2002), and semi-natural processes such as non-native vegetation invasions affected channel margin and floodplain
hydraulics (Kouwen et al., 1969; Carollo et al., 2002; Griffin et al., 2005), bank strength and erosion thresholds (Thorne, 1990; Simon and Collison, 2002; Tal et al., 2003; Wynn and Mostaghimi, 2006), and sedimentation rates (Schultz et al., 2002). Although all of the above processes affected geomorphic change, each affected the rate and magnitude of change differently.

Through flood attenuation and sediment trapping, the construction of infrastructure causes inevitable changes to the mass balance of water and sediment, however, based on the location of infrastructure within the basin, and actual changes to stream flow downstream, the magnitude of perturbations due to infrastructure may vary. At the beginning of the 20th century, the largest increases in reservoir storage had no apparent effect on stream flow and channel morphology on the lower Rio Grande (Fig. 2.4). Both La Boquilla Dam and Elephant Butte Dam exist hundreds of kilometers upstream from the Big Bend region. Thus, even though Rocky Mountain snowmelt was retained and diverted, precipitation from monsoon rains and tropical storms still produced large floods downstream from these dams. Nearly thirty years after the construction of La Boquilla and Elephant Butte Dams, the river was as wide as observations made at the turn of the 20th century.

The construction of dams and diversions causes sediment trapping and some changes to the flow regime, but the greatest changes to flows are due to drought and the resultant management decisions to exploit the potential for water storage, flood control, and diversions to cities and farm fields. The first measurable changes in channel width occurred during the drought of the 1940s and 1950s. Although management decisions to retain flow behind dams and divert water for irrigation most likely exacerbated the effects
of this drought, no data are available to decouple the direct effects of management
decisions during this period. However, the drought of the 1990s was more severe (Kim
et al., 2002) and the effect of management was greater. No large floods were allowed to
pass and stream flow was reduced which resulted in sediment accumulation within the
channel and channel narrowing. Additionally, managed elevated baseflows (Fig. 2.9),
which were a means to deliver water to users downstream, provided water subsidies for
establishing vegetation, and the lack of large dam releases failed to scour seedlings from
nascent channel margin surfaces. The resulting accelerated invasion of non-native
vegetation (Fig. 2.20) in the 1990s and 2000s caused a positive feedback by trapping
sediment on the floodplains and along the channel margins and exacerbating channel
narrowing. Channel narrowing and loss of channel capacity induced upward shifts in the
stage discharge relation which caused flooding at lower discharges and additional vertical
accretion.

Non-native vegetation may also limit the erosion potential of future floods.
Dense stands of cane and tamarisk have created high flow resistance at the channel
margins, and their root mass has increased the strength of the banks. Thus, even if large
floods occurred, historical dimensions of channel width may never be achieved without
the management of non-native vegetation.

Our analyses show that large uncontrolled floods that occurred from emergency
dam releases during tropical storms were effective at temporarily widening the channel
(Figs. 2.15, 2.16, and 2.19). However, the fact that channel reset floods only occurred
during emergency measures indicates that channel width will not be restored or
maintained without either a change in management policy to release large floods or an
increased frequency of large tropical storms in the Rio Conchos watershed. A change in management policy is politically, economically, and socially unfavorable, because hydropower and agricultural revenue would be lost. Additionally, an increase in emergency dam releases due to tropical storms would endanger water development infrastructure and communities established on the floodplain. Thus, without the reorganization of communities living along the Rio Conchos, the willingness of irrigators to allow large quantities of water to pass, and the voluntary loss of hydropower revenue, the managed re-institution of frequent large floods to the hydrograph may be impossible. Additionally, uncontrolled releases of climatically driven floods would seriously impact the safety and economic resources of the region.

In light of the discussion above, we created a general model of historic geomorphic changes that synthesis all analyzed data and the forcing mechanism involved (Fig. 2.24). This model synthesizes data including changes in cumulative reservoir storage (Fig. 2.24a), mean annual flow (Fig. 2.24b), channel width (Fig. 2.24c), relative vegetation abundance (Fig. 2.24d), and the relative influences of forcing mechanisms. This model illustrates three main points: (1) the onset of progressive channel narrowing occurred through mean and peak flow reductions during the 1940s and 1950s drought, (2) narrowing has been temporarily interrupted by infrequent large floods on the Rio Conchos, and (3) the most significant geomorphic changes have occurred in the recent decades during extended drought, extensive water management, and non-native vegetation invasion.
10. CONCLUSIONS

Reductions in stream flow to the lower Rio Grande in the Big Bend region due to the construction and management of water infrastructure and episodes of drought have resulted in channel narrowing, vertical floodplain accretion, and vegetation establishment. The channel of the lower Rio Grande has narrowed by more than 50% since 1941. Progressive narrowing was temporarily interrupted by 2 floods in excess of 1000 m³/s that widened the channel. These floods occurred in 1979 and 1991. The 1979 flood widened the channel by approximately 20%, and the 1991 flood widened the channel by over 30%. Another large flood also occurred in 1959, but we were unable to determine the geomorphic effect of that flood.

Following the flood of 1991, the channel has narrowed between 35 and 50%, when no flows exceeded 1000 m³/s. In two floodplain trenches, evidence shows that 2.75 and 3.5 m of vertical accretion occurred between 1991 and 2008. Floodplains accreted at a rate of 0.16 and 0.20 m/yr. In some localities, nearly 90% of bare, active channel bars were converted to vegetated floodplains during the same period. Additionally, channel width of all three study reaches has converged to within 5 m which reveals that as channel width is reduced, heterogeneity among reaches is also reduced.

Since 1991, 2 upward shifts in the stage discharge relation occurred as the channel lost capacity, floodplains vertically accreted, and non-native vegetation established. These upward shifts resulted in over-bank flooding at lower discharges and further vertical accretion. Thus, although the 2-yr flood magnitude between 1992 and 2006 was reduced by 30 to 50% compared to the previous period, over-bank flooding and vertical accretion occurred at high rates. Additionally, during the most recent drought, coarse
grained deposits grew at tributary mouths creating a stepped pattern in the longitudinal profile.

Overall, the changes observed on the lower Rio Grande reflect a shift in the geomorphic nature of the Rio Grande from a wide, geomorphically complex river created and maintained by frequent large floods to a simple rectangular channel with steep definable banks and few bare active geomorphic surfaces. These geomorphic changes have significantly affected the native and endemic ecosystem within the region.

In order to restore channel width, management options must include large, extended dam releases that cause erosion, smaller dam release that provide flood disturbance to establishing vegetation, and active vegetation removal. Currently, managed dam releases are politically and economically unfeasible, thus, vegetation management within parks and protected areas may be the only option for attempting to limit future reductions in channel width.

11. REFERENCES CITED


LeSeur, H., 1945. The ecology of the vegetation of Chihuahua, Mexico, north of parallel twenty-eight. Publication No. 4521, University of Texas, Austin, TX, USA.


Schmidt, J.C., Wilcock, P.R., 2008. Metrics for assessing the downstream effects of dams. Water Resources Research, 44(4), W04404


Table 2.1: Flight dates for aerial photographs

<table>
<thead>
<tr>
<th>Flight Date</th>
<th>Discharge (m³/s)</th>
<th>Scale</th>
<th>Flight Date</th>
<th>Discharge (m³/s)</th>
<th>Scale</th>
<th>Flight Date</th>
<th>Discharge (m³/s)</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/12/1941</td>
<td>44.2</td>
<td>1:24,000</td>
<td>7/17/1941</td>
<td>39.4</td>
<td>1:24,000</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10/26/1948</td>
<td>34</td>
<td>1:48,000</td>
<td>10/26/1948</td>
<td>34</td>
<td>1:48,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/17/1968</td>
<td>47.3</td>
<td>1:36,000</td>
<td>10/17/1968</td>
<td>47.3</td>
<td>1:36,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/5/1986</td>
<td>16</td>
<td>1:24,000</td>
<td>11/4/1984</td>
<td>16.9</td>
<td>1:24,000</td>
<td>10/18/84</td>
<td>39.4</td>
<td>1:24,000</td>
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</tbody>
</table>

Late 1950s | Unknown | 1:56,000 |

* = 1m resolution
Table 2.2: Hydrologic characteristics at the Rio Grande below Rio Conchos gage and at the Rio Grande at Johnson Ranch gage

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2yr&lt;sup&gt;a&lt;/sup&gt; MAF&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2yr&lt;sup&gt;a&lt;/sup&gt; MAF&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2yr&lt;sup&gt;a&lt;/sup&gt; MAF&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2yr&lt;sup&gt;a&lt;/sup&gt; MAF&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2yr&lt;sup&gt;a&lt;/sup&gt; MAF&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2yr&lt;sup&gt;a&lt;/sup&gt; MAF&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Below Rio Conchos</td>
<td>4220 - 9/4/04</td>
<td>422.00</td>
<td>378.35</td>
<td>518.85</td>
<td>232.00</td>
<td>297.26</td>
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<tr>
<td>Johnson Ranch</td>
<td>1850 - 10/1/78</td>
<td>657.00</td>
<td>283.00</td>
<td>346.83</td>
<td>124.19</td>
<td>247.00</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dur LT 2yr&lt;sup&gt;d&lt;/sup&gt; MAF&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Dur LT 2yr&lt;sup&gt;d&lt;/sup&gt; MAF&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Dur LT 2yr&lt;sup&gt;d&lt;/sup&gt; MAF&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Dur LT 2yr&lt;sup&gt;d&lt;/sup&gt; MAF&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Dur LT 2yr&lt;sup&gt;d&lt;/sup&gt; MAF&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Dur LT 2yr&lt;sup&gt;d&lt;/sup&gt; MAF&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Below Rio Conchos</td>
<td>293.7</td>
<td>39.1</td>
<td>4.33</td>
<td>4.48</td>
<td>3.38</td>
<td>7.1</td>
<td>1.14</td>
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<tr>
<td>Johnson Ranch</td>
<td>304.6</td>
<td>34.6</td>
<td>5.5</td>
<td>40.9</td>
<td>0.84</td>
<td>19.46</td>
<td>1.39</td>
</tr>
</tbody>
</table>

<sup>a</sup> = measurement in cubic meters per second
<sup>b</sup> = 2-year recurrence interval flood for indicated period
<sup>c</sup> = Mean annual flow for indicated period
<sup>d</sup> = Duration (% of time) the long term 2 year recurrence interval flood was equaled or exceeded for indicated period
<sup>e</sup> = Duration (% of time) the long term mean annual flow was equaled or exceeded for indicated period.
Table 2.3: Summary of oblique historical photograph data

<table>
<thead>
<tr>
<th>Photo Location</th>
<th>Number of photos replicated</th>
<th>Geomorphic Classification</th>
<th>Channel Narrowing by Floodplain accretion</th>
<th>Significant accumulations of Gravel</th>
<th>Significant Increase in Vegetative Cover</th>
<th>Vegetation Type (T, C, M)</th>
<th>Photos showing Bed Aggradation Degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Elena Creek</td>
<td>8</td>
<td>4 bedrock canyon</td>
<td>3/3</td>
<td>4/8</td>
<td>4/8</td>
<td>4T</td>
<td>4 Agg</td>
</tr>
<tr>
<td>Old River Road</td>
<td>3</td>
<td>3 alluvial</td>
<td>3/3</td>
<td>ND</td>
<td>3/3</td>
<td>3T/C/M</td>
<td>ND</td>
</tr>
<tr>
<td>River Road</td>
<td>4</td>
<td>4 alluvial</td>
<td>4/4</td>
<td>ND</td>
<td>4/4</td>
<td>4T/C/M</td>
<td>ND</td>
</tr>
<tr>
<td>Johnson Ranch</td>
<td>1</td>
<td>1 alluvial canyon</td>
<td>1/1</td>
<td>0/1</td>
<td>1/1</td>
<td>1T/C</td>
<td>ND</td>
</tr>
<tr>
<td>Hot Springs Canyon</td>
<td>9</td>
<td>7 alluvial canyon</td>
<td>8/8</td>
<td>8/9</td>
<td>8/9</td>
<td>7T/C, 1T/C/M</td>
<td>ND</td>
</tr>
<tr>
<td>Mouth of Boquillas Canyon</td>
<td>2</td>
<td>2 alluvial</td>
<td>2/2</td>
<td>2/2</td>
<td>2/2</td>
<td>Native Treatment Bar</td>
<td>ND</td>
</tr>
</tbody>
</table>

1 The number of photographs that show indicated change the number of photographs that have the indicated feature as a subject (Grams and Schmidt, 2002)

2 T = Tamarisk, C = Giant Cane, M = Mesquite

3 ND = Not Determined

4 Native Treatment Bar indicates that the increased vegetation is predominantly native due to NPS restoration treatments at that location
Table 2.4: Changes in channel width based on historic oblique photograph comparison

<table>
<thead>
<tr>
<th>Photo Location</th>
<th>2004 Width</th>
<th>1901 Width</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Springs Canyon 1</td>
<td>50.7</td>
<td>103.9</td>
<td>51.2</td>
</tr>
<tr>
<td>Hot Springs Canyon 2</td>
<td>39.4</td>
<td>81.8</td>
<td>51.8</td>
</tr>
<tr>
<td>Mouth of Hot Springs Canyon</td>
<td>51.0</td>
<td>88.3</td>
<td>42.2</td>
</tr>
</tbody>
</table>
Table 2.5. Hydraulic geometry of the Rio Grande at the Johnson Ranch gage

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Area Equation</th>
<th>R²</th>
<th>Velocity Equation</th>
<th>R²</th>
<th>Time Period</th>
<th>Width Equation</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>7.19Q^0.565</td>
<td>0.9216</td>
<td>0.14Q^0.456</td>
<td>0.89</td>
<td>1970</td>
<td>36.55Q^0.040</td>
<td>0.79</td>
</tr>
<tr>
<td>1979-1980</td>
<td>17.61Q^0.451</td>
<td>0.7396</td>
<td>0.13Q^0.441</td>
<td>0.86</td>
<td>1979-1990</td>
<td>39.35Q^0.050</td>
<td>0.35</td>
</tr>
<tr>
<td>1981-1990</td>
<td>8.292Q^0.315</td>
<td>0.9025</td>
<td>0.06Q^0.552</td>
<td>0.9</td>
<td>1991-1999 low flows^a</td>
<td>38.94Q^0.036</td>
<td>0.27</td>
</tr>
<tr>
<td>1991-1999</td>
<td>16.96Q^0.451</td>
<td>0.9025</td>
<td>0.11Q^0.464</td>
<td>0.85</td>
<td>1991-1999 high flows^a</td>
<td>4.61Q^0.405</td>
<td>0.6</td>
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<tr>
<td>2000-2006</td>
<td>9.041Q^0.555</td>
<td>0.9025</td>
<td>0.11Q^0.464</td>
<td>0.85</td>
<td>2000-2006 low flows^b</td>
<td>32.79Q^0.031</td>
<td>0.37</td>
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<tr>
<td></td>
<td>2000-2006 high flows^b</td>
<td>1.08Q^0.715</td>
<td>0.84</td>
<td></td>
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</tr>
</tbody>
</table>

^a Flows segregated by discharges higher and lower than 300 m³/s based on visual patterns in the data
^b Flows segregated by discharge higher and lower than 150 m³/s based on visual patterns in the data
Table 2.6: Active channel width of Rio Grande for Castolon, Johnson Ranch, and Boquillas reaches

<table>
<thead>
<tr>
<th>Reach</th>
<th>Flight Date</th>
<th>&quot;Best Estimate&quot;</th>
<th>Active Channel Width (m) Minimum</th>
<th>Active Channel Width (m) Maximum</th>
<th>Minimum Error (m)</th>
<th>Maximum Error (m)</th>
<th>% Change from Previous Photo Based on Best Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castolon</td>
<td>1941</td>
<td>102</td>
<td>101</td>
<td>122</td>
<td>1</td>
<td>20</td>
<td>-3</td>
</tr>
<tr>
<td></td>
<td>1948</td>
<td>99</td>
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<td>118</td>
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<tr>
<td></td>
<td>1968</td>
<td>74</td>
<td>72</td>
<td>75</td>
<td>2</td>
<td>0</td>
<td>-25</td>
</tr>
<tr>
<td></td>
<td>1986</td>
<td>68</td>
<td>65</td>
<td>79</td>
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<td>11</td>
<td>-9</td>
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<td></td>
<td>1991</td>
<td>90</td>
<td>86</td>
<td>101</td>
<td>4</td>
<td>11</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>68</td>
<td>66</td>
<td>95</td>
<td>2</td>
<td>27</td>
<td>-24</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>44</td>
<td>43</td>
<td>44</td>
<td>1</td>
<td>1</td>
<td>-36</td>
</tr>
<tr>
<td>Johnson Ranch</td>
<td>1941</td>
<td>88</td>
<td>88</td>
<td>99</td>
<td>0</td>
<td>12</td>
<td>-10</td>
</tr>
<tr>
<td></td>
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<td>78</td>
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<td>-10</td>
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<td>62</td>
<td>60</td>
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<td>43</td>
<td>44</td>
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<tr>
<td>Boquillas</td>
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<td>65</td>
<td>78</td>
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<td>-43</td>
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<td>1984</td>
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<td>16</td>
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<td>1991</td>
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<td>50</td>
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Table 2.7: Percent conversion of active channel surfaces

<table>
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<tr>
<th>Reach</th>
<th>&quot;Best Estimate&quot; % Conversion</th>
<th>Minimum % Conversion</th>
<th>Maximum % Conversion</th>
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</thead>
<tbody>
<tr>
<td>Castolon</td>
<td>76.5</td>
<td>74.1</td>
<td>83.1</td>
</tr>
<tr>
<td>Johnson Ranch</td>
<td>89.4</td>
<td>87.6</td>
<td>89.5</td>
</tr>
<tr>
<td>Boquillas</td>
<td>39.1</td>
<td>34.2</td>
<td>68.4</td>
</tr>
</tbody>
</table>
Fig. 2.1: (a) Map of the Big Bend region. (b) Study area
Fig. 2.2: (a) Reach location map, (b) Castolon reach, (c) Johnson Ranch reach, (d) Boquillas reach
Fig. 2.3: Median annual hydrographs prior to 1915 at IBWC gages Rio Grande above Rio Conchos and Rio Grande below Rio Conchos near Presidio, TX and Ojinaga, Chih. See Fig. 2.2b for location of gages.
Fig. 2.4: Cumulative reservoir storage of upper Rio Grande and Rio Conchos
Fig. 2.5: Mean annual flow of segments of the Rio Grande (a) prior to 1915, (b) between 1930 and 1940, and (c) between 1995 and 2005. The thickness of the lines are proportional to the mean annual flow.
Fig. 2.7: Annual peak flow characteristics (a) at the Rio Grande below Rio Conchos gage and (b) the Rio Grande at the Johnson Ranch gage. Annual peak flows are plotted with circles. A 10 year running average is also shown. The long-term 2-yr flood is shown with a thin straight line. Both the circles and the thin lines read on the left axis. Thick dark lines show the % of time the long-term 2-yr flood was equaled or exceeded for the given time periods at each gage. The thick dark lines read on the right axis.
Fig. 2.8: Flow duration curves at the (a) Rio Grande below Rio Conchos gage and at the (b) Rio Grande at Johnson Ranch gage. Note that discharges for the period of 1992-2006 do not exceed 1000 m$^3$/s and the duration curve plots below curves for all other periods with the exception of baseflows from 1943-1969.
Fig. 2.9: Annual hydrographs of the Johnson Ranch gage from 1992 to 1995. Hydrographs show that elevated baseflows (> 10 m$^3$/s) existed in 1992, 1993, and 1995 during the winter months, which may be responsible for saturating in-stream surfaces and providing vegetation the necessary moisture for establishment. The flat or ramped trajectories of the hydrographs indicate that elevated baseflows are controlled releases from dams on the Río Conchos.
Fig. 2.10: Historical oblique photo match in Hot Springs Canyon looking upstream toward Tornillo Creek. a) Photograph taken in 1901 by the Bailey-Oberholser field investigations of the Big Bend for the United States Biological Survey. b) Photograph taken on 3/4/08. Historic photo shows that the active channel spans the entire canyon width and contains alternate channel bars. Photo (b) shows significant accumulation of gravel, and fine sediment deposited on top of gravel which is stabilized by a thick growth of giant cane and tamarisk. The river has been converted from a river with bedrock channel banks to an alluvial river. The active channel width in photo b) is approximately 51% narrower than the historic 1901 photo.
Fig. 2.11. Historical oblique photo match looking downstream from the outlet of Hot Springs Canyon. (a) Photograph taken by unknown photographer in 1945. (b) Photograph taken on 2/12/08. 1945 photo shows a large bare sand bar on river right and a left bank with woody vegetation. Photo (b) shows the large bare sandbar present in photo (a) overgrown with tamarisk and giant cane. On river left, the historic channel bank can be seen in photo (b) by the break in vegetation where a thick growth of giant cane is inset into a terrace containing creosote and 4 large tamarisk. The active channel width in photo b is approximately 42% narrower than the historic 1945 photo.
Fig. 2.12: Historical oblique photo match looking downstream toward Black Dike. a) Photograph taken by unknown photographer in 1937. b) Photograph taken on 2/23/08. 1937 photo depicts the river flowing over and around outcrops of the dike with large bare channel margin bars colonized by a few annual plants. 2008 photo shows that nearly the entire view of the black dike is obscured by tamarisk. Smaller amounts of giant cane are growing on the channel margins. Fine sediment has accreted on the downstream portion of the dike outcrops and is stabilized by thick growths of tamarisk. River in 2008 flows to the right of all dike outcrops.
Fig. 2.13: Historical oblique photo match taken above the “rock slide” looking downstream in Santa Elena Canyon. (a) Photograph taken during the 1901 United Stated Geologic Survey of the canyons of the Big Bend. Survey leader R.T. Hill pictured sitting in a boat in the foreground. (b) Photograph taken on 2/28/08. 1901 photo depicts the river channel flowing between alternate gravel bars. The active channel spans the entire width of the bedrock walls. 2008 photograph depicts much the same channel morphology. However, features on the bedrock wall indicate that gravel has accumulated at this location causing approximately 1-2 meters of aggradation.
Fig. 2.14: Historical oblique photo match looking upstream from the Johnson Ranch stream gage.  a) Photograph taken by unknown photographer in 1945.  b) Photograph taken by Dean on 2/23/08.  Humans are present in the center of both photos for scale.  1937 photo depicts the river channel spanning the entire width of the bedrock walls.  Bare sandy alternate bars are seen in the center background and in the left foreground.  An eddy is present in the right mid-ground.  2008 photo depicts a floodplain surface inset within the bedrock walls with steep, high banks which are completely colonized by tamarisk and giant cane.  The eddy in the right foreground has filled with sediment and is colonized by giant cane.
Fig. 2.15: Hydraulic geometry relations at the Johnson Ranch gage. The 1970 data represent the oldest discharge measurement notes obtained. Data from measurements between 1970 and 1979 could not be located by the IBWC. Erosion and channel widening due to large floods is depicted by the increases in channel width and cross section area in 1979 (a, b) and 1991 (c, d). Channel narrowing and loss of channel cross section area during the 1990’s and 2000’s resulted in a reduction in the threshold discharge for over-bank flow from approximately 400 m /s in the 1990s to approximately 200 m /s after 2000 (e). The threshold discharges are depicted by the steep increase in channel width at these respective discharges. Error envelopes for width and area data represent the 95% confidence interval about the regression lines.
Fig. 2.16: Channel cross sections measured at the Johnson Ranch cableway. (a) Cross sections measured from 1981 to 1991. These measurements indicate up to 7 m of channel narrowing occurred between 1981-1990. Large floods in 1990 and 1991 rewidened the channel approximately 10 m and scoured the channel bed approximately 3 meters. (b) Cross sections measured from 1991-2005. Scour following the floods of 1990 and 1991 filled in by the 6/3/92. Narrowing in excess of 10 m occurred between 6/3/92 and 7/3/02. Narrowing occurred through the development of an inset floodplain. Between 7/23/02 and 7/28/05, additional narrowing as well as approximately 1 meter of vertical accretion occurred.
Fig. 2.17: Stage-discharge rating relations for flows measured at (a) JR and (b) the Castolon stage plate. Note in (a) a slight, temporary increase in stage apparently due to channel aggradation after the 1979 flood. Note in (a) and (b) the increase in stage starting in 1991 for flows less than approximately 300 m³/s. These shifts were caused as sediment accumulated within the channel following the floods in 1990 and 1991. A third increase in stage is shown in (a) from 2001-2006 for discharges greater than approximately 100 m³/s caused by reductions in channel capacity. (c) Timeline of rating relation shifts observed at JR.
Fig. 2.18: Stratigraphy and burial dates observed in the Castolon trench. (a) Surveyed cross section at the Castolon trench site upstream of Cottonwood Campground. Mapped stratigraphy of the Castolon trench is displayed on the left of the cross section. The approximate elevation of the 2-yr flood stage is also displayed. (b) Mapped stratigraphy of the Castolon trench. Stratigraphic contacts defined by unconformities and disconformities. (c) Castolon trench displaying locations of the dated tamarisk and willow trees (tamarisk (T), willow (W)). Approximate germination horizons are indicated in a dark black horizontal line. Dates indicate periods of sediment accretion as observed from the wood anatomy in trees. Approximate date of beer can constrains deposition for sediments deposited before 1991. Stages of the baseflow (~10 m³/s) and the approximate 2-year flood stage (305 m³/s) are also shown.
Fig. 2.19: Best estimate of the active channel width for the Castolon, Johnson Ranch, and Boquillas reaches. Note the general trend of narrowing prior to the channel resetting floods of 1990 and the rapid narrowing that occurred there after. Also, note that since 1941, the active channel width for each of the reaches has converged to within 5 m.
Fig. 2.20: Sediment accumulation and reductions in active channel width between (a) 1991 and (b) 1996. Conversion of active channel margin bars to vegetated floodplain between (b) 1996 and (c) 2004.
Fig. 2.21: Longitudinal profile of the water surface from Santa Elena Canyon to the Castolon trench site. Notice the stepped profile dictated by gravel accumulation at tributary mouths and gravel bars.
Fig. 2.22: Peak discharge and duration in cms days greater than 300 m³/s. Floodplain construction flows and channel resetting flows determined from discharge measurement notes, dendrogeomorphic and stratigraphic analyses of inset floodplain deposits, and aerial photographs. Floods greater than 1000 m³/s observed at the BRC gage before operation of the JR gage also plotted. Region of inferred channel maintenance flows prior to 1942 determined from distribution of large floods. Note the frequency of floods in excess of 1000 m³/s prior to 1942, and the lack of these flood magnitudes after 1942.
Figure 2.23: General model of historic channel changes. (a) Cross section representing channel observed in historic oblique photos between 1900 and 1941. (b) Channel narrowing as observed between the 1940s and the late 1970s. (c) Channel resetting flows as observed in 1979 and 1991. (d) Repeated channel narrowing after 1991. Narrowing occurs through the development of vertically accreting inset floodplains on top of active channel bars as inferred from floodplain trenches.
Fig. 2.24: Synthesis of historic channel change and its drivers. (a) Cumulative reservoir storage of upper the Rio Grande and the Rio Conchos. (B) Mean annual flow since 1900. (c) Changes in channel width observed from aerial photographs, and the hydrograph at the JR gage. (d) Relative abundance of vegetation, ranked from 0 to 8 from observation of historic oblique photographs and aerial photographs. (e) Time line of channel changes and drivers, and reconstructed trajectories of changes in channel width.
CHAPTER 3

STRATIGRAPHIC AND SEDIMENTOLOGICAL ANALYSIS OF FLOODPLAIN FORMATION IN BIG BEND NATIONAL PARK, TX

ABSTRACT

On arid and semi-arid rivers with high suspended sediment loads, rivers generally narrow through the development of vertically accreting inset floodplains. The channel of the lower Rio Grande has narrowed between 35 and 50% through the formation of vertically accreting inset floodplains between 1991 and 2008. We observed between 2.75 and 3.5 m of vertical accretion that occurred over a 17 year period in two long floodplain trenches. Within these trenches, we identified three sedimentological components of floodplain formation consisting of the active channel component, the floodplain conversion component, and the floodplain component. The active channel component consists of vertically and obliquely accreted fine grained bars on top of coarse lag deposits of sand and gravel. The floodplain conversion component consists of obliquely accreted beds displaying inclined heterolithic cross-stratification at the channel margins, and vertical accretion of fining upward couplets of sand and mud in the floodplain trough. The floodplain component is dominated by vertical accretion represented by natural levees at the channel margins and horizontally stacked muddy beds in the floodplain trough. Overall, floodplain formation evolved from mixed bedload and suspended load deposition during the initial stages to pure suspended sediment deposition in the latter stages. Grain-size analyses show that sediment fined upward through the floodplain and onshore from the channel margin.

1 Coauthored by John C. Schmidt
1. INTRODUCTION

On many rivers in arid and semi-arid regions, hydrologic reductions due to dams and irrigation diversions have resulted in channel narrowing through the development of vertically accreting inset floodplains (Graf, 1978; Friedman et al., 1998; Allred and Schmidt, 1999; Grams and Schmidt, 2002). Vertical accretion differs from lateral accretion (Leopold and Wolman, 1957) because it is a floodplain building mechanism characterized by disequilibrium (Mackin, 1948; Nanson and Young, 1981; Nanson, 1986; Pizzuto, 1994). This disequilibrium manifests itself in the vertical growth of the floodplain such that the threshold discharge for floodplain inundation continuously changes with each depositional flood event. As a result, floodplain inundation may either decrease as the channel banks grow progressively higher above the channel bed, or increase as the channel loses capacity resulting in increased flood stages for the same discharge over time.

Although many studies have addressed the magnitude and rates of vertical accretion on narrowing streams (Allred and Schmidt, 1999; Grams and Schmidt, 2002) and a few studies have described the stratigraphic relationships of these floodplains (Moody et al., 1999), few studies have shown how narrowing and vertical aggradation occur (Allmendinger, 2008; Pizzuto et al., 2008). We analyzed floodplain stratigraphy and sedimentology to describe the mechanisms of channel narrowing and floodplain formation in Big Bend National Park (BBNP), TX. We show that channel narrowing occurred by the formation of vertically accreting inset floodplains on top of previously active portions of the channel. Specifically, we describe three sedimentological components of floodplain formation that reflect similar sedimentological characteristics to those observed for scroll-bar formation (Nanson, 1980).
2. STUDY AREA

We analyzed recent floodplain formation in 2 trenches along the Rio Grande in BBNP (Fig 3.1). This study specifically addresses the mechanisms of recent channel changes and floodplain formation described in Chap. 2. BBNP lies within the greater Big Bend region, which extends from the confluence of the Rio Grande and Rio Conchos 490 km downstream to Amistad Reservoir.

Today, the Rio Grande in the Big Bend region is single-threaded, and flows through wide alluvial valleys in structural basins and narrow canyons that cross intervening ranges. Channel slope ranges from approximately 0.0013 in the alluvial valleys and 0.002 in the canyons. The bed of the Rio Grande is predominately sand, although alternate bars of gravel and cobbles exist at the mouths and downstream from ephemeral tributaries. In the alluvial valleys, numerous terraces bound the modern floodplain providing evidence of the long term cycles of incision and aggradation that occurred since the late Pliocene/early Pleistocene (Berry, 2008). Modern floodplain topography consists of ridges and swales previously identified by benches (Woodyer et al., 1979; Pizzuto, 1994), scrollbars (Leopold et al., 1964; Nanson, 1980), and point bars (Bridge, 2003, Fig 5.39d).

Main-stem floods have high suspended loads of fine sediment. Sources of sediment are the Rio Conchos downstream from Luis Leon Dam (Fig 3.1) and regional ephemeral tributaries that drain parts of the sparsely vegetated Chihuahuan Desert underlain be erodible sedimentary and volcanic rocks. The largest ephemeral tributaries are Alamito, San Carlos, Terlingua, and Tornillo Creeks (Fig 3.1).
Although spring snowmelt in the Rocky Mountains and monsoon rains and tropical storms in the Sierra Madre Occidental drove historic flood peaks, modern floods occur from dam releases on the Rio Conchos or from flash floods on ephemeral tributaries. Low magnitude, short duration floods from dam releases on the Rio Conchos and tributary flash floods cause vertical floodplain formation and channel narrowing. However, large, extended dam releases (>1000 m$^3$/s) cause floodplain erosion and channel widening. Here, we analyze floodplain stratigraphy and sedimentology to describe the mechanisms of channel narrowing following erosive floods in 1979 and 1991.

3. GEOMORPHIC BACKGROUND

Since the 1940s, construction and management of large dams on the Rio Conchos and upper Rio Grande, and intermittent periods of drought resulted in declines of mean and peak stream flow of the lower Rio Grande (Fig 3.1). These declines resulted in significant geomorphic changes of the lower Rio Grande including channel narrowing, vertical floodplain accretion, and reductions in channel capacity. Since the 1940s, the channel has narrowed by approximately 50%.

Although the trajectory of historic channel change has been channel narrowing, Dean (Chap. 2) depicted the temporal trends as a sawtooth pattern of decadal to multi-decadal narrowing interrupted by infrequent channel widening floods. Large dam releases on the Rio Conchos caused channel widening in 1979 and 1991. Since 1991, the onset of drought, lack of large dam releases, continued sediment inputs from tributaries, and non-native vegetation invasion resulted in rapid rates of narrowing and a loss of channel capacity. Narrowing occurred through the formation of floodplains inset within
natural levees created by the 1991 floods. Elevated baseflows from dam releases and lack of significant flood disturbance led to vegetation establishment on these surfaces. The loss of channel capacity resulted in upward shifts of the stage discharge relation, continued overbank flooding, and additional vertical accretion. Since 1991, the channel has narrowed between 33 and 55%, and the floodplains have vertically accreted by 2.75 to 3.5 m.

4. FLOODPLAIN FORMATION AND STRATIGRAPHY

On semi-arid rivers, with large suspended sediment loads, vertical accretion is the dominant mechanism of deposition and channel narrowing (Schumm and Lichty, 1963; Burkham, 1972; Pizzuto, 1994; Moody et al., 1999; Allred and Schmidt, 1999; Grams and Schmidt, 2002; Pizzuto et al., 2008). Floodplain formation often occurs on the inside of meander bends resembling point benches (Woodyer et al., 1979; Pizzuto, 1994; Pizzuto et al., 2008), point bars (Bridge, 2003), and scroll bars (Nanson, 1980). On tight, outer bends, where eddy recirculation occurs, floodplains form through the development of eddy accretions (Carey, 1969) or concave-bank benches (Woodyer, 1975). On straight reaches, floodplains form by sediment trapping around vegetation (Woodyer et al., 1979). In general, vertical accretion dominates on systems where lateral migration is limited due to either geologic confinement or cohesive bank material stabilized by vegetation (Nanson, 1986).

Pizzuto, (1994) Pizzuto et al., (2008) and Moody et al., (1999) described channel narrowing following a large flood on the Powder River in 1978. In response to this flood, the channel progressively narrowed through the construction of low-lying benches composed of interbedded sand and mud on top of coarser lag deposits at the channel.
margins (Moody et al., 1999). The bench crests consisted predominantly of sand which
fined onshore into sandy and silty clays in the floodplain trough (Moody et al., 1999).
Offshore of the floodplain crest, stratigraphy sloped toward the channel while in the
floodplain trough, bedding planes were horizontal. Over time, vertical accretion and
vegetation establishment resulted in the conversion of these surfaces to floodplains.

Nanson (1980) specifically described stratigraphic and sedimentologic
characteristics of scroll bars and their related floodplains. Initially, gravel and sand
bedload is swept onto the upstream portions of point bars, and sorted downstream as
velocities decline around the channel bend. A gradual transition from bedload to
suspended load occurs upward through the floodplain, and the sediments grade from
large scale cross-stratified gravels and sands at the base into small-scale cross-stratified
and structureless silts at the top. In the upper portions of the scroll bar, when suspended
load is dominant, a distinctive floodplain ridge (initial scroll) forms near the channel that
thins onshore. Above this “initial scroll,” vertical accretion through mostly suspended
sediment deposition is the dominant mechanism. Sedimentologically, scroll bars evolve
from coarse grained channel features to fine grained floodplain features that generally
fine downstream, upward, and onshore.

5. METHODS

We excavated 2 trenches through the floodplain along relatively straight reaches
of the river and mapped and interpreted the exposed stratigraphy. The Castolon trench
was approximately 9 km downstream from Terlingua Creek near Castolon, TX (Fig 3.2).
The Boquillas trench was approximately 1.5 km upstream from Boquillas, MX (Fig 3.2).
We excavated around the rootstock of tamarisk (*Tamarix* spp.) and willow (*Salix exigua*) trees located along the margins of the trench. We marked the location of each stratigraphic unit as it crossed the buried stock of each tree. We also noted the elevation of the rootcrown which indicates the approximate elevation at which the tree germinated (Hereford, 1984). We then removed the rootstock of the trees from the trench, and analyzed changes in tree ring anatomy due to burial (Friedman et al., 2005). We compared the location of the burial signals within the trees to the location of the stratigraphic contacts in order to identify years in which individual stratigraphic units were deposited. We collected 8 tamarisk trees from the Boquillas trench and 6 tamarisk trees and 1 willow from the Castolon trench. In the Castolon trench, we found a beer can which helped constrain the dates of deposits that were older than deposits dated by the trees. Anheuser-Busch (Sahaida, pers. comm., 2008) provided the earliest and latest possible bottling dates based on can artwork. We applied these dates to constrain the time of deposition even though the consumption of the beverage and subsequent burial of the can may have occurred after the latest possible date of bottling.

We collected sediment samples at equally spaced intervals along the length of the trenches for grain size analysis. At each sampling location, we collected samples along vertical profiles to characterize grain size trends vertically through the floodplain. We analyzed samples at $\frac{1}{2}$ phi intervals. We noted the presence of primary, secondary, and vegetation induced sedimentary structures to determine depositional processes.

6. RESULTS

Dendro-geomorphic and stratigraphic analyses of floodplain deposits showed two periods of vertical floodplain accretion due to channel narrowing: from 1982.5 ± 2.5 to
1991, and from 1991 to present. The first period occurred following the recession of a large flood in 1979. The second period occurred after two large floods had widened the channel in 1991. We observed floodplain formation during the first period in the Castolon trench and the second period in both the Castolon and Boquillas trenches.

In the Castolon trench, stratigraphic analyses, and an approximate bottling date from the beer can (Sahaida, pers. comm., 2008) showed that between the early to mid 1980s and 1991, narrowing occurred as sediment obliquely (Page et al., 2003) and vertically accreted onto a buried cutbank near station 2 (Fig 3.3b). During this period, we observed at least 20 m of narrowing and 3 m of vertical accretion that occurred at a rate of 35 ± 8 cm/year (Fig 3.3, station 2 - 7). The upper portion of this floodplain contained thick beds of cross stratified sand that formed a natural levee. We believe the floods of 1991 created this levee, because the base of the thick sand deposits were erosional and underlying beds were truncated, all trees offshore from this feature in the Castolon trench germinated on inset deposits after 1991, and trees T19A, T19B, and T21 in the Boquillas trench germinated in 1991 on top of this levee (Fig 3.4). Aerial photographs show that these levees were the channel banks following recession of the October 1990 flood.

Since 1991, a second period of narrowing occurred through the formation of another vertically accreting inset floodplain (Figs 3.3 and 3.4). Vertical accretion occurred by the deposition of fine grained sediment on top of bars of sand, gravel, and cobbles. Tamarisk trees germinated on fine grained deposits overlying the coarse-grained gravel bars that were exposed at the base of the trenches. We measured 3.5 and 2.75 m of vertical accretion since 1991 in the Castolon and Boquillas trench sites, respectively, and the rate of vertical accretion was 0.20 and 0.16 m/yr at these respective locations. Since 1991, the channel at the Castolon and Boquillas trench sites has narrowed by 55
and 33%, respectively, 83 and 90% of which was observed on the U.S. side within the trenches. Currently, thick groves of tamarisk are growing within the floodplain trough. Giant cane has colonized both the sandy levees as well as the current channel bank. We observed an abundance of buried cane within the current channel bank of the Castolon trench reflecting such rapid accretion of the floodplain that nearly 2 m of buried cane had not yet decomposed.

6.1 Stratigraphy and Sedimentology

Generally, floodplain stratigraphy and sedimentology consists of natural levees composed of parallel laminated and ripple drift cross stratified sand that fine onshore into horizontally bedded deposits of sand, silt, and clay. Within the natural levees, deposits generally fine upward into silt caps. In the floodplain troughs, bedding consists of fining upward couplets of very fine sand and silt overlain by silt and clay. We interpret these facies to represent three distinct sedimentological components of floodplain formation: (1) active channel component, (2) floodplain conversion component, and (3) floodplain component. Below, we describe in detail the characteristics of these components.

6.2 Active Channel Component

The active channel component is indicative of channel margin or mid-channel sandbars that are inundated by common floods (Bridge, 2003, Fig 5.54a). Sediment consists of both fine grained bedload and suspended sediment on top of coarse grained substrates (Fig 3.5a). Bedding ranges in thickness between 10 and 40 cm and consists of fine to very fine sand. These are vertically accreted on top of coarse grained gravel deposits or obliquely accreted onto the channel margins. Contacts may be erosional or conformable. Bed forms include extensive small scale ripple drift cross-stratification,
wavy parallel lamination, and to a lesser extent, climbing ripples, supercritically climbing ripples, and planar lamination (Fig 3.5b and c). Thin (5 mm - 10 cm) discontinuous bands of silt may be present. Silts are bioturbated and appear to represent past, temporary ground surfaces. Some vegetation induced sedimentary structures (VISS, Rygel et al., 2004) may be present and usually consist of root-casts and mud-filled hollows. These are formed by roots penetrating sandy substrates below the ground surface or decayed vegetation that has been replaced by mud. Lesser occurrences of downturned beds formed by decayed vegetation and soft-sediment deformation exist.

6.3 Floodplain Conversion Component

This component represents the vertical building of the active channel component as it is converted to a floodplain. This component dominantly consists of suspended load deposition, however, the occasional presence of coarse sand and fine gravel indicates that at some discharges, this component is still part of the active channel. Beds range in thickness between .05 m and 1 m, however, most beds are less than 0.20 m. Bedding either on-laps underlying topography resulting in vertical accretion or is inset obliquely within the active channel component. Contacts are dominantly conformable but thicker deposits near the channel margins may be erosional (Fig 3.6a). Near the channel margin, bedding is inclined upward and onshore and is sandy with thin caps of silt and clay (Fig 3.6a). In these locations, beds are dominated by ripple drift cross-stratification and parallel lamination that may be planar or wavy. Climbing ripples comprise a small proportion of this component. Onshore, bedding becomes horizontal with alternating couplets of thin rippled very fine to medium sand that fines upward into thicker caps of silt and clay (Fig 3.6b). Stratified sand is often only 0.02-0.05 m thick, and mud caps are
thicker and may be mud-cracked. Furthest onshore, some beds are entirely mud. Rippled sands often contain stratified vegetation fragments. Extensive bioturbation exists, especially in the muddy portions of the floodplain trough. Buried decomposing plants and extensive VISS are present including mud-filled hollows, rootcasts, upturned beds, downturned beds, and scour-and-mound beds. Although this component is dominated by vertically accreting sand and mud couplets formed by the rising and falling limbs of floods, beds occasionally contain ripple or dune stratified coarse sand and fine gravel indicating bedload transport does occasionally occur (Fig 3.6c).

6.4 Floodplain Component

This component represents floodplain building through the construction of natural levees at the channel margins and vertical accretion of the floodplain trough. Beds range in thickness between .05 m and 1 m within natural levees. Levees are often erosional at the base, but sometimes conformably drape onto underlying beds (Fig 3.7a). Levees are constructed of very fine to fine sand that contain climbing ripples, supercritically climbing ripples, ripple drift cross-stratification, planar lamination, and wavy parallel lamination (Fig 3.7). We occasionally observed complete flood cyclothems within the levees that represent deposition throughout the complete rise and fall of a flood (Nanson, 1980). Levee building sands are capped by thin bands of silt ranging in thickness between 0.005 m and 0.05 m. Some beds are obliquely inset into the natural levees which reflect deposition by small floods that do not inundate the floodplain. Levee building sands fine rapidly onshore into thin beds (0.02-0.10 cm) of faintly cross-stratified sand capped by silt and clay. Mud caps are often mud-cracked and filled with very fine sand from the overlying bed. Near the top of this component, buried layers of
tamarisk duff are sandwiched between mud and the overlying deposit reflecting past ground surfaces. VISS and bioturbation is most prominent within this component. Within the levees, VISS include mud-filled hollows, centroclinal cross strata, coalesced scour fills, and scour-and-mound beds (Fig 3.8). Buried vegetation is common. Onshore from the levees, mud-filled hollows and root casts dominate, with occasional downturned beds. Building occurs periodically due to evidence of past ground surfaces that accumulate vegetation duff.

6.5 Grain Size

The floodplains fine upward and onshore and mean grain sizes decrease from very fine sand for the active channel component to coarse silt for the floodplain component (Figs 3.3c, 3.4c, 3.9). The decrease in sorting from the active channel component to the floodplain component reflects the difference in grain size for the sand and mud couplets that dominate the floodplain conversion and floodplain component. Grain size trends observed indicate that as floodplain accretion occurs, dominant bedload deposition gives way to suspended sediment deposition.

7. DISCUSSION

Our stratigraphic and sedimentological analyses show that different stages of floodplain formation may incorporate a variety of both horizontal and vertical depositional relationships. In the nascent stages, we observed active channel sand bars vertically accreting through the progressive on-lapping of sand and mud couplets. Lateral accretion also existed as sediment was deposited at an angle inclined upward and onshore against the channel bar or channel margin similar to epsilon cross-stratification
(Allen, 1963), inclined heterolithic cross-stratification (IHS) (Thomas et al., 1987), and oblique accretion (Page et al., 2003).

As accretion continued, these emerging floodplain features, or benches, built through coincident lateral and vertical accretion. IHS and oblique accretion of sand and mud couplets occurred at the channel margins. However, in contrast to observations of Page et al. (2003), these sediments often overtopped the crest of the developing bench, resulting in vertical accretion in the developing floodplain trough. During this stage, floodplain building became less dependent upon lateral processes and more dependent upon vertical processes.

Vertical processes were dominated by the formation of levees through suspended sediment deposition at the channel margins. Levees built upward as a ridge similar to a scroll bar (Nanson, 1980) forming steep banks at the river margin and a gentle slope toward the floodplain trough. The highest deposition rates, and thickest beds, occurred adjacent to the channel. On the lower Rio Grande, sediment supply does not appear to be limited and thus the size of the levee appears to be related to magnitude and duration of the floods and the relative amount of sediment delivered by those floods. The large levee feature in the central portion of both trenches (Figs 3.3 and 3.4) was created by floods in excess of 1000 m$^3$/s, and the subtle levee feature at the current channel margin was created by floods less than approximately 650 m$^3$/s.

Floodplain building on the lower Rio Grande is similar to many of the mechanisms outlined by previous studies, however, these mechanisms occurred along relatively straight reaches of the river. Thus, deposition during channel narrowing along straight reaches mimics deposition patterns that usually occur at concave outer bends and convex point bars of typical meandering streams with high suspended sediment loads.
(Allen, 1965; Woodyer, 1975; Woodyer et al., 1979; Nanson, 1980). During channel narrowing, active channel bars at wide portions of the channel appear to act as seeds for bench and floodplain formation similar to observations on the Powder River by Pizzuto (1994) and Moody et al. (1999).

8. CONCLUSIONS

Channel narrowing of the lower Rio Grande occurred through the development of floodplains inset within previous channel margins along relatively straight reaches of the river. Narrowing occurred by some lateral, but mostly vertical, accretion on top of coarse grained mid-channel and channel margin bars. Initial stages of floodplain formation consisted of the vertical and oblique accretion of active channel bars resulting in bench formation. During this stage, sediment consisted of well sorted ripple cross-stratified and parallel laminated very fine sand as observed in the active channel component. Building continued which was dominated by IHS and oblique accretion at the channel margins and vertical accretion in the floodplain trough. At the channel margins, sediment consisted of very fine ripple cross-stratified sand that fined onshore into fining upward couplets of very fine sand and mud. We defined these sediments as the floodplain conversion component, because vertical accretion of active channel bars resulted in a transition from bedload deposition to suspended sediment deposition indicative of a floodplain. However, bedload deposits were occasionally present indicating that at some discharges, this portion of the floodplain was still part of the active channel. The final stage of floodplain development consisted of high suspended load deposition at the channel margin that created natural levees of ripple cross-stratified very fine sand that thinned and fined onshore into vertically accreting couplets of sand and mud. Sand deposition
dominated within the levees and mud deposition dominated in the floodplain trough. These sediments constituted the floodplain component and resulted in mostly vertical accretion. Through the above processes, 2.75 to 3.5 m of vertical accretion occurred as the channel narrowed between 33 and 55% over 17 years.

9. REFERENCES CITED


Fig 3.1: (a) Map of the Big Bend region. (b) Study area
Fig 3.2: Locations of the Castolon and Boquillas trench sites. Flow is from left to right.
Fig 3.3: Stratigraphy and sedimentology observed in the Castolon trench. a) Surveyed cross-section at the Castolon trench. Mapped stratigraphy of the Castolon Trench is displayed on the left of the cross-section. b) Mapped stratigraphy of the Castolon trench. Stratigraphic contacts defined by unconformities and disconformities. c) Stratigraphic columns, grain size distributions, and dominant sedimentary structures within the Rio Grande Village trench. Grain size depicted is the dominant grain size of the bed. Internal gradational changes are not depicted. d) Castolon trench displaying original location of the dated tamarisk (tamarisk codes listed). Germination horizons are indicated in a dark black horizontal line. Dates indicate periods of sediment accretion as observed from the wood anatomy of tamarisk trees. Stages of the baseflow (<10 m3/s), the approximate 2-year flood stage (310 m3/s) are also displayed. e) Castolon trench displaying 3 sedimentological component of channel narrowing.
Fig 3.4: a) Surveyed cross section at the Boquillas trench site near the Rio Grande Village boat ramp. Mapped stratigraphy of the Boquillas trench is displayed on the left of the cross section. The approximate elevation of the 2-yr flood stage is also displayed. b) Mapped stratigraphy of the Boquillas trench. Stratigraphic contacts defined by unconformities and disconformities. c) Stratigraphic columns, grain size distributions, and dominant sedimentary structures within the Boquillas trench. Grain size depicted is the dominant grain size of the bed. Internal gradational changes are not depicted. d) Boquillas trench displaying original location of the dated tamarisk (tamarisk codes listed). Germination horizons are indicated in a dark black horizontal line. Dates indicate periods of sediment accretion as observed from the wood anatomy of tamarisk trees. Stages of the baseflow (~10 cm), the approximate 2-yr flood stage (~310 cm) are also displayed.
Fig 3.5: Sedimentological facies of the active channel component. (a) Inclined parallel laminated silty sand overlying gravel deposit at the base of the Castolon trench. (b) Ripple drift cross-stratification fining upward into silty sand. (c) Planar bedded silty sand interrupted by overlying bioturbated mud.
Fig 3.6: Sedimentological facies of the floodplain conversion component. (a) Erosional contact showing inclined parallel lamination truncating ripple drift cross-stratification below. (b) Banded couplets of fine reddish sand overlain by caps of dark mud. (c) Planar laminated bedload gravels interfingered with couplets of reddish sand and dark mud.
Fig 3.7: Sedimentological facies of the floodplain component. (a) Sediment of levee in Castolon trench nears station 27. Note the erosional truncation of parallel laminated sediment in center, and the conformable sediment drapes that form the levee crest. (b) Ripple drift cross-stratification within the levee. (c) Supercritically climbing ripples within levee. (d) Planar laminated very fine sand. (e) Erosional truncation of rippled sand by overlying planar bedded sediment. (f) Horizontally bedded vertically accreting couplets of sand and mud within floodplain trough.
Fig 3.8: Vegetation induced sedimentary structures. (a) Mud-filled root cast or animal burrow, (b) upturned beds, (c) downturned beds, (d) mud-filled hollow, (e) root-cast, (f) centro-clinal cross-stratification.
Fig 3.9. Average grain size distribution of active channel component ($n = 5$), floodplain conversion component ($n = 21$), and floodplain component ($n = 36$).
CHAPTER 4

CONCLUSIONS

Hydrologic data, aerial photographs, discharge measurement notes, stratigraphy, and dendrogeomorphic analyses show that the lower Rio Grande in the Big Bend region is approximately 50% narrower than in the 1940s. Narrowing occurred as the construction and management of dams, stream-flow diversions, and levees reduced the frequency of large long duration floods and increased the relative frequency of low magnitude short duration floods. Narrowing occurred through the deposition of vertically accreting floodplains inset within previously wider channel margins. Non-native vegetation invasion exacerbated narrowing by stabilizing banks and inducing further sedimentation.

An analysis of various forcing mechanisms show that although dams trap sediment and attenuate flood peaks in their reservoirs, the management of the dams during drought has the greatest effect on channel morphology. Short, low magnitude dam releases cause channel narrowing and elevated baseflows from water deliveries to the lower basin promote vegetation establishment on active channel bars. More importantly, we show that large dam releases are effective at widening the channel and maintaining channel width.

Channel narrowing is widely believed to be negatively impacting the native and endemic in stream aquatic habitat through the loss of ecologically important habitats such as back waters, side channels, low velocity areas of the channel. In order to restore
historic measures of channel width, restoration activities must include the reinstitution of historical portions of the hydrograph, and the management of non-native vegetation.

4.1 MANAGEMENT OPTIONS

We propose three management options for restoring and maintaining channel width: (1) large magnitude, channel resetting dam releases that erode channel banks and create a diverse array of in channel geomorphic surfaces, (2) frequent, small dam releases that provide flood disturbance, prevent vegetation establishment, and do not promote vertical floodplain accretion, and (3) local vegetation management.

Evidence from discharge measurement notes and aerial photographs show that dam releases in excess of 1000 m$^3$/s that occur for extended durations are effective at widening the channel. However, analyses of hydraulic geometry relationships and channel cross section measurements show within 5 years after a channel resetting event, channel width usually contracts to measures predating the reset (Figs 2.14a, and 2.16b). Therefore, to maintain a wider channel through channel resetting floods, the frequency of these floods must increase.

Many studies show that through bank stabilization, increases in channel margin roughness, and reduction in lateral migration rates, vegetation effectively promotes channel narrowing and vertical floodplain accretion (Graf, 1978; Gran and Paola, 2001; Tal et al., 2003; Griffin et al., 2005; Tal and Paola, 2007). Thus, vegetation management must be an integral part of any restoration plan. Management is most important following channel resetting floods, because bare, moist surfaces that are created by these events are optimal for seedling establishment (Horton, 1960; Everitt, 1980; Scott et al.,
In early life stages, many riparian species including tamarisk must (Scott et al., 1996) remain protected from disturbance to survive. Erosion and burial of seedlings from high flows may effectively limit survival (Friedman and Auble, 1999; Levine and Stromberg, 2001; Polzin and Rood, 2006). Thus, frequent, small dam release floods that fill the channel yet do not overtop the banks may provide the disturbance necessary to prevent non-native seedling establishment on low active channel surfaces. Our analyses of floodplain deposits indicate that these flows must be less than approximately 200 m$^3$/s, because flows in excess of this discharge cause over-bank flow, vertical floodplain accretion, and channel narrowing, thus undermining the purpose of the release.

We recognize that the potential for both large and small dam releases for environmental purposes is small. Indeed, large dam releases may only occur through the chance of tropical storms that fill Rio Conchos reservoirs, necessitating a dam release. However, the potential of vegetation disturbance floods are possible through the present framework of management. International treaties, interstate compacts, and instate rights define a context of water allocation that is rarely changed once established. International treaties between the United States and Mexico negotiated in 1906 and 1944 (U.S. and Mexico, 1906; U.S. and Mexico, 1944) determined the amount of water available for consumptive use by each country from the upper Rio Grande, Rio Conchos, other tributaries, and the lower Rio Grande. Within this framework, management decisions regarding reservoir operations, irrigation needs, and available water resources determine year to year and seasonal flows. Although the volume of water entitled to users is defined by law, the manner in which a volume of water is transferred from one stakeholder to another is not. For example, elevated baseflow releases that occur in the
late fall and winter months are generally water delivery flows that transfer water from upper basin reservoirs to the lower basin. In 1993 and 1995, elevated baseflows for water delivery occurred for nearly 100 and 50 days, respectively, but never exceeded 20 m$^3$/s (Fig 2.8). If these releases were restructured to be shorter and larger in magnitude, they could serve two purposes: vegetation control through managed flood disturbance, and water delivery to the lower basin.

We admit speculation concerning the effectiveness of the flood disturbance method. Tamarisk and giant cane are opportunistic colonizers. Tamarisk seeds are viable nearly 7 months of the year (Everitt, 1980), and giant cane may establish through deposition of small root fragments (Bell, 1997). Additionally, plants that have matured beyond the seedling stage may tolerate floods. In the Big Bend region, plants may grow sufficiently in 1 to 2 years following germination to survive flood disturbance. However, aerial photographs and hydrologic analyses indicate that the most successful establishment period for vegetation in the 1990s was between 1992 and 1998 when flood disturbance in the form of the two year flood was reduced, and elevated managed baseflows occurred. Thus, frequent flood disturbance, without promoting vertical floodplain accretion, may limit successful seedling establishment, and must be considered as a management option.

At the local level, vegetation management must consist of the removal of non-native vegetation, most importantly, giant cane, which grows in impenetrable thickets, overhangs the channel, and directly affects channel margin flow. This is especially important in the absence of disturbance flows following channel resetting events, or periods of low flow when bare moist surfaces are exposed for establishment. At this
time, it is uncertain whether the current dense vegetation will effectively limit the erosion potential of a future large flood. Thus, vegetation removal may potentially destabilize vegetated banks, and limit the roughness effects at the channel margins, potentially maximizing the erosive potential of future large floods.

Frequent, large, dam release floods are the best option for restoring and maintaining channel width and diverse in-stream geomorphic features. In the absence of these flows, vegetation management through on site removal and managed environmental floods appears to be the best method for limiting the rate and magnitude of channel narrowing and vertical floodplain accretion.

4.2 REFERENCES CITED


APPENDIX

SUPPLEMENTAL STRATIGRAPHIC AND DENDROGEOMORPHIC DATA
Big Bend – Ring Reading Notes

Ring Reader: J.K.                                      Reading Date: 3/26/07
Site ID: 19A Rio Grande Village                      Collection Date: Jan, 2007
Tree/Hole ID: 19A                                      Slab ID: G5

Ring Counts/Notes:
J2X Filename: RG19A J2X.txt

Number of radii measured: 2

J2X Series Id: RG19A G5A, RG19A G5B

Jki - Recorded radii A + B into J2X.

<table>
<thead>
<tr>
<th>Slab</th>
<th>Diamet. Measurement(in)</th>
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<tbody>
<tr>
<td>G5</td>
<td>19.4</td>
</tr>
<tr>
<td>Slab 2</td>
<td>20.5</td>
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<tr>
<td>Slab 3</td>
<td>16.8</td>
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<tr>
<td>Slab 4</td>
<td>12.8</td>
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</table>

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:  
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

'96 - narrow  
'94-'05 - wider  
'93 - narrow  
'92 - narrow  
'91 - big, healthy yt, w/ pitch 0  
'99 - odd side wood-false ring?  
'94 - '99 - wide, healthy yrs.
Big Bend - Ring Reading Notes

Ring Reader: J.K.  

Reading Date: 3/26/07  

Site ID: Rio Grande Village  

Collection Date: Jan. 2007  

Tree/Hole ID: 19A  

Slab ID: 2

\[ \left( \frac{L_z}{m} + \frac{m}{m} \right) \]

Ring Counts/Notes:

J2X Filename: RG19AJ2X.txt  

Number of radii measured: 2  

J2X Series Id: RG19A2A, RG19A2B

\[ j.R. - \text{Recorded radii } A + B \text{ into } J2X. \]

Proportion of circumference with secondary growth:

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<th>Start Year</th>
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<th>Proportion</th>
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\[ j.R. - \text{burial after 1993} \]

\[ M.S. - \text{slight build after 2000?} \]

Wood Anatomy Change Notes:

- No obvious PILL(?)  Mike says yes, there is pith.
- 05 +06 - compressed  
- 03 - wide  
- 02 - false ring  
- 01 - narrower  
- 99 - slight false ring  
- 98 - on one spot on slab is injury  
- 91 - large center w/ tiny pith, cracked  
- bit of false ring also  
- 97 - no visible change  
- 20 - unknown
Big Bend – Ring Reading Notes

Ring Reader: J.R. Reading Date: 3/26/07
Site ID: Río Grande Village Collection Date: Jan, 2007
Tree/Hole ID: 19A Slab ID: 3

Ring Counts/Notes:
J2X Filename: RG19A32X.txt
Number of radii measured: 2
J2X Series Id: RG19A3A, RG19A3B

J.R. – recorded radii A & B into J2X.

Proportion of circumference with secondary growth:

<table>
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<th>Proportion</th>
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J.R. – broad compression after 03

Wood Anatomy Change Notes:

Radii A + B - 1991 - 2006 center cracked

'04 - '06 - wide yrs.
'01 - '03 - Similar
'95 - '99 - wide yrs.
'74 - narrower
'93 - 2nd false ring

'92 - nervous
'91 - center of Teeny pith, large yrs.
and false rings,
Big Bend – Ring Reading Notes

Ring Reader: R. 
Reading Date: 

Site ID: Rio Grande Village
Collection Date: Jan. 2007

Tree/Hole ID: 19A
Slab ID: / (c/p)

Ring Counts/Notes:
J2X Filename: RG19A J2X.txt
Number of radii measured:
J2X Series Id:

Proportion of circumference with secondary growth:

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<th>Start Year:</th>
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Wood Anatomy Change Notes:

- No pit
- All root weird!
- Buried.
- Establish 1991
Big Bend - Rio Grande Village

TREE 19A

10-12 cm
RG-19A-6S
\( \Theta = \text{made GS} \)

-17 cm
RG-19A-1

9-11 cm
RG-19A-2
\( \Theta = \text{made M/N} + N/A \)

12-16 cm
RG-19A-3
\( \Theta = \text{made M/N} + N/A \)

7.5-8 cm
RG-19A-4
\( \Theta = \text{made clay} + D \)

9-8 cm
RG-19A-5
\( \Theta = \text{made clay} + D \)

5 cm
RG-19A-6
\( \Theta = \text{made clay} + 5/k \)

cont. \( \rightarrow \)
BIG BEND - RIO GRANDE VILLAGE

TREE 19A

R6-19A - 15
Q = nail + tag

~ 43 in.
Big Bend - Ring Reading Notes

Ring Reader: J.R. + D.D

Site ID: Rio Grande Village

Tree/Hole ID: 198

Slab ID: GS -

Collection Date: Nov. 2006

Describing Button:
Tob has 2 notches and is heavily weathered.

Ring Counts/Notes:

J2X Filename: RG198J2X.txt

Number of radii measured: 9

J2X Series Id: RG198G64 RG198G65

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

07-06: similar
07 wide
01-02 similar
97-00 wide
False Ring 98
95 - Narrow
94 - wide
93-92 - wide
93 False Ring

Injury in 95

Center has Rot. Difficult to see pitch, may be barely present

\[ 1990 - 1991 \]
Big Bend - Ring Reading Notes

Ring Reader: L. R. + D. D.  
Reading Date:  

Site ID: Rio Grande Hillside  
Collection Date: Nov. 2006  

Tree/Hole ID: 748  
Slab ID: 2  

Ring Counts/Notes:  
J2X Filename: R619A2A.TLV  
Number of radii measured: 2  
J2X Series Id: R619 A2A R619 B2B  

Proportion of circumference with secondary growth:  
Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes:  
9/2006  
- Buried after 2000  
- OV side - relatively  
- OV-06 - similarly narrow  
- 97-2000 similar  
- Injury in 95 - cracked  
- Filer Ring in '93  
- '91 center w/healthy pitch
Big Bend - Ring Reading Notes

Ring Reader: J.R. & L.D.  
Reading Date: __________________  

Site ID: Rb. Grande Village  
Collection Date: Nov. 2006  

Tree/Hole ID: 17/3  
Slab ID: 3  

Ring Counts/Notes:  

J2X Filename: Rb.198.32x.Tyr  
Number of radii measured: 3  
J2X Series Id: Rb.198.3A  Rb.198.3B  

Proportion of circumference with secondary growth:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes:  

17-2006:  
- Buited after '00  
- 01 - band appears thicker than in slab a - Unburied? Happin good? Waeker Buried?  
- 03: 2000 $minor  
- Injury in '95-'96  
- 94 Late  
- 95 Early  
- 96 strong  
- 97-98 similar  
- 99-2000 strong
Big Bend - Ring Reading Notes

Ring Reader: J.K. D.D.  
Reading Date: 

Site ID: Rio Grande Village  
Collection Date: Nov. 2006  

Tree/Hole ID: 143  
Slab ID: 4  

Ring Counts/Notes:

12X Filename: RG185345.TXT
Number of radii measured: 2
12X Series Id: RG1845

Proportion of circumference with secondary growth:

Start Year:       Stop Year:       Proportion:       
Start Year:       Stop Year:       Proportion:       
Start Year:       Stop Year:       Proportion:       

Wood Anatomy Change Notes:

4/1996
- 01-06 - compressed.
- 75-76 - highcompact.
- 91 - heart w/healthy ftth.
- after 93 - wood looks better?
Big Bend – Ring Reading Notes

Ring Reader: ____________________  Reading Date: ____________________

Site ID: Rio Grande Village  Collection Date: Nov. 2006

Tree/Hole ID: 1918  Slab ID: <

Ring Counts/Notes:

12X Filename: R07.98.52x.txt

Number of radii measured: 2

12X Series Id: RG1985A  RG1985B

Proportion of circumference with secondary growth:

Start Year: _____  Stop Year: _____  Proportion: _____

Start Year: _____  Stop Year: _____  Proportion: _____

Start Year: _____  Stop Year: _____  Proportion: _____

Wood Anatomy Change Notes:

9/2006

- Stick in "cane" of stem where plant appears to be uninjured.
- 75-90% x-contential
- Measure from 91-94
- Burnt after '93? But maybe all burned
## Big Bend - Ring Reading Notes

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<th>Ring Reader:</th>
<th>Reading Date:</th>
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<td>Site ID:</td>
<td>Collection Date:</td>
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<td>Nov 2006</td>
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<td>Tree/Hole ID:</td>
<td>Slab ID:</td>
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<td>198</td>
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### Ring Counts/Notes:

- **12X Filename**: R6 19BLAX.72T
- **Number of radii measured**:  
- **12X Series Id**: R6 19BGA. RG1B0B.

### Proportion of circumference with secondary growth:

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<th>Proportion:</th>
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### Wood Anatomy Change Notes:

- 91 - ?
- No Path
- all Buried?
- 91-93 Visible
Big Bend - Ring Reading Notes

Ring Reader:  

Reading Date:  

Site ID:  

Collection Date:  

Tree/Hole ID:  

Slab ID:  

Ring Counts/Notes:

J2X Filename:  

Number of radii measured:  

J2X Series Id:  

Proportion of circumference with secondary growth:

Start Year:  

Stop Year:  

Proportion:  

Start Year:  

Stop Year:  

Proportion:  

Start Year:  

Stop Year:  

Proportion:  

Wood Anatomy Change Notes:

Radii A & E - 1991 - 2006

'94-'95 - wide
'94 - false width
'93 - wide
'92 - wide without ring
'91 - center with true false ring
'90 - wide
'89 - wide
'88 - wide
'87 - wide
'86 - wide
'85 - narrow
'84 - narrow
'83 - narrow
'82 - narrow
'81 - narrow

'06 - similar wide
'05 - wide
'04 - wide
'03 - wide
'02 - wide without ring
'01 - wide
'00 - wide
'99 - wide
'98 - wide
'97 - similar wide
'96 - narrow

'95 - similar wide
'94 - similar wide
'93 - similar wide
'92 - similar wide
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'85 - similar wide
'84 - similar wide
'83 - similar wide
'82 - similar wide
'81 - similar wide
'80 - similar width
Big Bend – Ring Reading Notes

Ring Reader: bd > fd

Site ID: Rio Grande Village

Tree/Hole ID: 21

Reading Date:

Collection Date: 2022: Term 922

Slab ID: 0

Ring Counts/Notes:

J2X Filename: R522l5b.txt

Number of radii measured: 2

J2X Series Id: R6.31.9A R6.32.9B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

J.R. - perhaps burial after '03

Wood Anatomy Change Notes:

Radii A + B 1991 - 2006

'04-'06 - Similarly wide
'01-'03 - Similar w/ false ring
'97-2000 - Similarly wide
'94+95 - False ring - wide
'91-93 - False rings
'91 - Center cracked w/pith

ancestral: ∆ after '91
Big Bend - Ring Reading Notes

Ring Reader: D.K. + D.D.  
Reading Date: 

Site ID: Rio Grande Village  
Collection Date: Nov 2006 - Jan 2007 

Tree/Hole ID: 2  
Slab ID: 3 (L1/M) 

Ring Counts/Notes:

12X Filename: RG2136k.TX 
Number of radii measured: 2

12X Series Id: RG2136, RG2138 

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

3.R. buried after 03

Wood Anatomy Change Notes:


04-06 - similar  
01-03 - similar width  
01+02 - false rings  
96-99 - wide  
96-99 - wide tissues cells  
98-95 - wide anthocyanins  
 anatomical A after 91.  
91+ outer w/speck of pith  
 bottom cut 50% lower  
 2 in. wood
Big Bend - Ring Reading Notes

Ring Reader:  
Reading Date:  

Site ID:  
Collection Date:  Jan. 2007  

Tree/Hole ID:  
Slab ID:  

Ring Counts/Notes:

J2X Filename:  
Number of radii measured: 0  
J2X Series Id:  

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  


Wood Anatomy Change Notes:

'04 - '06 - thinning  
'01 - '03 - similar wide false rings  
'00 - false ring width  
'99 - wide throughout yr.  
'96 - '99 - wide  
'93 - '95 - wide  
'91 - center false ring, no pitch  

"r = A after 9/1, 00
Big Bend – Ring Reading Notes

Ring Reader: D. D. – J. R.  
Reading Date: 

Site ID: ?is Beams / Stage  
Collection Date: Nov, 2006 – Jan, 2007  

Tree/Hole ID: 31  
Slab ID: 7  
(M2/N)  

Ring Counts/Notes:  

J2X Filename: RG127.MT  
Number of radii measured:  

J2X Series Id: R22674, R22675  

Proportion of circumference with secondary growth:  

Start Year: _______  
Stop Year: _______  
Proportion: _______  

Start Year: _______  
Stop Year: _______  
Proportion: _______  

Start Year: _______  
Stop Year: _______  
Proportion: _______  

J.R. – burned after ’02, looks like burn after ’91.  

Wood Anatomy Change Notes:  

’04 – ’06 – narrowing  
’61 – ’03 – wide w/false rings  
2000 – false ring  
1999 – lg. false ring  
’95 – ’99 – wide  
’91 – center w/ no pith.
Big Bend - Ring Reading Notes

Ring Reader: JR + B.D.  
Reading Date: 

Site ID: Rio Grande Village  
Collection Date: Nov 2006 Jan 2007

Tree/Hole ID: 21  
Slab ID: 8  
(N/D)

Ring Counts/Notes:

J2X Filename: RG218X.txt

Number of radii measured: 2

J2X Series Id: RG218A, RG218B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion:

JrK: Buried after 91

Wood Anatomy Change Notes:

Radii A + B - 1991 - 2006

All Looks Buried ()

2000-08 - false rings
98+1999 - false ring wider
91 - center can't detect pitch
Big Bend - Ring Reading Notes

Ring Reader: J.R. & D.D.  
Reading Date:  

Site ID: Rio Grande Village  
Collection Date: Nov. 2006 - Jan. 2007  

Tree/Hole ID: 21  
Slab ID: 9  
(o/p)

Ring Counts/Notes:

J2X Filename: R212X.txt  
Number of radii measured: 2  
J2X Series Id:  

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  
J.R.: possible burial effect '90, All!

Wood Anatomy Change Notes:

'01-'06 - compressed  
'02 - false ring  
1999 - false ring  
'93 - 2006 - similar widths  
'92 - pinches, bolt moon  
'91 - wide  
'90 - wide across, we put  
Radii A+B - 1990 - 2006
Big Bend – Ring Reading Notes

Ring Reader: J. R. & D.D.  
Collection Date: Nov. 2006 Jan. 2007

Site ID: Rio Grande Village  
Slab ID: [Blank]

Tree/Hole ID: 21  
(f/d)

Ring Counts/Notes:

I2X Filename: RG211 A, RG211 B

Number of radii measured: 2

I2X Series Id: RG211 AB

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

L.K. burial wall

Wood Anatomy Change Notes:

Injury between 01 & 02
1999 - false ring
73 - 2000 - ring nearly rotted 98 ring
90 - center of ring pitch.
Big Bend - Ring Reading Notes

Ring Reader: J.R. + D.J.  

Reading Date: ______________________

Site ID: Rio Grande Village  

Collection Date: ____________ Jan. 2007

Tree/Hole ID: 21  

Slab ID: 12  

Ring Counts/Notes:

J2X Filename: R G 21 .csv  

Number of radii measured: 2  

J2X Series Id: Rg21.J2X Rg21ab  

Proportion of circumference with secondary growth:

Start Year: ________  

Stop Year: ________  

Proportion: ________

Start Year: ________  

Stop Year: ________  

Proportion: ________

Start Year: ________  

Stop Year: ________  

Proportion: ________

- 3.x. All Buried

Wood Anatomy Change Notes:


- Thin false ring

- Varied color

- Some rings difficult to read (01-02)

- Hard to identify pitch

- Dark blue staining in center
Big Bend - Ring Reading Notes

Ring Reader: J.R. + D.D.  
Reading Date: 

Site ID: K. o Grande Village  
Collection Date: Jan. 2006

Tree/Hole ID: 21  
Slab ID: 14

Ring Counts/Notes:

12X Filename: RGZ1SZYXRZ

Number of radii measured: 2

12X Series Id: RGZ11NA RGZ11YR

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  
Start Year:  Stop Year:  Proportion:  

Wood Anatomy Change Notes:

1994 - 2000

1977 – Fast Ring  – No Pink  
1980 - Large

Radii A - 1994 - 2000  
Radii B - 1997 - 2000
Big Bend - Ring Reading Notes

Ring Reader: ___________________  Reading Date: ___________________

Site ID: P1a Creek 4 Hig  Collection Date: Jan. 2007

Tree/Hole ID: 21  Slab ID: 16

Ring Counts/Notes:

12X Filename: R031.txt  

Number of radii measured: 2  

12X Series Id: R031/6  R031/6B

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

S & R all Buined

Wood Anatomy Change Notes:

- No pith - all piths Poorly  

Not many distinguishable years - not worth measuring - Don't Jot.
Big Bend Rio Grande Village

TREE 21

7-10.5 cm  RG - 21 - GS  ◊ = only GS

19 cm  RG - 21 - 1

10 cm  RG - 21 - 2

10-12 cm  RG - 21 - 3  (Top + bottom outlined)

13-15 cm  RG - 21 - 4

6-8 cm  RG - 21 - 5  □ = mill w/ M1 M2

3-5 cm  RG - 21 - 6

cont. →
Big Bend - Rio Grande Village
TREE 21

- ~8 cm  RG-21-7  ⊗ = mud M/N
- ~7 cm  RG-21-8  ⊗ = mud N/O
- 5.5 cm  RG-21-9  ⊗ = mud O/P
- 6 cm  RG-21-10
- 7-8 cm  RG-21-11  ⊗ = mud P/O
- 6 cm  RG-21-12  ⊗ = mud A/R
- 6 cm  RG-21-13
- ~7 cm  RG-21-14  ⊗ = mud R/S
- ~9 cm  RG-21-15

J.R.,
3/20xx
pg. 2 of 3
Big Bend - Rio Grande Village

TKEE 21

5.5 - 6.5 cm    RG-21-16

6 cm    RG-21-17

9 cm    RG-21-18

6.5-7 cm    RG-21-19

7-8.5 cm    RG-21-20

8-14 cm    RG-21-21

Θ = Neil 2/7

Ω = Neil 7/6

J.R.
3/2004
PG.343
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 2/12/07

Site ID: Rio Grande Village (RG)  
Collection Date: Nov. 2006

Species: J2X  
Slab ID: GS

Ring Counts/Notes:

J2X Filename: RG335J2X.txt

Number of radii measured: 2

J2X Series Id: RG335A, RG335B

D.D. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

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<th>Start Year</th>
<th>Stop Year</th>
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Wood Anatomy Change Notes:

Furled A+B 1995-2006  
Center is cracked.

06 - large year
04 - "
02 - large hole
all years are change.
75 center split (said live though)
Big Bend – Ring Reading Notes

Ring Reader: J.R. Reading Date: 3/12/07
Site ID: Rio Grande Village Collection Date: Nov. 2006
Tree/Hole ID: 335 Slab ID: 2 B/C

Ring Counts/Notes:

J2X Filename: RG335J2X.txt
Number of radii measured: 2
J2X Series ID: RG3352A, RG3352B

D. D. – Recorded radii A & B into J2X.

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

03-06 – wide ring.
79 – Slight false ring.
95 center split! ②
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/12/07

Site ID: Rio Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 335  
Slab ID: 5

Ring Counts/Notes:

12X Filename: RG335J2X.txt

Number of radii measured: 2

12X Series Id: RG 3355A, RG 3355B

D.D. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

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<th>Start Year:</th>
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M.S. burned after 05 possibly '04

Wood Anatomy Change Notes:

Radii A + B - 1995 - 2006  

'05 +'06 - Show slight burial
'94 - Slightly thick
'03 -  
'92 -  
'91 -  
'90 -  
'97 - bit of light yellow
'96 -  
'95 - center which 8
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/12/07

Site ID: Rio Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: RSC

Slab ID: 6

Ring Counts/Notes:

J2X Filename: RG356J2X.SXT

Number of radii measured: 2

J2X Series Id: RG356A, RG356B

D.D. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes:

Radii A + B - 1995 - 2006

'84 - '86 - slow slight burial
'84 - wide

'92 - narrower, more ring
'99 - slight burls
'97 - '01 - wide

'96 - wide (stretched)
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 3/12/07

Site ID: Rio Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 331  
Slab ID: 7

Ring Counts/Notes:

J2X Filename: RG3357A, RG3357B

Number of radii measured: 2

J2X Series Id: RG 3357A, RG 3357B

P.D. found radii A + B into J2X

Proportion of circumference with secondary growth:

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J.K. - burial after 03.
MS. - burial after 03.

Wood Anatomy Change Notes:

Radii A + B - 1995 - 2006  
Cont. 2 marked

04 - 06 - burial signs
03 - intermittent false ring
02 - interval of false ring
97 - 98 - wood exit
95 - wood exit
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/10/07

Site ID: Rio Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 335  
Slab ID: 9

Ring Counts/Notes:

J2X Filename: KG 335 12X, 2X
Number of radii measured: 2

J2X Series Id: KG 335 9A, KG 335 9B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:  
Start Year: Stop Year: Proportion:  
Start Year: Stop Year: Proportion:

J.R. - buried Oct 2001,  
M.S. - buried after '02.

Wood Anatomy Change Notes:

Radii A+B - 1995-2006 - evaluated:

'95 - check tree map file info.  
'96 - check tree map file info.  
'95 - see tree path forest away

'02 - shake tree  
'97 - '01 - move
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/6/07

Site ID: El Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 335  
Slab ID: 11

Ring Counts/Notes:

J2X Filename: RG 335 J2 X. C X

Number of radii measured: 2

J2X Series Id: RG 33511 A, RG 33511 B

DD. Entered into JAY

Proportion of circumference with secondary growth:

Start Year:_________  
Stop Year:_________  
Proportion:_________

Start Year:_________  
Stop Year:_________  
Proportion:_________

Start Year:_________  
Stop Year:_________  
Proportion:_________

J.R. - Buried after 2001
M.S. - Buried after '01, 2000 t `01 Traditional or shallow burial

Wood Anatomy Change Notes:


(Compression after '99.)  '96 - False ring
2001 - WIDE  '96 - Clear
02 - Resin  75 - Clear
99 - 01 - Similar  76 - New center w/pitch
2000 - Wide  77 + 98 - WIDE
99 - Trace of false ring
Big Bend – Ring Reading Notes

Ring Reader: J.K. 

Reading Date: 2/4/43

Site ID: Rio Grande Village

Collection Date: Nov. 2006

Tree/Hole ID: 735

Slab ID: 12

Ring Counts/Notes:

12X File Name: RG 335 A 2X, 3X

Number of radii measured: 2

12X Series Id: RG 33512 A, RG 335 B

12X Extrad 1st 50x

Proportion of circumference with secondary growth:

Start Year: ________ Stop Year: ________ Proportion: ________

Start Year: ________ Stop Year: ________ Proportion: ________

Start Year: ________ Stop Year: ________ Proportion: ________

J.K. - Buried after 2001, possibly under.

Wood Anatomy Change Notes:

Radii A + B - 1994 - 2002

-02 = small, humid
-01 = wide
-97 = 2000 - 2001
-96 = Field, etc.
-95 = small
-94 = new center w/ pitch +

Δ in wood anatomy after '96.
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 9/24/7

Site ID: Rio Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 335  
Slab ID: 14

Ring Counts/Notes:

I2X Filename: RG_33514A.txt
Number of radii measured: 2
I2X Series Id: RG_33514A, RG_33514B
DD entered into I2X

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:

M.S. - buried after 99 & earlier
J.R. - buried after 99 & earlier

Wood Anatomy Change Notes:

Radii 148-1994-2001 (some outer cortex)

81 - wood
'97 - 2000 - similar
'96 - inner cortex - good wood
'95 - small
'94 - center + pitch 0
Big Bend - Ring Reading Notes

Ring Reader:  J. R.  

Date:  3/1/89

Site ID:  Rio Grande Village

Collection Date:  Nov. 2006

Tree/Hole ID:  335

Slab ID:  16

Ring Counts/Notes:

J2X Filename:  535JX

Number of radii measured:  2

J2X Series Id:  RG 33516 A, RG 33516 B

J.D. Fitted into JX

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  

Start Year:  
Stop Year:  

Start Year:  
Stop Year:  

J.R. - Buried after 1996
M.S. - Buried after 96.

Wood Anatomy Change Notes:


97 - medium on B, wide on A
96 - good wood, slight flare rings
95 - good wood
94 - center w/pith 0

Outer Pitted Slab.
Big Bend – Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/2/07

Site ID: Río Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 325  
Slab ID: 17

Ring Counts/Notes:

12X Filename: KG 325 32X.DAT

Number of radii measured: 2

12X Series Id: KG 325 17A, KG 325 17B

Proportion of circumference with secondary growth:

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J.K. – buried after ’96,  
M.S. – buried after ’96.

Wood Anatomy Change Notes:

Radii A & B 1994: ’76  slab & matrix  
’94 – center of pitch
Big Bend - Ring Reading Notes

Ring Reader: J.R.                                                    Reading Date:              

Site ID: Rib Grande Village (kg)                                 Collection Date: Nov. 2006 

Tree/Hole ID: 33S                                              Slab ID: 20

(Rom)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       

Ring Counts/Notes:                                                                                                                                                                                                                                                                                                                                                                                                                  

J2X Filename: RG 33S J2X, TX                                                                                                                                                                                                                                                                                                                                                                                                                                                             

Number of radii measured:                                                                                                                                                                                                                                                                                                                                                                                                                                                                 

J2X Series Id: 1                                                                                                           DO NOT J2X                

Proportion of circumference with secondary growth:                                                                                                                                  

Start Year:                                                    Stop Year:                                                                                                               Proportion:               

Start Year:                                                    Stop Year:                                                                                                               Proportion:               

Start Year:                                                    Stop Year:                                                                                                               Proportion:               

1993 - 1996                                                                                                                                                                                                                                                                                                                                                                                                                       

1996 - narrow                                                                                                             95 - wide                                                                                                                       

94 - small BRITTLEST!!! Has pitch 8                                                                                                                                                    

93 - pitch 8, pitch 6. Perhaps not this dating in (93),

Wood Anatomy Change Notes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                 

outer scaling
Big Bend

Tree 33.5

10-12 cm

11.5-14 cm

6-8 cm

5-8 cm

~4 cm

BB-335-7

BB-335-8

BB-335-9

BB-335-10

BB-335-11

BB-335-12

BB-335-13

\( \diamond \) = half D/F

(2 centimeters)
Big Braid

TREE 33.5

- 6 cm
- 6 cm
- 7.5 cm
- 6.5 cm
- 9 cm
- 19 cm
- 13.5 cm

BB-335-14
BB-335-15
BB-335-16
BB-335-17
BB-335-18
BB-335-19 (outer wood rotted)
BB-335-20 (sanded Top & Bottom) (outer wood rotted)

References to (3) on pg. 106

1/20/69
Big Bend – Ring Reading Notes

Ring Reader: J.R.  

Site ID: Rio Grantes Village (RG)  

Tree/Hole ID: 34A  

Reading Date: 2/12/07  

Collection Date: Nov. 2006  

Slab ID: GS  

(Top + Bottom 20-21)  

Ring Counts/Notes:  

J2X Filename: RG34AGSA.J2XTXT  

Number of radii measured: 2  

J2X Series Id: RG34AGSA, RG34AGSB  

DD Entered Into TAX  

Proportion of circumference with secondary growth:  

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Wood Anatomy Change Notes:  


'06 – small  

'07 – wider  

'08 – wide, false ring 2000 – center with small  

'09 – narrow  

'02 – widest piece of false ring
Big Bend - Ring Reading Notes

Ring Reader: J.R.                                      Reading Date: 3/22/07

Site ID: Rio Grande Village                                    Collection Date: Nov. 2006

Tree/Hole ID: 34A                                                Slab ID: 2

Ring Counts/Notes:

J2X Filename: KG34A1J2X.txt

Number of radii measured: 2

J2X Series Id: P634A2A, P634A2B

DD Edmund Jox

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

J.R. = buried in '85
M.S. = buried after '04.
Wood Anatomy Change Notes:

Radii A4 B - 1999 - 2006

'06 - narrow

'05 - burred or compressed

'04 - wide 1/6 of false ring

'02 + 03 - similar

'01 - narrower

2000 - narrow w/true false ring

1999 - small center w/pith 0
Big Bend – Ring Reading Notes

Ring Reader: J.R.  Reading Date: 3/13/07
Site ID: Rio Grande Village  Collection Date: Nov. 2006
Tree/Hole ID: 34A  Slab ID: 3

Ring Counts/Notes:
J2X Filename: RG34A3A J2X. ext
Number of radii measured: 2
J2X Series ID: RG34A3A, RG34A3B

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

J.R. 05 stone burial
M.S. – buried after 04.

Wood Anatomy Change Notes:
Radii A + B – 1999-2006 – Center shadowed

'06 = unknown
'05 = buried or compressed
'04 = white (yellow)
'02–'03 = similar
'01 = unknown with false rings

2000 = narrow with false rings
1999 = small center w/ pitch &
Big Bend – Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/03/07
Site ID: Rin Grotto Village
Collection Date: Nov. 2006
Tree/Hole ID: 34A  
Slab ID: 4  
Note: Level surface

Ring Counts/Notes:
J2X Filename: 34A_J2X.txt
Number of radii measured: 2
J2X Series ID: RG34A4A, RG34A4B
D.D. Entred into JAX

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:  
Start Year: Stop Year: Proportion:  
Start Year: Stop Year: Proportion:  
J:J - buried after 04.  
M:J - buried- w/in 04 evidence of burial.

Wood Anatomy Change Notes:
Radii A+B - 1999-2006
2000 - narrow w/thin false rings  
1990 - small center w/pith 0
95+96 - show some burial  
94 - wide
92+93 - similarly narrower  
91 - narrower w/free rings
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 7/13/07

Site ID: Rio Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 34A  
Slab ID: 7 (note c/o)

Ring Counts/Notes:

J2X Filename: RG-34A-2 X, X, X

Number of radii measured: 2

J2X Series Id: D. ds. entered into 30x

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Lkr - buried after 2004
Mso - buried after 2003.

Wood Anatomy Change Notes:

Radin A+B - 1999-2006

'05-'06 - buried  
'04 - wide
'03 - similar
'01 - false ring
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/24/97

Site ID: Rio Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 34A  
Slab ID: 8

Ring Counts/Notes:

J2X Filename: KG_34A_32X.txt

Number of radii measured: 2

J2X Series Id:

D. S curve into SXR

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

J.R. - burried after '03,
M.S. - buried after '03.

Wood Anatomy Change Notes:

Radii A+B - 1997 - 2006

Radii A+B '05 & '06 - burried
Radii B - '04 - compressed
Radii - '04 - wide
'03 - narrow
'02 - narrower
Big Bend - Ring Reading Notes

Ring Reader: J.R.  

Reading Date: 3/2/07

Site ID: Rio Grande Village

Collection Date: Nov. 2006

Tree/Hole ID: 04 A  

Slab ID: 9

Ring Counts/Notes:

12X Filename: RG34AJ2X.txt

Number of radii measured: 2

12X Series Id: RG34A9A, RG34A9B

DB. scored with JVR

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:  

Start Year: Stop Year: Proportion:  

Start Year: Stop Year: Proportion:  

JVR - burial after 2003.  
MVR - buried after 203.

Wood Anatomy Change Notes:

Radii A+B - 1997-2005  
1982-03 - similar  
1987 - narrow + yellow  
2000 - narrow with thin ring (black)  
1999 - very narrow without ring

'98 - narrow  
'97 - center wide w/ thick
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/3/97

Site ID: Río Grande Village  
Collection Date: Nov. 20016

Tree/Hole ID: 34A  
Slab ID: 10

Ring Counts/Notes:

J2X Filename: RG34A J2X.txt

Number of radii measured: 2

J2X Series Id: 20000005  

dj entered into jay

Proportion of circumference with secondary growth:

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<th>Start Year</th>
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<th>Proportion</th>
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J.A. - buried after '03.
M.S. - buried after '03.

Wood Anatomy Change Notes:

Radii A+B - 1997 - 2006

04 - 06 - Buried
03 - wide
02 - normal
01 - narrow + yellow
2000 - narrow w/few rings

1999 - narrow w/few rings
1998 - narrow
97 - wide w/ tiney with 0
Big Bend - Ring Reading Notes

Ring Reader:  J.E.  
Reading Date:  3/18/07

Site ID:  Rio Grande Village  
Collection Date:  Nov. 2001

Tree/Hole ID:  34A  
Slab ID:  11  
(nail D/F3)

Ring Counts/Notes:

J2X Filename:  RG 34A J2X.txt

Number of radii measured:  2

J2X Series Id:  26034a11a  26034a11b

D.J. entered into J2X

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Jrk - burned 1/2
M.S. - burned 3/4

Wood Anatomy Change Notes:

Radii A + B - 1996 - 2004

1996 - Cont. w/good pith

1997 - Narrow w/false rings

1998 - Narrow w/false rings

1999 - Narrow

2000 - Narrow w/false rings

2001 - Narrow w/false rings

2002 - Narrow w/false rings

2003 - Narrow w/false rings

2004 - Narrow w/false rings

1996 - Narrow w/false rings

1997 - Wide

1998 - Narrow

1999 - Narrow

2000 - Narrow

2001 - Narrow

2002 - Narrow

2003 - Narrow

2004 - Narrow

1996 - Yellow + similar to 92

1997 - Yellow + similar to 92

1998 - Yellow + similar to 92

1999 - Yellow + similar to 92

2000 - Yellow + similar to 92

2001 - Yellow + similar to 92

2002 - Yellow + similar to 92

2003 - Yellow + similar to 92

2004 - Yellow + similar to 92
Big Bend - Ring Reading Notes

Ring Reader: J. R.  
Reading Date: 5/13/77

Site ID: R'o Creede Village  
Collection Date: Nov. 2006

Tree/Hole ID: 34A  
Slab ID: 12

Ring Counts/Notes:

J2X Filename: RG 34A J2X.txt

Number of radii measured: 2

J2X Series Id: P16 34A 12A, RG 34A 12B
D.D. entered into J2X

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

J.R. - Buried after '02.

Wood Anatomy Change Notes:

Radii A+B - 1996 - 2002

01 + 02 similar, but 01 is yellow.
2000 - false rings + 3 collars
1999 - false rings opposite (injury)
07 - very narrow
97 - wide
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 3/14/99

Site ID: Río Grande Village  
Collection Date: Nov. 2006

Tree/Hole ID: 34A  
Slab ID: 13

Ring Counts/Notes:

J2X Filename: R G 34A J2x.txt

Number of radii measured: 2

J2X Series Id: R634A13A, R63413B

D.D. cut two rings in 3A

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  

J.K. - barked after 01

Wood Anatomy Change Notes:

Red A+B - 1996 - 2001

‘91 - small
2000 - thick ring & variable width
1999 - very renewal
‘98 - mild renewal
‘97 - wide

(cracked center)
Big Bend - Ring Reading Notes

Ring Reader: J. R.  
Reading Date: 3/3/67

Site ID: Rio Grande Village  
Collection Date: Nov. 20016

Tree/Hole ID: 34A  
Slab ID: 14

Ring Counts/Notes:

J2X Filename: RG 34AJ2X.EVT

Number of radii measured: 2

J2X Series Id: RG 34A/4A, RG 34A/14B

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion: 

Start Year:  
Stop Year:  
Proportion: 

Start Year:  
Stop Year:  
Proportion: 

J.R. - burial site 1987

Wood Anatomy Change Notes:

Radii A + B - 1996 - 2001

'98 - 2001 - compacted very narrow
2000 - Gills short
'97 - wide
'96 - center right
Big Bend - Ring Reading Notes

Ring Reader: J.K. Reading Date: 3/3/77

Site ID: Rio Grande Village Collection Date: Nov. 20016

Tree/Hole ID: 34A Slab ID: 15

Ring Counts/Notes:

J2X Filename: RG34A J2X.txt

Number of radii measured: 2

J2X Series Id: GCN4156, GCN4157

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 1

Start Year: Stop Year: Proportion: 2

Start Year: Stop Year: Proportion: 3

JR. - Burial #: 97, (98+99 compressed very much)

Wood Anatomy Change Notes:

Radii A & B - 1996 - 1997

Compressed after '97

'97 - wide

'96 - center w/ pitch
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 3/1/57

Site ID: Rio Grande Village  
Collection Date: Nov. 2005

Tree/Hole ID: 34A  
Slab ID: 18  
(Top + Bottom Sandies)

Ring Counts/Notes:

12X Filename: KG 34A J2 x t t t

Number of radii measured: 2

12X Series Id: KG 34A 12A  KG 34A 18  
D. interior with sAX

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

J.K. - Bumed after 77

Wood Anatomy Change Notes:

Top 1976 & 1977

Center is '96 w/1/7th
Big Bend – Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/3/97

Site ID: Rio Grande Village  
Collection Date: Nov. 2009

Tree/Hole ID: 34A  
Slab ID: 19

Ring Counts/Notes:

J2X Filename: RG.34A.32x.txt

Number of radii measured: 2

J2X Series Id: RG.34A.19A, RG.34A.19B

P.D. entered into J8C

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:

Start Year:  
Stop Year:  
Proportion:

Start Year:  
Stop Year:  
Proportion:

J.R. – Burial #4 77 n 76.

Wood Anatomy Change Notes:


‘97 – narrow
‘96 – wide
‘95 – new center w/ microscopic pith
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 3/3/87

Site ID: Rin Grande Village  
Collection Date: May, 2000

Tree/Hole ID: 34A  
Slab ID: 21  
(F/2)

Ring Counts/Notes:

12X Filename: RG 34A 2X .txt

Number of radii measured: 2

12X Series Id: RG 34A 21A P03080218

DD entered into 5ex

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

J.R., - broad after 95

Wood Anatomy Change Notes:


'95 - center of good pitch.
Big Bend—Ring Reading Notes

Ring Reader: J.R.  Reading Date: 3/13/07
Site ID: Rio Grande Village  Collection Date: Nov. 2007
Tree/Hole ID: 34A  Slab ID: 23  (6/1)

Ring Counts/Notes:

J2X Filename: RG34A32X.txt

Number of radii measured: 2

J2X Series Id: RG34A234  RG34A238

OD Entered into J2X

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:

J.R. - broad of in '96.

Wood Anatomy Change Notes:

Radial A + B - 1995 - '96.

'95 - center upright
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 3/13/67

Site ID: Rin Grande Village  
Collection Date: 5/24/66

Tree/Hole ID: 34A  
Slab ID: 25

Ring Counts/Notes:

J2X Filename: RG_34A_J2X_EXT

Number of radii measured: 2

J2X Series Id: RG34A25A RG34A25B

Proportion of circumference with secondary growth:

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J.R. - Exceed after 96.

Wood Anatomy Change Notes:

Radii A+B - 95-96

95-w/ good pith
Big Bend - Ring Reading Notes

Ring Reader: JLR
Reading Date: 2/13/85

Site ID: K10 Grande Village
Collection Date: Nov 2006

Tree/Hole ID: 34A
Slab ID: 26 (2 center)

Ring Counts/Notes:

J2X Filename: KG34AJ2X.7X7

Number of radii measured: 2

J2X Series Id: D934A8A4, D934A8008
DD around 5th sax.

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

JR - Buried after '96.

Wood Anatomy Change Notes:

Radii A & B - 1994 - '96

'96 - narrow
'95 - wider, younger center
'94 - small, new, older center w/pith

Date: 1994
Big Bend - Rio Grande Village

Tree 34A

(3 stems)

~35cm

~4cm

~4cm

~5cm

~6cm

~4.5cm

~5cm

~4 cm

~9.5 cm

~6.5 cm

RG-34A-0

RG-34A-1

RG-34A-2

RG-34A-3

RG-34A-4

RG-34A-5

RG-34A-6

RG-34A-7

RG-34A-8

RG-34A-9

RG-34A-10

RG-34A-11
Big Bend - Rio Grande Village

TREE 34A

7 cm
RG - 34A - 12 (Top Sanded)

4 cm
RG - 34A - 13 (Top Sanded)

6.5 cm
RG - 34A - 14 (Top Sanded)

6.5 cm
RG - 34A - 15 (Top Sanded)

15 cm
RG - 34A - 16

5.5 cm
RG - 34A - 17 (Top Sanded)

2.5 cm
RG - 34A - 18 (Top & Bottom Sanded)
RG - 34A - 18.1

3.4 cm
RG - 34A - 19 (Top Sanded)

7 - 9 cm
RG - 34A - 20

5 cm
RG - 34A - 21 (Top Sanded)
Neck = F/6

10 cm
RG - 34A - 22
Big Bend - Rio Grande Village
TREE 34A

~5.5 cm ~5.5 cm ~3 cm ~6 cm

RG-34A-23 RG-34A-24 RG-34A-25 RG-34A-26

(Top: Rounded) width = 6/8
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/18/07  
Collection Date: Jan. 2007

Site ID: Rio Grande Village  
Tree/Hole ID: 34B  
Slab ID: GS

Ring Counts/Notes:

J2X Filename: RG34B.J2X.txt

Number of radii measured: 2

J2X Series Id: RG-34B-GSA, RG-34B-GSB

J.R. - Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

Radius A+B - 1997 - 2006

06 - wide
04 + 05 - narrow
03 - narrow 02 - wide - wide w/false rings
02 - wide w/false ring
01 - wide
2000 - wide w/false ring

Stem Elongated

Ground surface questionable since cut in 1995(1580)
Big Bend - Ring Reading Notes

Ring Reader: J.R.  Reading Date: 5/18/07

Site ID: Rio Grande Village

Tree/Hole ID: 34B

Collection Date: Jan. 2007

Slab ID: 1 (2 centers)

Ring Counts/Notes:

J2X Filename: RG34B J2X.TXT

Number of radii measured: 2

J2X Series Id: RG34B1A, RG34B1B

J.R. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

Radii A + B - 1997 - 2006

Radii A

03-06 - narrow
02 - wider
01 - wide
97 - 2000 - wide w/ false rings
97 - center w/ good pith O

Radii B

04-06 - wide
02 - very wide
02 - wide w/ false ring
01 - narrower w/ false ring
97-2000 - wide w/ false rings
97 - center w/ good pith O

O
Big Bend - Ring Reading Notes

Ring Reader: J.R.                Reading Date: 5/18/07
Site ID: Rio Grande Village
Tree/Hole ID: 34B
Collection Date: Jan. 2007
Slab ID: 3

Ring Counts/Notes:
J2X Filename: RG34B3J2X.txt
Number of radii measured: 2
J2X Series Id: RG34B3A, RG34B3B

J.R. - Replaced radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year:                Stop Year:                Proportion:
Start Year:
Start Year:
Start Year:
J.R. - Burned after 04.
Make - burned after 94.
Wood Anatomy Change Notes:
Radii A + B - 1997 - 06
97 - 03 - all wide
97 - callus w/ thorns
02 - split ring
2000 - cracked, injury
97 - 99 - split rings
Big Bend – Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/18/07

Site ID: Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 34B  
Slab ID: 6  
(Bottom Sanded)(c/d)

Ring Counts/Notes:

J2X Filename: RG34B J2X.txt

Number of radii measured: 2

J2X Series Id: RG 34B6 A, RG 34B6 B

J.R. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

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J.R. - Buried after 03.

M.S. - Buried after 03 either.

Wood Anatomy Change Notes:


97-03 – wide

01 & 02 – darker wood

1996 – crack, injury

78-99 – false ring 8 or ring 9?  Other injury in 98

96 - Small new section within 2
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 5/18/07

Site ID: Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 34B  
Slab ID: 8

Ring Counts/Notes:

J2X Filename: RG34B32X.txt

Number of radii measured: 2

J2X Series Id: RG34B3A  RG34B3B

J.K. - Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

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M.S. - Buried after 03 partial in 03 also

Wood Anatomy Change Notes:

Radius A - 1996 - 2002  
Radius B - 1996 - 2003

on 'B', 02 +03 - similar
01 - large, darker wood, wide false ring
98 - 2000 - bits of false rings
2000 - injury
1996 - center, small width
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 5/18/07  

Site ID: Rio Grande Village  
Collection Date:  

Tree/Hole ID: 34B  
Slab ID: 9  
(Top + Bottom Sanded)

Ring Counts/Notes:

J2X Filename: RG348J2X_04.01  
Number of radii measured: 2  

J2X Series Id: RG3489A, RG3489B

J.R. - Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion: 

J.R. - Burial after 2002, 
M.S. - Burial after '02.

Wood Anatomy Change Notes:

Top Radii: A + B - 1996-2002

2001 - wide, dark wood
97 - 2000 - wide, false ring bits
96 - center width Ø
Big Bend – Ring Reading Notes

Ring Reader:  J.R.  
Site ID:  Rio Grande Village  
Tree/Hole ID:  34B  
Reading Date:  5/13/07  
Collection Date:  Jan. 2007  
Slab ID:  11  

Ring Counts/Notes:

J2X Filerame:  RG 34B J2X.txt  
Number of radii measured:  2  
J2X Series Id:  RG 34B 11A, RG 34B 11B  

J.R. - Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  

J.R. - Buried after 02, possibly earlier also.
M.S. - Buried after 02 + period by 03 after 2000.
Wood Anatomy Change Notes:

Radii A+B - 1996 - 2002

'01 & '02 - similar
2000 - false ring
'96-'97 - wide
'97-'98 - false rings
'96 - center w/small pitch
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/19/07

Site ID: Rio Grande Village

Collection Date: Jan, 2007

Tree/Hole ID: 34B  
Slab ID: 13

Ring Counts/Notes:

J2X Filename: RG34B_J2X.txt

Number of radii measured: 2

J2X Series Id: RG34B13A, RG34B13B

J.R. - Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:


2000 - narrower
99 - narrower
98 - wide w/false rings
97 - wider false rings in late wood.
96 - center, wide false rings & pit.
Big Bend – Ring Reading Notes

Ring Reader: J.R.  Reading Date: 5/18/07
Site ID: Rio Grande Village  Collection Date: 5/18/07
Tree/Hole ID: 34 B  Slab ID: 14

Ring Counts/Notes:

J2X Filename: RG34B14A.txt
Number of radii measured: 2
J2X Series Id: RG34B14A, RG34B14B

J.R. – Recorded radii A & B into J2X.

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:

M.S. – Boreal after 2000 & partial in 1999

Wood Anatomy Change Notes:


1999 – narrow
’98 – wide with false ring
’97 – wide with false ring
’96 – wide, little width
Ring Reader: J.R.  
Reading Date: 5/18/07  
Site ID: Rio Grande Village  
Collection Date: Jan. 2007  
Tree/Hole ID: 34B  
Slab ID: 15 (Top sanded)

Ring Counts/Notes:

J2X Filename: RG34B J2X .txt
Number of radii measured: 2

J2X Series Id: RG34B15A, RG34B15B

J.R. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

Start Year:    Stop Year:    Proportion:    
Start Year:    Stop Year:    Proportion:    
Start Year:    Stop Year:    Proportion:    

J.R. - broad after '99,
M.S. - broad after partially '97 + strong after '99.

Wood Anatomy Change Notes:

Radii A + B - 1996 - 1999

'99 - narrow
'98 - wide w/ bit of false ring
'97 - wide w/ false ring
'96 - wide center w/ small pith & false ring.
Big Bend - Ring Reading Notes

Ring Reader: J.K.                                      Reading Date: 5/18/07

Site ID: Rio Grande Village                        Collection Date: Jan. 2007

Tree/Hole ID: 34B                                      Slab ID: 16

Ring Counts/Notes:

J2X Filename: RG 34B J2X.txt

Number of radii measured: 2

J2X Series Id: RG 34B16A, RG 34B16B

J.K. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

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J.K. - Warren after '77 or '78,
M. S. - but'd after '77

Wood Anatomy Change Notes:

Top Radii A + B - 1994 - 1998

'98 - wide w/ bit & false ring
'97 - false ring
'96 - false ring
'95 - small w/ tiny lines
'94 - new center w/ small pith
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 5/18/07

Site ID: Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 34B  
Slab ID: 18 (F/G)

Ring Counts/Notes:

J2X File Name: RG34B32X.txt

Number of radii measured: 2

J2X Series Id: RG34B18A, RG34B18B

J.R. - Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

J.R.-Busted after '96.
M.S.-Busted after

Wood Anatomy Change Notes:

Radii A+B < 1994-1996
'94 - Winter w/ frost
'95 - Tiny false rings
'96 - False ring
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/17/07

Site ID: Río Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 34B  
Slab ID: 20  
(Top & Bottom Sanded)

Ring Counts/Notes:

J2X Filename: RG34B20A.txt  
Number of radii measured: 2

J2X Series Id: RG34B20A, RG34B20B

J.R. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:

Start Year:  
Stop Year:  
Proportion:

Start Year:  
Stop Year:  
Proportion:

J.R. - Buck after '96
M.S. - Basal after '96

Wood Anatomy Change Notes:

'96 - false rings
'95 - tiny false rings
'94 - center widening w/pith Ø
Big Bend - Ring Reading Notes

Ring Reader: J.R.  Reading Date: 5/18/07

Site ID: Ro Granite Village  Collection Date: Jan. 2007

Tree/Hole ID: 34B  Slab ID: 23

Ring Counts/Notes:

12X Filename: RG34B12x.txt

Number of radii measured: 2

12X Series Id: RG34B23A, RG34B23B

J.R. - Recorded radii A+B into 12X.

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

Buried in '96

Wood Anatomy Change Notes:

Radii A+B - 1994-95.

'95 - false ring
'94 - center still has pith, but some not present.
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 

Site ID: Rio Grande Village  
Collection Date: Jan. 2007  

Tree/Hole ID: 34B  
Slab ID: 24

Ring Counts/Notes:

J2X Filename: 
Number of radii measured: 
J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

'94 + '95 present + still stem wood.  
Center rotted, so pith unseen. 

'94 - may be established.  
May still be a year or 2 extending into clay, but stem too rotted to call for sure.
BIG BEND - RIO GRANDE VILLAGE

TREE 34B

TR.
3/8th
PP. 1 of 4

9 cm
RG-34B-0 (Top Sanded)

5 cm
RG-34B-00 (Top Sanded)

RG-34B-05

6.5-6cm
RG-34B-1 (Top Sanded)

34.5 cm
RG-34B-2

RG-34B-3 (Top Sanded)

RG-34B-4

14 cm
RG-34B-5

9 cm
RG-34B-5

cont. →
BIG BEND - RIO GRANDE VILLAGE

TREE 34B

-7.5 cm  RG-34B-6  (Bottom Sanded)
-4.0 cm  RG-34B-7
9.5 cm  RG-34B-8  (Top Sanded)
6.5 cm  RG-34B-9  (Top & Bottom Sanded)
-2.0 cm  RG-34B-10
4.0 cm  RG-34B-11  (Top Sanded)
6.0 cm  RG-34B-12  (Top Sanded)
10.0 cm  RG-34B-13  (Top Sanded)

cont. →
BIGBEND - Rio Grande Village
The 34B

190

<table>
<thead>
<tr>
<th>Length (cm)</th>
<th>Code</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>6</td>
<td>RG-34B-14</td>
<td>(Top Sanded)</td>
</tr>
<tr>
<td>5.5</td>
<td>RG-34B-15</td>
<td>(Top Sanded)</td>
</tr>
<tr>
<td>7.5</td>
<td>RG-34B-16</td>
<td>(Top &amp; Bottom Sanded)</td>
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<tr>
<td>11.5</td>
<td>RG-34B-17</td>
<td></td>
</tr>
<tr>
<td>~9</td>
<td>RG-34B-18</td>
<td>(Top Sanded) k = 0.01 F/6</td>
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<tr>
<td>~11</td>
<td>RG-34B-19</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RG-34B-20</td>
<td>(Top Sanded)</td>
</tr>
<tr>
<td>~16</td>
<td>RG-34B-21</td>
<td></td>
</tr>
<tr>
<td>~5</td>
<td>RG-34B-22</td>
<td>(Top Sanded) (Same rot)</td>
</tr>
</tbody>
</table>

cont. →
Big Bend - Rio Grande Village

Tree 348

RG-348-23 (Top Seeded)
Some...tut

RG-348-24 (Top Seeded)
Tutted
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/9/07

Site ID: Rio Grande Village  
Collection Date: Jan., 2007

Tree/Hole ID: 35  
Slab ID: G5

Ring Counts/Notes:

12X Filename: RG35J2X.txt

Number of radii measured: 2

12X Series Id: RG35GSA, RG35GSB

JK-Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Wood Anatomy Change Notes:

Radii A+B > 2000-2006

2006 - wide
2004 - wide w/false ring
02-03 - wide, similar
2001 - wide w/false rings
2000 - center w/good pitch
Big Bend – Ring Reading Notes

Ring Reader: J.R.                                      Reading Date: 5/9/07
Site ID: Rio Grande Village                          Collection Date:
Tree/Hole ID: 35                                    Slab ID: 2

Ring Counts/Notes:
J2X Filename: RG35J2X.jkt
Number of radii measured: 2
J2X Series Id: RG252A, RG352B
J.R. – Rounded radii A+B into J2X.

Proportion of circumference with secondary growth:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

M.S. – Evidence of slight burial after ’04.

Wood Anatomy Change Notes:
Radii A+B ≥ 2000 – 2006
2006 – wide
2004 –jumbotron w/else rings
02+03 – very similar
01 – wider w/else rings
2000 – smaller w/wood pitch
Big Bend - Ring Reading Notes

Ring Reader: J.R. 
Reading Date: 5/9/07

Site ID: Rio Grande Village
Collection Date: Jan. 2007

Tree/Hole ID: 35
Slab ID: 3

Ring Counts/Notes:

J2X Filename: RG35 J2X.txt

Number of radii measured: 2

J2X Series Id: RG35A, RG35B

J.R. - entered under A+B into J2X.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

45. - slight burl in A+B.

Wood Anatomy Change Notes:

Radii: A+B - 2000 - 2006
56 - wide
54 - wide w/ false rings
52 + 03 - similar
51 - false rings
2000 - center w/ good pitch
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 5/9/07
Site ID: Rio Grande Village  
Collection Date: Jan. 2007
Tree/Hole ID: 35  
Slab ID: S

Ring Counts/Notes:

J2X Filename: RG35J2X.txt
Number of radii measured: 2
J2X Series Id: RG355A, RG355B

J.R. - Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

M.S. - Burial offer '04 & partial w/in '04,

Wood Anatomy Change Notes:

Radii A+B - 2000-2006

'06 - wide, but narrowing
'05 - narrower
'04 - wide
'02 & '03 - similar, '03 false ring
'01 - wide w/false ring
2000 - center w/pith 0
Big Bend - Ring Reading Notes

Ring Reader: John
Reading Date: 5/7/07

Site ID: Rio Grande Village
Collection Date: Jan. 2007

Tree/Hole ID: 35
Slab ID: 7
(3 centers)
(new center is older)

Ring Counts/Notes:

12X Filerame: R G 35 J 2X .EXT

Number of radii measured: 2

12X Series Id: Don't J2X

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

J B - Burned after 04
M S - Burnt after 03

Wood Anatomy Change Notes:

Radiata A - 1996 - 2000
Radiata B - 1996 - 2003

Wood damage
Big Bend – Ring Reading Notes

Ring Reader: J.R.  Reading Date: 5/9/07

Site ID: K:0 Grande Village

Collection Date: Jan. 2007

Tree/Hole ID: 35

Slab ID: 8

Ring Counts/Notes:

J2X Filename: RG35J2X.txt

Number of radii measured: 2

J2X Series Id: RG35PA, RG35PB

J.R. recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

J.R. Binned after 03.
M.S. Binned after 03

Wood Anatomy Change Notes:
Radii A+B - 1996 – 2004
### Big Bend - Ring Reading Notes

**Ring Reader:** J.R.  
**Reading Date:** 5/9/07

**Site ID:** Rio Gravelle Village  
**Collection Date:** Jan. 2007

**Tree/Hole ID:** 35  
**Slab ID:** 9

**Ring Counts/Notes:**

- **J2X Filename:** RE35J2X.txt
- **Number of radii measured:** 2
- **J2X Series Id:** RE359A, RE359B

J.R. - measured radii A+B into J2X.

### Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

J.R. - Based on J2X.

M.S. - Burial

### Wood Anatomy Change Notes:

<table>
<thead>
<tr>
<th>Radix A</th>
<th>1996 - 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>White, wide</td>
</tr>
<tr>
<td>1997</td>
<td>First ring</td>
</tr>
<tr>
<td>1998</td>
<td>White, wide</td>
</tr>
<tr>
<td>2002</td>
<td>Second ring</td>
</tr>
<tr>
<td>1999</td>
<td>Narrow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radix B</th>
<th>1996 - 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>Wide center with late growth</td>
</tr>
<tr>
<td>1997</td>
<td>White</td>
</tr>
<tr>
<td>1996</td>
<td>White</td>
</tr>
<tr>
<td>1995</td>
<td>Narrow</td>
</tr>
</tbody>
</table>
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/9/07

Site ID:  Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 35  
Slab ID: 10

Ring Counts/Notes:

J2X Filename:  RG35J2X.txt

Number of radii measured: 2

J2X Series Id:  RG3510A,  RG3510B

J.R. - recorded radii: A+B into J2X.

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  Proportion:  
Start Year:  
Stop Year:  Proportion:  
Start Year:  
Stop Year:  Proportion:

M.S. - Bailed after 2002, partially in 02.

Wood Anatomy Change Notes:

Radii A + B = 1996-2003

03 - wide  97 - wide
02 - thin ring  96 - wide center of small, dark pith
01 - wide white ring - 2 toned  00 - with white ring
99 - narrow 98 - same narrow white ring width
Big Bend – Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/9/07

Site ID: Rio Grande Village
Collection Date: Jan. 2007

Tree/Hole ID: 35  
Slab ID: 12

Ring Counts/Notes:

J2X Filename:  
RG35J2X.EXT

Number of radii measured: 2

J2X Series Id: RG3512A, RG3512B

J.R. – Rendered radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

Radii A+B – 1996 - 2003

Annual width increases after 2000, with few narrow growth rings. 
Center wider in growth ring.
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/14/07
Site ID: Rio Grande Village
Collection Date: Jan. 2007
Tree/Hole ID: 35
Slab ID: 13

Ring Counts/Notes:
12X Filename: RG35J2X.txt
Number of radii measured: 2
12X Series Id: RG3513A, RG3513B

JK - Reconstructed radii A+B into J2X.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

MS - Basal after 2000.

Wood Anatomy Change Notes:
Radii A+B - 1995 - 2000
2000 - Narrowing
99 - 98 - Rady. Increase
97 & 98 - Injury
96 - Centre W/damaged & H.
Big Bend - Ring Reading Notes

Ring Reader: J.K.  
Reading Date: 5/14/07

Site ID: Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 35  
Slab ID: 14

Ring Counts/Notes:

12X Filename: RG35J2X.txt

Number of radii measured: 2

12X Series Id: RG3514A, RG3514B

JR: Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:

Start Year:  
Stop Year:  
Proportion:

Start Year:  
Stop Year:  
Proportion:

JR, burial after 2000.

MG, burial after 2000.

Wood Anatomy Change Notes:

Radii: A+B - 1996-2000

99+2000 - narrow
98 + very narrow
97 = wide
96 = wide center with

Big Bend – Ring Reading Notes

Ring Reader: J.K.  

Reading Date: 5/14/07  

Site ID: Rio Grande Village  

Collection Date: Jan. 2007  

Tree/Hole ID: 35  

Slab ID: 15  

(F3/F)

Ring Counts/Notes:

J2X Filename: RG3515A_LTX4  

Number of radii measured: 2  

J2X Series Id: RG3515A, RG3515B  

J.K. - Readied radii A+B into J2X.

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:  

Start Year: Stop Year: Proportion:  

Start Year: Stop Year: Proportion:  

J.R. - buried after '93  
M.S. - buried after '98  

Wood Anatomy Change Notes:

Radii A+B - 1996-98  

'98 - extreme narrow  
'97 - narrowing  
'96 - wide center w/ good pith & false ring
Big Bend – Ring Reading Notes

Ring Reader: J.R.                                      Reading Date: 5/14/07
Site ID: Rio Grande Village                           Collection Date: Jan. 2007
Tree/Hole ID: 35                                      Slab ID: 17 (F/6)

Ring Counts/Notes:

J2X Filename: KG35J2X.txt
Number of radii measured: 2
J2X Series Id: KG3517A, KG3517B

J.R. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

Start Year:                                            Stop Year:                                                     Proportion:

Start Year:                                            Stop Year:                                                     Proportion:

Start Year:                                            Stop Year:                                                     Proportion:

J.R. - Buried after '77.
MS1 - buried after '77 partially in '87
Wood Anatomy Change Notes:

Radii A + B - 1996-1997

'96 - center w/pitch, wide
'97 - narrow
Big Bend – Ring Reading Notes

Ring Reader: J.R. Reading Date: 5/4/07

Site ID: Río Grande Village Collection Date: Jan. 2007

Tree/Hole ID: 35 Slab ID: 19

Ring Counts/Notes:

J2X Filerame: K635J2X.txt

Number of radii measured: 2

J2X Series Id: K63519A, K63519B

J.R. – Recorded radii A+B into J2X.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

J.R. – burial after ’76.
M.S. – burial after ’76
Wood Anatomy Change Notes:

Radii A + B - 1996 – ’97

’96 – center w/ good pith & false ring.
’97 – renew.
Big Bend - Ring Reading Notes

Ring Reader: J.P.  
Reading Date: 5/4/07

Site ID: Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 35  
Slab ID: 21

Ring Counts/Notes:

J2X Filename: RG35J2X.TXT
Number of radii measured: 2
J2X Series Id: RG3521A, RG3521B

J2X: Revised radii A+B into J2X.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

J1k. buried after 96.
M.S. - buried after 96
Wood Anatomy Change Notes:

Radii A+B - 1996

'96 - wide center w/pith (obliterated)
'97 - narrows means
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/14/07

Site ID: Ro. Claude Village
Collection Date: Jan. 2007

Tree/Hole ID: 35  
Slab ID: 23

Ring Counts/Notes:

J2X Filename: KG35J2X.Im
Number of radii measured: 2
J2X Series Id: KG35J23A, KG35J23B

J.R. - Recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

Start Year:  
Stop Year: 
Proportion: 

Start Year:  
Stop Year: 
Proportion: 

Start Year:  
Stop Year: 
Proportion: 

J.R. - Burned after '96.
Misc. Burned after '96

Wood Anatomy Change Notes:

Radius A - 1996 - '97
'97 - wide, dark again.
'96 - wide center, good pitch + false ring.

Radius B - 1996
'96 - wide center w/pitch
Big Bend – Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/14/07

Site ID: Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 35  
Slab ID: 24

(Bottom Sanded)

Ring Counts/Notes:

12X Filename: RG35J2X.txt

Number of radii measured: 2

12X Series Id: RG35J24A, RG35J24B

J.R. - recorded radii A + B into J2X.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
</tbody>
</table>

Wood Anatomy Change Notes:

Radix A+B - 1996

'96 - large center with pitch @
Big Bend - Ring Reading Notes

Ring Reader: J.R.  Reading Date: 5/14/07

Site ID: Rio Grande Village  Collection Date: Jan. 2007

Tree/Hole ID: 35  Slab ID: 25

(Top & Bottom Samples)

Ring Counts/Notes:

J2X Filename: R35J2X.4x4

Number of radii measured:

J2X Series Id:

PROPORTION OF CIRCUMFERENCE WITH SECONDARY GROWTH:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

Start Year:  Stop Year:  Proportion:

Wood Anatomy Change Notes:

Top - pitch present

Bottom - appears to be all root:

E. 1996, - 1996
Big Bend - Ring Reading Notes

Ring Reader: J.R.  
Reading Date: 5/14/07

Site ID: Rio Grande Village  
Collection Date: Jan. 2007

Tree/Hole ID: 35  
Slab ID: 26  
(Bottom sanded)

Ring Counts/Notes:

12X Filename: 
Number of radii measured:

12X Series Id: 

No 12X

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:  
Start Year: Stop Year: Proportion:  
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

Estop. 1996 - between Top & Bottom of this piece.

All Root
<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Sample Code</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>RG-35-1</td>
<td>(Top Sanded) E = null</td>
</tr>
<tr>
<td>7.0</td>
<td>RG-35-3</td>
<td>(Top Sanded) E = null, c/d</td>
</tr>
<tr>
<td>11.5</td>
<td>RG-35-4</td>
<td></td>
</tr>
<tr>
<td>12.8</td>
<td>RG-35-5</td>
<td>(Top Sanded) E = null, c/d</td>
</tr>
<tr>
<td>13.5</td>
<td>RG-35-6</td>
<td>(2 stems)</td>
</tr>
<tr>
<td>13.7</td>
<td>RG-35-7</td>
<td>(Top Sanded)</td>
</tr>
<tr>
<td>13.8</td>
<td>RG-35-8</td>
<td>cont. (up)</td>
</tr>
</tbody>
</table>
Big Bend - Rio Grande Village

Tree 35

65-70 cm

RG-35-9

(Top Sanded)

\[ \square = \text{rind D/F3} \]

7.5 cm

RG-35-10

(Top Sanded)

\[ \Phi = \text{rind D/F} \]

8.5 cm

RG-35-11

6 cm

RG-35-12

(Top Sanded)

7 cm

RG-35-13

(Top Sanded)

6.5 cm

RG-35-14

(Top Sanded)

~6.5 cm

RG-35-15

\[ \square = \text{rind F2/F} \]

19 cm

RG-35-16

6.5 cm

RG-35-17

(Top Sanded)

\[ \square = \text{rind F/F} \]

cont. →
Big Bend - Rio Grande Village

**TREE 35**

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Sample Code</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>RG-35-18</td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td>RG-35-19</td>
<td>(Top Sanded)</td>
</tr>
<tr>
<td>13</td>
<td>RG-35-20</td>
<td></td>
</tr>
<tr>
<td>~6</td>
<td>RG-35-21</td>
<td>(Top Sanded)</td>
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<tr>
<td>~8</td>
<td>RG-35-22</td>
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<tr>
<td>~11</td>
<td>RG-35-23</td>
<td>(Top Sanded)</td>
</tr>
<tr>
<td>~13</td>
<td>RG-35-24</td>
<td>(Bottom Sanded)</td>
</tr>
<tr>
<td>~12</td>
<td>RG-35-25</td>
<td>(Top &amp; Bottom Sanded)</td>
</tr>
<tr>
<td>~9</td>
<td>RG-35-26</td>
<td>(Bottom Sanded) - root</td>
</tr>
</tbody>
</table>
Big Bend - Ring Reading Notes

Ring Reader: J. Keel
Reading Date: Nov.

Site ID: Costolone
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: GS

Ring Counts/Notes:

J2X Filename: csl15J2x.txt

Number of radii measured: 2

J2X Series Id: csl15GSA, csl15GSB

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1998 - 2007)

2007 - med.
'06 - low growth
'05 - med. slight ring in 3/4 nut.
'04 - med. slight ring in 3/4 nut.
'03 - med., prominent false ring in 3/4 way.
'02 - med., w/true false rings in late yrs.
'01 - med., w/thicker ring in late yrs.
2000 - med. half false rings.
'99 - wide
'98 - center clearer than usual pitch.
### Big Bend - Ring Reading Notes

**Ring Reader:** L Roth  
**Reading Date:** 

**Site ID:** Castolon  
**Collection Date:** Feb 2008  

**Tree/Hole ID:** 15  
**Slab ID:** 3  

#### Ring Counts/Notes:

**J2X Filename:** CS15 J2X.txt  

Number of radii measured: 2  

**J2X Series Id:** CS153A, CS153B

#### Proportion of circumference with secondary growth:

<table>
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<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</tbody>
</table>

#### Wood Anatomy Change Notes: (1997 - 2007)

- 2007 - wide
- 06 - mid, wide tree ring 3/4 out
- 05 - wide, wide tree ring 3/4 out
- 04 - wide, wide tree ring 3/4 out
- 03 - mid, wide tree ring 3/4 way
- 02 - wide, wide tree ring 3/4 way
- 01 - mid, wide tree ring in late yrs.

- 2000 - narrower
- 99 - wide
- 98 - wide
- 97 - new center, small, cracked within fifth
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 4 (5/6 E 4)

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS154A, CS154B

Proportion of circumference with secondary growth:

<table>
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<tr>
<th>Start Year:</th>
<th>Stop Year:</th>
<th>Proportion:</th>
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</table>

Wood Anatomy Change Notes: (1997 - 2007)

2007 - wide
2006 - med, w/late ring n/3 out,
2.5 - wide, w/late ring n/3 out,
3/4 - wide w/late ring n/3 out,
2 - med, w/late ring in late yrs,
2 1/2 - med, w/late ring in late yrs,
2000 - narrow,
'99 - wide

'98 - wide
97 - center, small, cracked w/ting path.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 5

Ring Counts/Notes:

J2X Filename: CS1552X.txt

Number of radii measured: 2

J2X Series Id: CS155A, CS155B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1997 - 2007)
- 2007 - wide, slightly dotted.
- 96 - med. w/ false ring & straight
- 95 - wide w/ false ring & straight
- 94 - wide w/ false ring & straight
- 93 - wide w/ prominent false ring & straight.
- 02 - wide w/ false ring in late yr.
- 01 - med. w/ false ring in late yr.
- 99 - wide
- 98 - med.
- 97 - center; crooked w/ pitch.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  
Reading Date: 

Site ID: Castolon  
Collection Date: Feb. 2008

Tree/Hole ID: 15  
Slab ID: 6 (E^4)  

Ring Counts/Notes:

J2X Filename: cs15j2x.txt

Number of radii measured: 2

J2X Series Id: CS156A, CS156B

Proportion of circumference with secondary growth:

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<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</table>

Wood Anatomy Change Notes: (1997 - 2007)

2007 - White, hardwood  
96 - White, softwood ring 1/4 in. thick, hardwood  
95 - White, softwood ring 1/8 in. thick, hardwood  
94 - White - White, softwood ring 1/8 in. thick,  
93 - White, no prominent softwood ring 1/8 in. thick,  
92 - White, softwood ring in late yrs.  
91 - White, no prominent softwood ring 1/8 in. thick,  
2000 - White - White  
99 - White  

97 - Center, crack, tiny pits.
Big Bend – Ring Reading Notes

Ring Reader: J. Roth

Site ID: Castolon

Tree/Hole ID: 15

Reading Date:

Collection Date: Feb. 2008

Slab ID: 8 \( \frac{E3}{E2} \)

Ring Counts/Notes:

J2X Filename: c515J2X.CYT

Number of radii measured: 2

J2X Series Id: c5158A, c5158B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1997-2007)

2005-07 - Removing - Burn

04 - Wide w/false ring ~3/4 out.

03 - Wide w/not enough false ring to count.

02 - Wide w/false ring late in yr.

01 - Med. w/false ring in late yr.

2000 - mid.

99 - Wide

98 - Wide

97 - Center, cracked w/bry pith.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: Castolon

Collection Date: Feb 2008

Tree/Hole ID: 15

Slab ID: 9 (E9) 

<table>
<thead>
<tr>
<th>Ring Counts/Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>J2X Filename: CS159J2X.txt</td>
</tr>
<tr>
<td>Number of radii measured: 2</td>
</tr>
<tr>
<td>J2X Series Id: CS159A, CS159B</td>
</tr>
</tbody>
</table>

| Proportion of circumference with secondary growth: |
| Start Year: | Stop Year: | Proportion: |
| Start Year: | Stop Year: | Proportion: |
| Start Year: | Stop Year: | Proportion: |

Wood Anatomy Change Notes: (1997 - 2004)

- 1997 - Wood thinning in mid 97-98.
- 1998 - Wide
- 1999 - Very wide
- 2000 - mid.
- 2001 - med, w/late ring in late yrs.
- 2002 - Wide, w/late ring in late yrs.
- 2003 - Wide w/prominent false ring/knot.
- 2004 - Wide w/late ring in late yrs.
- 2005 - Wide
- 2006 - wide
- 2007 - Center cracked w/paths.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castalon
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 10

Ring Counts/Notes:

J2X Filename: CS/5 J2X.txt

Number of radii measured: 2

J2X Series Id: CS1510A, CS1510B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1997 - 2004)

2004 - med, slight rust spot, false ring late.
2003 - wide, prominent false ring, n/Kant, damage on Radius E
2002 - wide
2001 - narrow, 1 false ring in late 89
2000 - med.
99 - med/wide
98 - med/wide
97 - center, broad ring w/ small pith
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date:

Site ID: Castalon

Collection Date: Feb. 2008

Tree/Hole ID: 15

Slab ID: 11 (E)

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS1511A, CS1511B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1997 - 2004)

2004: med. flourish - foliar-ring late spring
'03: wide, major false ring ~ Y out
'02: wide
'01: narrower W false ring in late yrs.
2000: med.
'99: med./wide
'98: wide, brown
'97: center lot of false ring w/pitch,
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: __________

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 15

Slab ID: 14 (c3 / c2)

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS1514A, CS1514B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year:</th>
<th>Stop Year:</th>
<th>Proportion:</th>
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</table>


Broad after 2003.

2003 - mid, partial bundle
2002 - narrow on B, wide on A
First false ring in late 92.
91 - wide, subtle ring in late yr, slight band sign.
90 - wide
99 - wide, very
98 - wide
97 - center, cracked, w/pith
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date:

Site ID: C0st/0lch
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 15 (9)

Ring Counts/Notes:

J2X Filename: CS15J2X.CXT

Number of radii measured: 2

J2X Series Id: CS1515A, CS1515B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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2003 - narrower on B
+ '01 - some burial in '02
01 - wide, false ring 3/4 out
slight burial
2000 - slight false ring, mid/late
99 - very wide, lot of false ring
98 - very wide
97 - center wide, bit of false ring
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: CasTolon

Collection Date: Feb. 2008

Tree/Hole ID: 15

Slab ID: 18

(multi centered)

Bottom switches to another stem
(shown on drawing of CS/15/17)

Ring Counts/Notes:

J2X Filename: CS/15J2X.txt

Number of radii measured: 2

J2X Series Id: CS/15/18A, CS/15/18B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Wood Anatomy Change Notes: (1997 - 2001)

2001 - Broad undegn B. false ring 24m x t.
2000 - wide - broad
1999 - wide, slight broad
1998 - very wide
1997 - growing center w/ false ring 4 1/4th.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date:

Site ID: Casteloh

Collection Date: Feb. 2008

Tree/Hole ID: 15

Slab ID: 19 (C4)

Another side stem on

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS1519A, CS1519B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

Radius A - 1997-2000

1997-98 = wide, all visible earlywood ring.
98-99 = wide, wide, narrow, partial false ring.
99-2000 = wide, narrow, partial false ring.

Radius B - 1994-2000

1994-1997 = wide, all visible earlywood ring.
97-98 = wide, narrow, partial false ring.
98-1999 = narrow, narrow, partial false ring.

New Year's

99-1999 = cracked, wide, diffuse false ring.
98-99 = cracked, narrow, diffuse false ring.
97-98 = wide, narrow, diffuse false ring.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castldon
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 20 (CS1520B)

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS1520A, CS1520B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Wood Anatomy Change Notes:  

1996 - Check runs through 1996 and later.
1997 - Partially filled ring on A
1998 - Wide
1999 - Partially filled ring on A, very narrow on B.
1996 - Narrow filled on A, bit of rot.
1995 - Narrow filled, check runs, filled ring one way.
1994 - Medium, cracked filled, center width.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  
Reading Date: 

Site ID: Castolon  
Collection Date: Feb. 2008  

Tree/Hole ID: 15  
Slab ID: 21 

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS1521A, CS1521B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</table>


1999 - Burned, wide
98 - Very wide
97 - Narrow bit of false ring, flake wide
96 - Narrow, bit of false ring
95 - Med/wide of false ring, slant way
94 - Center, contact with pith.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  
Reading Date: 

Site ID: Castolon  
Collection Date: Feb. 2008  

Tree/Hole ID: 15  
Slab ID: 23 (c x c)

Ring Counts/Notes:

J2X Filename: CS15J2X.txt  
Number of radii measured: 2

J2X Series Id: CS1523A, CS1523B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</tbody>
</table>

Wood Anatomy Change Notes: (1994 - 1998)

- 97 - narrowed med. within range in late 80's
- '96 - narrow w/d of false rings
- '95 - med. abundance false rings very tight
- '94 - center, cracked width
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date:

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 25

Ring Counts/Notes:

J2X Filename: CS1525A.6x6

Number of radii measured: 2

J2X Series Id: CS1525A, CS1525B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1994 - 1997)

Burned after 1996.

1997 - narrow, burned.
96 - broadest set of late rings.
95 - mid, were incised.
94 - center, cracked. edge.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Site ID: Castolon

Tree/Hole ID: 15

Reading Date: 

Collection Date: Feb. 2008

Slab ID: 26 (C1/8)

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS1526A, CS1526B

Proportion of circumference with secondary growth:

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<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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Wood Anatomy Change Notes: (1994-1996)

- Buried after 1996.
- 95: root, w/ false ring, nearest.
- 94: center, small crack up/pith.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 15

Slab ID: 28 \( \frac{\text{b4}}{\text{b5}} \)

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS15-28A, CS15-28B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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Wood Anatomy Change Notes: \( 1994-1996 \)

1996 - mid. (972 new rings)
1995 - mid. whole ring visible, 974 center cracked with pith.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 29

Ring Counts/Notes:

J2X Filename: 0515J2X.txt

Number of radii measured: 2

J2X Series Id: 051529A, 051529B

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:


Buried after 1995.

1996 - compressed w/ burial signs, narrow A', med. on B.
95 - compressed w/ slight bulge.
94 - cracked, med.
93 - New center, cracked w/ pitch, red/brown
Big Bend - Ring Reading Notes

Ring Reader: J. Roth                       Reading Date: 

Site ID: Castolon                        Collection Date: Feb. 2008

Tree/Hole ID: 15                         Slab ID: 30

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS15.30A, CS15.30B

Proportion of circumference with secondary growth:

Start Year: _______                      Stop Year: _______                     Proportion: _______

Start Year: _______                      Stop Year: _______                     Proportion: _______

Start Year: _______                      Stop Year: _______                     Proportion: _______

Wood Anatomy Change Notes: (1993-1996)

Burned after '94

96 - few, some annual rings wide, others ringless

95 - some annual rings, med., wide, ring one band

94 - med., narrower on 'B'

93 - red/orange center, slight dark white pith,
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 15
Slab ID: 31

Ring Counts/Notes:

J2X Filename: CS15J2X.txt

Number of radii measured: 2

J2X Series Id: CS1531A, CS1531B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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Wood Anatomy Change Notes: (1993-1995)

Buried after 94.
94 - shows some slight burnel sign.
93 - growing center red orange with slight check.

Mean will see false ring action in 95.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 15

Slab ID: 33

Ring Counts/Notes:

J2X Filename: cs15J2X.txt

Number of radii measured: 2

J2X Series Id: cs1533A, cs1533B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</table>

Wood Anatomy Change Notes: (1993-1994)

Buried after 94.

94 stil has some internal sign, a little larger than previous slab.

93 - center growing, red/orange, w/good pitch,
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  
Reading Date:  

Site ID: Castolon  
Collection Date: Feb. 2008  

Tree/Hole ID: 15  
Slab ID: 34 \(\frac{52}{81}\)  

Ring Counts/Notes:  
J2X Filename: CS15J2X.txt  
Number of radii measured: 2  
J2X Series Id: CS1534A, CS1534B  

Proportion of circumference with secondary growth:  
Start Year: _______  Stop Year: _______  Proportion: _______  
Start Year: _______  Stop Year: _______  Proportion: _______  
Start Year: _______  Stop Year: _______  Proportion: _______  

Wood Anatomy Change Notes: (1993-1994)  
Buried after 1994.  
Top-93-center, red/orange w/ clear pith.  
Bottom appears to be all root w/ no pith, but see wood slash...
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  
Reading Date: 

Site ID: Castolon  
Collection Date: Feb. 2008  

Tree/Hole ID: 15  
Slab ID: 35  

Ring Counts/Notes:

J2X Filename: CS15_J2X.txt  

Number of radii measured:

J2X Series Id:

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</table>

Wood Anatomy Change Notes:

All Root - on bottom.
-Top appears like it may have a tiny pith left, but there is a cut seen that goes into the center, making it difficult to discern 100%.
So, establishment is 1993.
BIG BEND - CASTELLON

THE E 15

1978

September 2003

AP. 2.4

5.65 cm  CS.15.9  \[ a = \frac{E}{b} \] (Serrid)

7 cm  CS.15.10  \[ a = \frac{E}{b} \] (Serrid)

9 cm  CS.15.11  \[ a = \frac{E}{b} \] (Serrid)

13.5 cm  CS.15.12

16 cm  CS.15.13

16 cm  CS.15.14  (Serrid) \[ a = \frac{C^2}{2A} \]

16 cm  CS.15.15  \[ a = \frac{D}{2} \] (Serrid)

5.5 cm  CS.15.16

8.5 cm  CS.15.17  2 stones squared (Serrid side stout)

5.5 cm  CS.15.18  4 stones joined here (Serrid)
**Big Bend - Oak Pass**

**TREE 15 Cont.**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Sample</th>
<th>MLP</th>
<th>Memo</th>
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<tbody>
<tr>
<td>6-9cm</td>
<td>02/15/19</td>
<td>0.56 = 0.65</td>
<td>Sampled</td>
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<tr>
<td>8cm</td>
<td>02/15/20</td>
<td>0.63 = 0.63</td>
<td>Sampled</td>
</tr>
<tr>
<td>8.5cm</td>
<td>02/15/21</td>
<td>0.63 = 0.63</td>
<td>Sampled</td>
</tr>
<tr>
<td>9cm</td>
<td>02/15/22</td>
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<tr>
<td>9.5cm</td>
<td>02/15/23</td>
<td>0.57 = 0.57</td>
<td>Sampled</td>
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<tr>
<td>14-15cm</td>
<td>02/15/24</td>
<td></td>
<td></td>
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<tr>
<td>16-17cm</td>
<td>02/15/25</td>
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</tr>
<tr>
<td>18cm</td>
<td>02/15/26</td>
<td>0.63 = 0.63</td>
<td>Sampled</td>
</tr>
<tr>
<td>19cm</td>
<td>02/15/27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20cm</td>
<td>02/15/28</td>
<td>0.63 = 0.63</td>
<td>Sampled</td>
</tr>
</tbody>
</table>
Big Bend - Ring Reading Notes

Ring Reader: J. R. L. K.  
Reading Date: 

Site ID: C06-10  
Collection Date: Feb. 2008

Tree/Hole ID: 23-2  
Slab ID: GS

Ring Counts/Notes:

J2X Filename: cs232j2x.txt

Number of radii measured: 2

J2X Series Id: cs23265, cs23265b

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1991-2007)
2.07 wide w/late ring late in yr.
.96 wide of prominent late in 1/3 way through.
.05 wide of prominent early in ring, ring is cut.
.04 wide of prominent ring is cut 3/4 way out.
.03 very wide w/false rings early and late in yr.
.02 wide of prominent rings.
.01 med. w/huge false ring late in yr.
2.00 med. w/false ring well way through.
Big Bend - Ring Reading Notes

Ring Reader: \( J_{kR_{1}} \)  
Reading Date: 

Site ID: Castle  
Collection Date: Feb. 2008  
Tree/Hole ID: \( 23.2 \)  
Slab ID: \( 2 \left( \frac{E}{F} \right) \)

Ring Counts/Notes:

J2X Filename: c5232j2x.txt  
Number of radii measured: 2  
J2X Series Id: c52322A, c52322B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year:</th>
<th>Stop Year:</th>
<th>Proportion:</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Wood Anatomy Change Notes: 1997 - 2007

2007 - Med. increase height  
1997 - wide dark, brief false ring,  
98 - wide, dark, brief false ring.  
97 - New year width tiny pitch,  
96 - narrow, dark false ring.  
95 - wide, short, narrow false ring,  
94 - narrow, short, narrow false ring.  
93 - wide, short, narrow false ring.  
92 - narrow, short, narrow false ring.  
91 - narrow, short, narrow false ring.  
90 - narrow, short, narrow false ring.  
99 - wide, elongated
Big Bend - Ring Reading Notes

Ring Reader: JK

Reading Date:  

Site ID:  

Collection Date: Feb. 2008  

Tree/Hole ID: 23-2  

Slab ID: 3  

Ring Counts/Notes:

J2X Filename: cs232 J2X.txt  

Number of radii measured: 2  

J2X Series Id:  

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:  

Start Year: Stop Year: Proportion:  

Start Year: Stop Year: Proportion:  

Wood Anatomy Change Notes: (97-2007)

- '97 = Slightly compressed; false tri glab. 
- '98 - wide, lot of false rings,  
- '99 - center off ring  
- '00 - false rings,  
- '01 - glab and ring  
- '02 - wide, mostly ring,  
- '03 - false rings,  
- '04 - false rings,  
- '05 - false rings,  
- '06 - false rings,  
- '07 - false rings,  
- '08 - false rings,  
- '09 - wide, armored winter rings.
Big Bend - Ring Reading Notes

Ring Reader: J.K.  

Reading Date:  

Site ID:  

Collection Date: Feb. 2008  

Tree/Hole ID: 23-2  

Slab ID: 4 (E6)  

Ring Counts/Notes:  

J2X Filename: 0523223x.txt  

Number of radii measured: 2  

J2X Series Id:  

Proportion of circumference with secondary growth:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes: (1997-2007)  

97 - Band  
96 - prominent false ring slight burnish  
95 = bands with major false ring  
94 = wide false ring  
93 = wide, white false ring  
92 = wide, white false ring and  
91 = prominent false ring  
90 = wide, white false ring  
89 = wide, white and false ring  
88 = wide, bit of false ring  
87 = center unknown  

98 - center unknown  
97 - center unknown
Big Bend - Ring Reading Notes

Ring Reader: [Name]
Reading Date: [Date]
Site ID: [Site ID]
Collection Date: Feb. 2008
Tree/Hole ID: 23-2
Slab ID: 6 (56)

Ring Counts/Notes:

J2X Filename: c52326txt

Number of radii measured: 2

J2X Series Id: c52326A, c52326B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Wood Anatomy Change Notes: (1997-2007)

07 - Bright + strengthening
06 - Prominent false .25 to .5cm.
05 - Wide alternate ring 1.5cm.
04 - Wide alternate ring 0.5cm.
03 - Wide alternate ring 0.25cm.
02 - Very thin ring .01 cm.
01 - Wide alternate ring .01 cm.
2000 - N.D. Alternate ring 0.5cm.
99 - N.D.
98 - N.D.
97 - N.D.
96 - N.D.
**Big Bend - Ring Reading Notes**

<table>
<thead>
<tr>
<th>Ring Reader: J.R. Path</th>
<th>Reading Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site ID: Casad06</td>
<td>Collection Date: Feb. 2008</td>
</tr>
<tr>
<td>Tree/Hole ID: 23-2</td>
<td>Slab ID: 8 (E? E?)</td>
</tr>
</tbody>
</table>

**Ring Counts/Notes:**

- J2X Filename: casad06_j2x.txt
- Number of radii measured: 2
- J2X Series ID:

**Proportion of circumference with secondary growth:**

<table>
<thead>
<tr>
<th>Start Year:</th>
<th>Stop Year:</th>
<th>Proportion:</th>
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</tbody>
</table>

**Wood Anatomy Change Notes: (1997 - 2005)**

**J2X A**

- `05 - Compressed`
- `04 - Wide false ring 7/10`
- `03 - Moderate false ring 9/10`
- `02 - Wide false ring`
- `01 - Some damage to false ring 3/10`
- `2000 - Crack between false ring 3/10`
- `99 - Wide false ring`
- `98 - False ring`
- `97 - Control sample`

**J2X B**

- `2005 - Wide false ring 7/10`
- `06 - Wide false ring 4/10`
- `05 - Moderate false ring 9/10`
- `04 - False ring 7/10`
- `03 - Some damage to false ring 6/10`
- `2000 - Narrow false ring 7/10`
- `99 - False ring wide`
- `98 - False ring wide`
- `97 - Control sample`
Big Bend - Ring Reading Notes

Ring Reader: J. Kooh

Reading Date: 

Site ID: Cosl

Collection Date: Feb. 2008

Tree/Hole ID: 23-2

Slab ID: 16

(2 centre)

Ring Counts/Notes:

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Wood Anatomy Change Notes: (1977 - 2004)

Burl after 2004

49 = wide annual ring = 90
85 = narrow, major false ring = 90
12 = wide false ring = 45
83 = damaged false ring = 90
200 = damaged false ring = 0
19 = medium false ring
99 = inch false ring
04 = expanding center of pitch
Big Bend - Ring Reading Notes

Ring Reader: J.Kett

Reading Date:

Site ID: Cast'on

Collection Date: Feb. 2008

Tree/Hole ID: 23-2

Slab ID: 11 (58 5.2)

Ring Counts/Notes:

J2X Filename: c523232x.4x+

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

Burned after 2004
'04 - narrowing w/fine rings
'03 - wide w/major false rings 5x2 ft
'02 - wide w/false ring 1/2 way
'01 - med. damaged w/major rotting 3/4 way
2000 - med. w/false ring half way
'99 - med. w/false rings
'97 - center, cracked w/pith.
Big Bend - Ring Reading Notes

Ring Reader: J. K. S. 

Site ID: 

Reading Date: 

Collection Date: Feb. 2008

Tree/Hole ID: 23-2

Slab ID: 13 (E2/E1)

Ring Counts/Notes:

J2X Filename: 

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1997-2004)

Same as slab II.
Big Bend - Ring Reading Notes

Ring Reader: J. Koplitz
Reading Date: __________

Site ID: Caseiple
Collection Date: Feb. 2008

Tree/Hole ID: E3-2
Slab ID: 15 (E-B)

Ring Counts/Notes:

J2X Filename: cs23215A.txt

Number of radii measured: 2

J2X Series Id: cs23215A, cs23215B

Proportion of circumference with secondary growth:

Start Year: _______  Stop Year: _______  Proportion: _______
Start Year: _______  Stop Year: _______  Proportion: _______
Start Year: _______  Stop Year: _______  Proportion: _______


- Burnt after 2003
- 2002: some turiel-wide a-B
- '02-wide, false ring, damaged
- '01-wide, damage, w/false ring 3/4 out
- 2000 - Med. damage, false ring 3/4 way
- '98 - '99-wide w/false rings
- '97-center, cracked w/pith
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: ____________

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 23-2
Slab ID: 16

Ring Counts/Notes:

J2X Filename: cse12J2X.txt

Number of radii measured: 2

J2X Series Id: ___________

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</table>

Wood Anatomy Change Notes: (1997 - 2002)

2002 - wide in A, wide in B,
97 - wide in A, wide in B, false ring 3 out, damaged

2000 - wide, damaged, false ring 3 way,
99 - wide with false rings
98 - wide with false rings, 3 out,
97 - Center, growing up Dirth,  

Died after 2002
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 23-2

Slab ID: 18 (c6/c5)

Ring Counts/Notes:

J2X Filename: CS232J2X.txt

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</tbody>
</table>

Wood Anatomy Change Notes: (1997 - 2001)

Rotted slab.

Radiate A

'98-'99 = wide w/ false rings, some r.

'97 - rotten with rotten away-center

Radiate B

2001 - Buried w/ false ring's up

2000 - wide w/ false ring's up

'Buried after 2000.'
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 23-2
Slab ID: 19 \( \frac{c.2}{c.2} \)

Ring Counts/Notes:

J2X Filename: c5232 J2X.txt

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</tbody>
</table>

Wood Anatomy Change Notes:

Centric Rotted.

Radii A
99 - wide x 2 false rings
85 - wide w/ 2 false rings
97 - mostly rotted + gone
39 - still cont.

Radii B
2005 - wide w/ false + x 2 way
39 - wide w/ 2 false rings (entire x 5)
95 - wide w/ false ring + some rot
97 - mostly rotted + gone

Burial date 2000.
Big Bend - Ring Reading Notes

Ring Reader: [Name]    Reading Date: ________

Site ID: Castolon  Collection Date: Feb. 2008

Tree/Hole ID: 23-2  Slab ID: 2 | (04) (03)

Ring Counts/Notes:

J2X Filename: c532 j2x.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: Buried after 1999

Radius A (1999)
Center rotted
'98 - wide wiitced early yr.
'99 - med. rot, false/irise rings.

Radius B (99-2000)
2000 - Some burial-wide/rising rings
1999 - wide wide/rising rings
'99 - ½ rotted
'97 rotted - but can see where rings meet in center,
Big Bend - Ring Reading Notes

Ring Reader: J. R. D. 
Reading Date: 

Site ID: C-05-3/34 
Collection Date: Feb. 2008 

Tree/Hole ID: 23-2 
Slab ID: 22 (Note: scrubbed out?)

Ring Counts/Notes:

J2X Filename: c52322 J2X.XXT 

Number of radii measured: 2

J2X Series Id: c523222 A, c523222 B

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year:</th>
<th>Stop Year:</th>
<th>Proportion:</th>
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</thead>
<tbody>
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</tbody>
</table>

Wood Anatomy Change Notes: Buried after 1998

Redline A
- still looks like 1997 though
- 99 - wide, dense w/ finite rings, lateral closure
- 08 - partially filled - mad.

Redline B
- 2000 - buried - mad
- 99 - wide w/ finite rings
- 97 - indistinguishable - broken, testify.
Big Bend - Ring Reading Notes

Ring Reader: J. Rolf
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 232
Slab ID: 24 (c82) 
(Top)

Ring Counts/Notes:

J2X Filename: c5232.j2x.txt

Number of radii measured: 2

J2X Series Id: 

LAST SLAB

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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<tbody>
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</tbody>
</table>

Wood Anatomy Change Notes: Buried after 1998

98: wide, mostly rotten - cracks + holes.
96: looks like a new year + pitch still present - cracked through center. 
 Bottles, estimate is 1996.
CASTOLOU S3A2

Tree (LS025, etc.) for AB51 1816

<table>
<thead>
<tr>
<th>Size (cm)</th>
<th>Code</th>
<th>NIAD</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5-6</td>
<td>S2.3</td>
<td>2.0</td>
<td></td>
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<tr>
<td>4.5</td>
<td>S2.3</td>
<td>2.6</td>
<td>NIAD = 95</td>
</tr>
<tr>
<td>4</td>
<td>S2.3</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>S2.3</td>
<td>2.2</td>
<td>NIAD = 95</td>
</tr>
<tr>
<td>4.5</td>
<td>S2.3</td>
<td>2.3</td>
<td>NIAD = 95</td>
</tr>
<tr>
<td>6</td>
<td>S2.3</td>
<td>2.4</td>
<td>NIAD = 95</td>
</tr>
<tr>
<td>3.5-4</td>
<td>S2.3</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>S2.3</td>
<td>2.6</td>
<td>NIAD = 95</td>
</tr>
<tr>
<td>8</td>
<td>S2.3</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>S2.3</td>
<td>2.8</td>
<td>NIAD = 95</td>
</tr>
</tbody>
</table>

Note: NIAD values are approximate.
Big Bend - Cartoon

Tree 23.2 = 23A2

4.0 cm  

3.8 cm

2.5 cm

1.8 cm

9.5 cm

4.5 cm

2.0 cm

-0.6 cm

---

05.23.2.16  Top has two small (Sanded)

05.23.2.11  naiS = 6.2  (Sanded)

05.23.2.12  naiS = 5.1  Silked

05.23.2.13  naiS = 5.0  Silked

05.23.2.14  naiS = 5.0  Silked

05.23.2.15  naiS = 5.0  Silked

05.23.2.16  naiS = 5.0  Silked

05.23.2.17  

05.23.2.18  naiS = 5.0  Silked
BIG BEND - CASTILLO

TREE 2342 - 23.2

0.7m  cs.23.2.19  \text{hail} = \frac{c_3}{c_2}

0.65m  cs.23.2.20

0.5m  cs.23.2.21  \text{hail} = \frac{c_4}{c_3}

0.55m  cs.23.2.22  \text{hail} = \text{unordered}

0.6m  cs.23.2.23

3.5-7m  cs.23.2.24  \text{hail} = \frac{c_5}{c_2}
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Site ID: Castolon

Tree/Hole ID: 23-3

Reading Date: 

Collection Date: Feb. 2008

Slab ID: G5

Ring Counts/Notes:

J2X Filename: ES233JE2X.txt

Number of radii measured: 2

J2X Series Id:

Could be better sanded dates.

Proportion of circumference with secondary growth: (1998 - 2007)

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
</tr>
</thead>
</table>

Wood Anatomy Change Notes:

'06 - '05 - Similar width (if wider on 'B')
'04 - Very wide w/false ring 3/4 out.
'03 - narrower than 04 w/false ring poorly out.
'02 - Narrower w/false ring 3/4 way out.
'00 - Similar to '01, w/false ring 3/4 way out
'99 - Wide w/false ring 3/4 out & away.
'98 - Central w/notch
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date:

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 3

Ring Counts/Notes:

J2X Filename: CS 233 J2X.txt

Number of radii measured: 2

J2X Series Id:
Send better Dave.

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</table>

Wood Anatomy Change Notes: (1998 - 2007)

'98 - Wide, center w/ pitch & a little rolled.
'99 - Wide, w/ false ring ½ way.
'01 - Narrow w/ false ring ½ way, hot on '02.'
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  
Reading Date: 

Site ID: Castelna  
Collection Date: Feb. 2008  

Tree/Hole ID: 23-3  
Slab ID: 4 

Ring Counts/Notes:

J2X Filename: CAST03J2X.TEX 

Number of radii measured: 2 

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Wood Anatomy Change Notes: (1997-2007)
07 - wide, 06 - prominent false ring, about 1/2 way up.
05 - 04 - similar widths, 04 has false ring 1/3 way up.
04 - 03 - very wide, false rings.
01 - slightly narrower, false rings 2/3 way up in 02.
2000 - wide, thin, false rings are every 2 or 3, flat at top.
1999 - wide, false ring.
1998 - wide, cracked, some rot.
1997 - center is cracked, some rot. New Year.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Site ID: Castolon

Tree/Hole ID: 23-3

Reading Date: 

Collection Date: Feb. 2008

Slab ID: 5

(EN)

Ring Counts/Notes:

J2X Filename: C5233J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1997 - 2007)

'07 - slight linear sign w/ false ring.
'04 - '05 - similar wide widths w/false rings.
'03 - very wide w/false ring halfway out.
'02 - narrower w/false ring halfway out.
'01 - narrower than '02, w/false ring halfway out.
Some damaged wood.
2000 - wide w/false ring halfway through.
1999 - wide w/false ring halfway out.
'98 - wide w/false ring a little damaged.
'97 - centen cracked w/false.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 23-3

Slab ID: 

Ring Counts/Notes:

J2X Filename: CS233 J2x.txt

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

<table>
<thead>
<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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</tbody>
</table>

Wood Anatomy Change Notes: (1997 - 2007)

07 - narrow: slight evidence of false ring
16 - prominent false ring mostly way through, slight burnish
2005 - faded, delaminated, with few false rings
02 - wide, false rings mostly way out
01 - wide, false ring mostly way out, cracked at end of yrs
2000 - wide, false ring mostly way out
1999 - faded, false ring mostly way out
98 - wide, with damage
97 - center of wood splits
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Site ID: Castolon
Tree/Hole ID: 23-3

Reading Date: 
Collection Date: Feb. 2008
Slab ID: 7

Ring Counts/Notes:

J2X Filename: 05233J2X.EXT
Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

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<tr>
<th>Start Year</th>
<th>Stop Year</th>
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Wood Anatomy Change Notes: (1997-2005)
- 07 - buried, Renewer
- 06 - prominent false ring by way, buried signs
- 04-05 - similarly wide, false ring - 05 has slight burl.
- 03 - wide w/ more false ring by way.
- 02 - wide w/ fast false ring by way.
- 01 - narrowing w/ prominent false ring 1/4 out.
- 2000 - made w/ false ring 1/3 way through.
- 1999 - wide w/ fast false ring 1/3 way through.
- 1998 - wide w/ damage.
- 1997 - center - damaged.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: __________

Site ID: Castano
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 11

Ring Counts/Notes:

J2X Filename: cs233j2x.cxt

Number of radii measured: 2

J2X Series Id: cs23311A, cs23311B

Proportion of circumference with secondary growth:

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<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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Wood Anatomy Change Notes: (1997 - 2004)

- Buried after 2004, 04-wide false rings 1/2 way through.
- 03+02 - wide false rings 1/2 way through.
- 01 - narrow, wide false rings 1/2 way through.
- 2000 - narrower on B than A, false ring 1/2 way.
- 1999 - wide false ring 1/2 way through.
- 98 - wide, checked.
- 97 - wide, center, checked.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Site ID: Castolon

Tree/Hole ID: 23-3

Reading Date:

Collection Date: Feb. 2008

Slab ID: 13

Ring Counts/Notes:

J2X Filename: C5233J2X.EXE

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes: (1997-2004)

- Annual after 03. 03-wide w/false rings.
- 02 - wide w/false ring nth way.
- 01 - wide w/false ring nth out.
- 2000 - narrowing w/false ring nth way.
- 1999 - wider w/false ring nth way through, obliterated
- 98 - wider, along w/false ring.
- 97 - med. center w/false rings & tiny pith.
Big Bend – Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 16 (EI)

Ring Counts/Notes:

J2X Filename: c5233j2x.txt

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

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<tr>
<th>Start Year:</th>
<th>Stop Year:</th>
<th>Proportion:</th>
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</thead>
</table>


03+02: Similar widths. Band 02 after 2002, wider rings.
01: Wide, wider ring? 2005, check between 01+02.
2006: Wide, wider ring not way through.
98: Wide
97: Hard. Center, wider rings + tiny pith.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castelon
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 18

Ring Counts/Notes:

J2X Filename: cs233J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

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<th>Start Year</th>
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'02+03 - wide w/ false rings
'Burial after 2002.'

'01 - med. w/ major false ring ~ 3/4 out.

2000 - med. w/ false ring ~1/2 way.

1999 - showing wide w/ false ring ~1/2 way through.

'98 - wide

'97 - center, w/ false ring & tiny pith.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 19

Ring Counts/Notes:

J2X Filename: c5233J2X.txt

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion: 
Start Year: Stop Year: Proportion: 

Wood Anatomy Change Notes: (1997 - 2002)

2002 - Slightly buried 1/8 inch reddish falter ring 1/2 way, 
01 - Wide white ring 1/4 out, 
2000 - Hammer on 1/4 than 2, white ring 1/4-3/8 out, 
99 - Hammer on 1/4 than 2, white ring in outside part of ring. 
98 - Wide white ring 
97 - Center, wide white ring, nothing else.
**Big Bend - Ring Reading Notes**

<table>
<thead>
<tr>
<th>Ring Reader: J. Roll</th>
<th>Reading Date:</th>
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<tbody>
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<td>Site ID: Cetolou</td>
<td>Collection Date: Feb. 2008</td>
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<tr>
<td>Tree/Hole ID: 23-3</td>
<td>Slab ID: 20 (Top)</td>
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**Ring Counts/Notes:**

- J2X Filename: C5233 J2X.txt
- Number of radii measured: 2
- J2X Series Id: 

**Proportion of circumference with secondary growth:**

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<th>Start Year:</th>
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**Wood Anatomy Change Notes:** (1997 - 2001)

- 2001 - Shows slight burried w/false ring m ½ way through yr. - Wide
- 2000 - Wide w/false ring m½ way.
- '99 - Wide w/false ring m½ way.
- '98 - wide
- '97 - Wide center w/false ring bit cracked w pitch.
Big Bend - Ring Reading Notes

Ring Reader: J. Rith

Reading Date: 

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 23-3

Slab ID: 21

Ring Counts/Notes:

J2X Filename: 55233J2X.4X4

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes: (1997 - 2001)

Burned after 2000

2001 - wide, with few rings, 1/2 way through

2000 - narrow, thin, 1/2 way through

99 - wide, with few rings, early & late

98 - wide, some damage

97 - center, damaged with thin, elongated, flowing
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date:

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 22

Ring Counts/Notes:

J2X Filename: C523J2X4XE

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes: (1997-2001)

Burial after 2000,

2001 - med. w/ false ring & w/ welly - buried
2000 - reversing w/ false ring ~ 3/4 out,
99 - wide 1st w/ false ring ~ 5/8 out,
98 - wide
97 - elongated w/ at + pith-X-center - false ring,
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castileum
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 24

Ring Counts/Notes:

J2X Filename: c0233J2X.jpg

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes: (1997-2001)

Buried after 2000.

2000 - slight burial slight w/fade ring ½ out.
1999 - wide w/late ring only on way.
1998 - very wide, some damage.
1997 - center, ablong, tiny pitch, some damage.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  Reading Date:  
Site ID: Castolon  Collection Date: Feb. 2008  
Tree/Hole ID: 23-3  Slab ID: 26  

Ring Counts/Notes:  
J2X Filename: cs233J2X.txt  
Number of radii measured: 2  
J2X Series Id:  

Proportion of circumference with secondary growth:  
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Wood Anatomy Change Notes: (1997-2001)  
Buried after 1999.  
2001 - Buried w/ false ring still visible.  
2000 - Buried w/ false ring & narrowest than previous slab.  
1999 - Constricted, some annual evidence - narrowest, false ring  
98 - Very wide.  
97 - Shrink-fitted center, cracked up/with & grey false ring.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth  

Reading Date:  

Site ID: Castolon  

Collection Date: Feb. 2008  

Tree/Hole ID: 23-3  

Slab ID: 27  

Ring Counts/Notes:  

J2X Filename: cs233J2X.txt  

Number of radii measured: 2  

J2X Series Id:  

Proportion of circumference with secondary growth:  

Start Year:   Stop Year:   Proportion:  

Start Year:   Stop Year:   Proportion:  

Start Year:   Stop Year:   Proportion:  

Wood Anatomy Change Notes: (1997 - 2000)  

Buried after 1999.  

2000 - had false rings  

99 - partial annual & false rings/2 rings  

98 - white w/ some rot.  

97 - center w/ pitch & some rot.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 23-3

Slab ID: 29

Ring Counts/Notes:

J2X Filename: C5233J2X;6X6

Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1997 - 2000)

Buried after 1999.

2000 - burned with few rings. 1/2 way in tree.
1999 - wide on E, narrow on N
1998 - wide with little damage.
1997 - center with tiny pith.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth
Reading Date: 

Site ID: Castolon
Collection Date: Feb. 2008

Tree/Hole ID: 23-3
Slab ID: 31

Ring Counts/Notes:

J2X Filename: 05233J2X.txt
Number of radii measured: 2

J2X Series Id: 

Proportion of circumference with secondary growth:

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<th>Start Year:</th>
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Wood Anatomy Change Notes: (1997 - 99)

- Burnt after 1999
- 99 - slight spiral grain, wide bit of false ring
- 98 - wide
- 97 - Center false ring + string pitch
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date:

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 23-3

Slab ID: 33

Ring Counts/Notes:

J2X Filename: cs2333J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes: (97-99)

- 99 = slight shrivel, wide, thickening late yrs.
- 98 = slight shrivel, previous than 99.
- 97 = center up pitch.
### Big Bend - Ring Reading Notes

<table>
<thead>
<tr>
<th>Ring Reader:</th>
<th>J. Roth</th>
<th>Reading Date:</th>
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<tr>
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<td>Castl/on</td>
<td>Collection Date: Feb. 2008</td>
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<tr>
<td>Tree/Hole ID:</td>
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<td>Slab ID: 34</td>
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#### Ring Counts/Notes:

- J2X Filename: cs233J2X.txt

- Number of radii measured: 2

- J2X Series Id: 

#### Proportion of circumference with secondary growth:

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#### Wood Anatomy Change Notes: (97-99)

- Burial after 99
- '99: Bath of false ring - slight burial
- '98 - med.
- 97 - Center with false ring later.
Big Bend - Ring Reading Notes

Ring Reader: J. Roth

Reading Date: 

Site ID: Castolon

Collection Date: Feb. 2008

Tree/Hole ID: 23-3

Slab ID: 37

Ring Counts/Notes:

J2X Filename: cs333j2x.EXT

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

<table>
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Wood Anatomy Change Notes:

Pith still present. 1997-98

97: Soft, outer ring + pith
98: Med.

Burned after 1999.
BIG BEND
CASTOLON ~ Tree 23 stem 3

(8.5 cm) 8 x 1.3 • 1.33

(8 cm) 8 x 1.3 • 1.34

(7.5 cm) 8 x 1.3 • 1.35

(4.5 cm) 8 x 1.3 • 1.36

(-10 cm) 8 x 1.3 • 1.37

Neil = 0.3 / 0.3 (Sand d)
Big Bend - Ring Reading Notes

Ring Reader: [Name]  
Reading Date: 

Site ID:  
Collection Date: Feb. 2008  

Tree/Hole ID:  
Slab ID:  

Ring Counts/Notes:

J2X Filename: 

Number of radii measured:  

J2X Series Id: 

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

- '57 - wide
- '60 - narrow
- '65 - slightly wider than '65
- '92 - wider than '65, some heart, darker rings
- '73 - wider than '65, darker heart
- '95 - medium, wider than '95
- '98 - medium
- '99 - very narrow, darker
- '01 - very thin
- '06 - very dark, grey/black
- '07 - darker

Note: The provided text appears to be a mix of measurements and dates, possibly indicating changes in wood anatomy over time.
Big Bend - Ring Reading Notes

Ring Reader: [Name]                      Reading Date: [Date]

Site ID: [Site ID]                       Collection Date: Feb. 2008

Tree/Hole ID: Ø38                      Slab ID: 2 N 1 5 5

Ring Counts/Notes:

J2X Filename: _________________________

Number of radii measured: ____________

J2X Series Id: _________________________

Proportion of circumference with secondary growth:

Start Year: _______ Stop Year: _______ Proportion: _______

Start Year: _______ Stop Year: _______ Proportion: _______

Start Year: _______ Stop Year: _______ Proportion: _______

Wood Anatomy Change Notes:

07 - medium to wide
06 - medium
05 - wider than 06
04 - medium to wide
03 - wide - False ring - very ordered
02 - wide - many False rings
01 - medium
00 - wide - dark grey/brown
99 - very narrow - dark brown
98 - medium thick - narrow

07 - Medium - False Ring - Brown
06 - Medium - False Ring
05 - Medium - 2 False Rings
04 - Medium - 3 False Rings
03 - Medium - 4 False Rings
02 - Medium - 5 False Rings
01 - Medium - 6 False Rings
00 - Medium - 7 False Rings
99 - Very Narrow - Black
98 - Medium Thick - Narrow
Big Bend - Ring Reading Notes

Ring Reader: ___________________  Reading Date: ___________________

Site ID: Cadilow  Collection Date: Feb. 2008

Tree/Hole ID: 39.5  Slab ID: 3  \$7 11A 1

Ring Counts/Notes:

J2X Filename: ___________________

Number of radii measured: ___________________

J2X Series Id: ___________________

Proportion of circumference with secondary growth:

Start Year: ______  Stop Year: ______  Proportion: ______

Start Year: ______  Stop Year: ______  Proportion: ______

Start Year: ______  Stop Year: ______  Proportion: ______

Wood Anatomy Change Notes:

07 - medium
06 - narrow - section in sprout.
05 - wide - than 06
04 - wide - fiber ring 2 by 2 mm

03 - narrow 04 - fiber ring 2 by 2 mm
02 - wide
01 - narrow - section in sprout
00 - wide - green tissue
99 - hollow - dark brown

98 - medium - gray
97 - medium - fiber ring halfway
96 - medium - fiber ring 50% reddened
95 - medium - fiber ring 95% reddened
94 - center - center cracked
93 - fiber ring
92 - small dots
91 - reddish - green tissue
90 - brown - fiber ring
89 - medium - gray
88 - medium - gray
87 - dark brown
86 - wide - green tissue
85 - medium - gray
84 - medium - gray
83 - medium - gray
82 - medium - gray
81 - medium - gray
80 - medium - gray
79 - medium - gray
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10 - medium - gray
9 - medium - gray
8 - medium - gray
7 - medium - gray
6 - medium - gray
5 - medium - gray
4 - medium - gray
3 - medium - gray
2 - medium - gray
1 - medium - gray
0 - medium - gray
Big Bend - Ring Reading Notes

Ring Reader: ____________________  Reading Date: ____________________

Site ID: ________________  Collection Date: Feb. 2008

Tree/Hole ID: ______  Slab ID: 1/Na[4] - ZC

Ring Counts/Notes:

J2X Filename: ____________________

Number of radii measured: ____________________

J2X Series Id: ____________________

Proportion of circumference with secondary growth:

Start Year: ______  Stop Year: ______  Proportion: ______

Start Year: ______  Stop Year: ______  Proportion: ______

Start Year: ______  Stop Year: ______  Proportion: ______

Wood Anatomy Change Notes:

07 - Medium thickness - Curved or crooked annual
08 - Thin - straight annual
09 - Medium thickness - Arched Annual
0E - Wide
02 - Curved thin and faint ring - Only count annual
03 - Medium
04 - Wide thicken growth
0T - Hard - solid growing rings or plates
0A - Solid - solid growth/soft section
97 - Very thin - don't count
96 - Medium - false ring or false additional growth
9C - Medium - a small rings
4D - Rad
4W-0Y
9C-00
5: Solid growth on 11-01-01
Big Bend - Ring Reading Notes

Ring Reader: [Name]  
Site ID: [ID]  
Tree/Hole ID: [ID]  
Reading Date:
Collection Date: Feb. 2008  
Slab ID: [ID]

Ring Counts/Notes:

J2X Filename:
Number of radii measured:
J2X Series Id:

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

07 - Medium - Brown
08 - Medium - Transparent
05 - Medium - Grey, Translucent
04 - Medium - Grey, Slightly Translucent
03 - Medium - Grey, 1/4 Translucent
02 - Medium - Grey, 1/2 Transparent
01 - Medium - Grey, 3/4 Transparent
00 - Medium - Grey, Transparent

99 - Very Light - Clear
98 - Light - Transparent
97 - Medium - Grey, Transparent
96 - Medium - Grey, Slightly Transparent
95 - Medium - Grey, Translucent
94 - Medium - Grey, Slightly Translucent
93 - Medium - Grey, Transparent
92 - Medium - Grey, 1/4 Transparent
91 - Medium - Grey, 1/2 Translucent
90 - Medium - Grey, 3/4 Translucent
89 - Medium - Grey, Transparent
88 - Medium - Brown, Transparent
87 - Medium - Brown, Slightly Transparent
86 - Medium - Brown, Translucent
85 - Medium - Brown, Slightly Translucent
84 - Medium - Brown, Transparent
83 - Medium - Brown, 1/4 Transparent
82 - Medium - Brown, 1/2 Translucent
81 - Medium - Brown, 3/4 Translucent
80 - Medium - Brown, Transparent
79 - Very Dark - Black
78 - Dark - Transparent
77 - Medium - Black, Transparent
76 - Medium - Black, Slightly Transparent
75 - Medium - Black, Translucent
74 - Medium - Black, Slightly Translucent
73 - Medium - Black, Transparent
72 - Medium - Black, 1/4 Transparent
71 - Medium - Black, 1/2 Translucent
70 - Medium - Black, 3/4 Translucent
69 - Medium - Black, Transparent
68 - Very Dark - Dark Brown
67 - Dark - Transparent
66 - Medium - Dark Brown, Transparent
65 - Medium - Dark Brown, Slightly Transparent
64 - Medium - Dark Brown, Translucent
63 - Medium - Dark Brown, Slightly Translucent
62 - Medium - Dark Brown, Transparent
61 - Medium - Dark Brown, 1/4 Transparent
60 - Medium - Dark Brown, 1/2 Translucent
59 - Medium - Dark Brown, 3/4 Translucent
58 - Medium - Dark Brown, Transparent
57 - Very Dark - Dark Brown
56 - Dark - Transparent
55 - Medium - Dark Brown, Transparent
54 - Medium - Dark Brown, Slightly Transparent
53 - Medium - Dark Brown, Translucent
52 - Medium - Dark Brown, Slightly Translucent
51 - Medium - Dark Brown, Transparent
50 - Medium - Dark Brown, 1/4 Transparent
49 - Medium - Dark Brown, 1/2 Translucent
48 - Medium - Dark Brown, 3/4 Translucent
47 - Medium - Dark Brown, Transparent
46 - Very Dark - Dark Brown
**Big Bend - Ring Reading Notes**

Rina Reader: D.L. - TD

Site ID: 0364/4

Tree/Hole ID: J2X

Reading Date: 

Collection Date: Feb. 2008

Slab ID: 8 N=0 - F:

**Ring Counts/Notes:**

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

**Proportion of circumference with secondary growth:**

<table>
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<tr>
<th>Start Year</th>
<th>Stop Year</th>
<th>Proportion</th>
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**Wood Anatomy Change Notes:**

| 07 | Medium - Buried. |
| 06 | More black - difficult to distinguish - Buried. |
| 05 | Than to medium - Buried. |
| 04 | Medicine - Untried (untried). |
| 03 | Dark - Buried - Intra - 95% untried. |
| 02 | Inside - Buried - 95% untried. |
| 01 | Very thin - untried Secondary wood. |
| 00 | Untried - Dark Buried. |

| 98 | Medium - gray at Buried. |
| 97 | Dark gray - Derel. (Derel) to very untried. |
| 96 | Medium - Dark gray - 10% untried. |
| 95 | Medium - Dark Buried. |
| 94 | Medium - grayed. |
| 93 | Buried after 54. |
Big Bend - Ring Reading Notes

RIng Reader: 191.5

Site ID: H-18

Reading Date: 

Collection Date: Feb. 2008

Tree/Hole ID: 234

Slab ID: 10 1

Ring Counts/Notes:

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Wood Anatomy Change Notes:

07 - Thin Burls
05 - Very Thin - Indistinct - nearly unnoticeable. 
04 - Nothin - Transitioned Burls
03 - Single - filtering ~ 90% way reduced.
02 - Single - Variable on outside
01 - Single - outer boundary within 2-3mm
00 - Wide - dark brown/gray
99 - Very Thin - dark brown.
98 - Burls on groups
97 - Greyish/Brown - edge very - 1/2 way reduced
96 - Mod.
95 - Mod. - 1/2 way brown, 1/2 way reduced
94 - Medium.
93 - Medium.
92 - Medium.
91 - Medium.
90 - Medium.
89 - Medium.
88 - Medium.
87 - Medium.
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10 - Medium.
9 - Medium.
8 - Medium.
7 - Medium.
6 - Medium.
5 - Medium.
4 - Medium.
3 - Medium.
2 - Medium.
1 - Medium.
0 - Medium.
Big Bend - Ring Reading Notes

Ring Reader: 7/24-5/22

Site ID: 5000

Tree/Hole ID: 28B

Reading Date: 

Collection Date: Feb. 2008

Slab ID: 12

Ring Counts/Notes:

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Wood Anatomy Change Notes:

07: New - Barred
06: Very Thin - All Pits Not Present - Barred
05: Thin - Barred
04: Middle - Barred
03: Middle - Large Pits
02: Very Thin - Medium Barred
01: Very Thin - Should Take at Least Large
00: Wide

197: Medium - Very
198: Middle - Barred Ring
93: Barred - All Ring
95: Middle - Thin Ring
96: Middle - Medium Ring

07: Very Thin - Barred

Pruned after 03 more 03
Big Bend - Ring Reading Notes

Ring Reader: 

Site ID: 

Tree/Hole ID: 

Reading Date: 

Collection Date: Feb. 2008

Slab ID: 

Ring Counts/Notes:

J2X Filename:

Number of radii measured:

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Start Year: Stop Year: Proportion: 

Wood Anatomy Change Notes:

97 - Very thin - cloudy - Brown
96 - Medium - Gray
95 - Medium - Gray - White - Gray - Gray - White - Gray
97 - Medium - Gray - White - Gray - White - Gray - White
96 - Medium - Gray - White - Gray - White - Gray - White
95 - Medium - Gray - White - Gray - White - Gray - White
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04 - Medium - Gray - White - Gray - White - Gray - White
03 - Medium - Gray - White - Gray - White - Gray - White
02 - Medium - Gray - White - Gray - White - Gray - White
01 - Medium - Gray - White - Gray - White - Gray - White
00 - Medium - Gray - White - Gray - White - Gray - White
Big Bend - Ring Reading Notes

Ring Reader: DO - JR

Site ID: Castelina

Tree/Hole ID: 23B

Reading Date: 

Collection Date: Feb. 2008

Slab ID: 15...Nad 2c

Ring Counts/Notes:

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

Proportion of circumference with secondary growth:

<table>
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<tr>
<th>Start Year</th>
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Wood Anatomy Change Notes:

07 - Buried. Tree.

06 - Insert is aloof. Buried (Ben Sid).  

05 - Buried. Tree.

04 - Buried. Tree.


02 - Undet. From Log 0 1/2 2-3 field. Buried.

01 - No short-term injury. Buried.

00 - Untw. Grayish Brown. False ring. 2 cm thick.

99 - Thin, Black, White.

98 - Medium-gray.

97 - Medium-gray. Buried. False ring. 6 cm.

96 - Medium. False ring. 2 cm. Embossed.

95 - Medium.

94 - Medium.

92 - Buried after ca. 81.
Big Bend - Ring Reading Notes

Ring Reader: TD Jr. Th.  

Reading Date: 

Site ID: Cebolone 

Collection Date: Feb. 2008 

Tree/Hole ID: 288 

Slab ID: 17. N, 03. 05. 05 

Ring Counts/Notes: 

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

Proportion of circumference with secondary growth: 

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Wood Anatomy Change Notes: 

07 - OR - Compressed Bark, 1. Reddish, Sooty, Black, 2. Red Bark  
04 - Buried - Thin to Med.  
03 - Medium - Grayish - Buried  
08 - Med. to wide - Grayish - Buried.  
01 - Very thin - Buried, Mostly Tight, Irregular  
00 - Very wide - Grayish to Buff, Buried or partially Buried  
79 - Thin - Brown  
98 - Med. - Gray - Medium Buried  
97 - Med. - Grayish - Full Ring 0.5 way 

16 - Medium - Faded Ring 2/3 Cut and Buried  
35 - Med. - Dark Brown  
44 - Medium - Brown  
97 - Buried after 97
Big Bend - Ring Reading Notes

Ring Reader: ____________  Reading Date: ______________

Site ID: ________________  Collection Date: Feb. 2008

Tree/Hole ID: ____________  Slab ID: ____________

Ring Counts/Notes:

J2X Filename: ______________

Number of radii measured: ______________

J2X Series Id: ______________

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

01 - Heartwood - Dark J2V
03 - Heartwood
04 - Red - Buried - Starting of Greasy Sooty
05 - Very thin - difficulty to distinguish Band
06 - Band - Swollen in center
99 - Dead - Sawn - Thin
98 - Red - Swollen in center - Buried
97 - Medium - Pale 2 in. 2 way
96 -

96 - Medium - Pale 2 in. 90 % out
45 - Natural
44 - Medium
40 - 07

Buried after 77
Big Bend - Ring Reading Notes

Ring Reader: \[\text{Ring Reader}\\\]
Reading Date:

Site ID: \[\text{Site ID}\\\]
Collection Date: Feb. 2008

Tree/Hole ID: \[\text{Tree/Hole ID}\\\]
Slab ID: \[\text{Slab ID}\\\]

Ring Counts/Notes:

J2X Filename:
Number of radii measured:

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: \[\text{Start Year}\\\]
Stop Year: \[\text{Stop Year}\\\]
Proportion:

Start Year: \[\text{Start Year}\\\]
Stop Year: \[\text{Stop Year}\\\]
Proportion:

Start Year: \[\text{Start Year}\\\]
Stop Year: \[\text{Stop Year}\\\]
Proportion:

Wood Anatomy Change Notes:

01 - 06: Burned
07 - 08: Burned
09 - 19: Red - Brown
10 - 19: Red - Black - Brown
19 - 29: Red - Black - Brown - Black - Red
30 - 39: Red - Black - Red - Black - Red
40 - 49: Red - Black - Red - Black - Red
50 - 59: Red - Black - Red - Black - Red
60 - 69: Red - Black - Red - Black - Red
70 - 79: Red - Black - Red - Black - Red
80 - 89: Red - Black - Red - Black - Red
90 - 99: Red - Black - Red - Black - Red
00 - 07: Burned

90 - 07: Burned after 07.
Big Bend - Ring Reading Notes

Ring Reader: ____  Reading Date: ____

Site ID: ____  Collection Date: Feb. 2008

Tree/Hole ID: 23b  Slab ID: 23

Ring Counts/Notes:

J2X Filename: __________________________

Number of radii measured: ________________

J2X Series Id: __________________________

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion: 

Start Year:  Stop Year:  Proportion: 

Start Year:  Stop Year:  Proportion: 

Wood Anatomy Change Notes:

07 - 01 - Burnt - Dead Stem
86 - Light gray, Bud - Burnt - Taller ring for
99 - Thinner
98 - Hard - Light gray, Burnt
97 - Hard - Burnt on partially
96 - Light color, Carbon Las - Sappy
95 - Hard - Sappy
94 - Hard
93 - Very small amount fill
Big Bend - Ring Reading Notes

Ring Reader: John
Reading Date:

Site ID: 50/420
Collection Date: Feb. 2008

Tree/Hole ID: 238
Slab ID: 2.310 2.3

Ring Counts/Notes:

J2X Filename:

Number of radii measured:

J2X Series Id:

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

90-91 - S+V unavailable - Burned
90 - Red heart - Felled Red heart 2 app
90 - Thin Dinner
97 - Red - Burned
96 - Red - Burned in Partially Burned
95 - Red - Burned
94 - Red - Burned
93 - Thin
Big Bend - Ring Reading Notes

Ring Reader: 310
Reading Date: 

Site ID: 
Collection Date: Feb. 2008

Tree/Hole ID: 39
Slab ID: 39

Ring Counts/Notes:

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

Proportion of circumference with secondary growth:

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Start Year: 
Stop Year: 
Proportion: 

Wood Anatomy Change Notes:

- 97-98 - old Burial; difficult to distinguish. Look for 19
- 19-92 - thin, moist Burial - Dark CoR
- 92: wood is distinguishable
- 99 - same; Bog at 92
- 92: wood is questionable
- 99: medium; Buried
- 92: medium; Bog at 92
- 93: medium; Bog at 92
- 92: wood; Bog at 92
- 93: medium; Bog at 92
- 92: medium; Bog at 92
- 92: medium; Bog at 92

93-97: Burial after 92 or 93.
Big Bend - Ring Reading Notes

Ring Reader: [Name]  
Reading Date:  

Site ID: [Site ID]  
Collection Date: Feb. 2008  

Tree/Hole ID: [ID]  
Slab ID: [Slab ID]  

Ring Counts/Notes:

J2X Filename: 

Number of radii measured: 

J2X Series Id: 

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

67-01 - Barked - Date July 93-07  
60 - Barked - [Info]  
99 - thin - Barked  
18 - Medium - Barked  
97 - Hard - Barked  
96 - soft - Barked - Date Feb. 93 - outward  
95 - [Info]  
94 - [Info]  
93 - [Info]
Big Bend - Ring Reading Notes

Ring Reader: RB

Site ID: Padd/ry

Collection Date: Feb. 2008

Tree/Hole ID: 250

Slab ID: 26

Ring Counts/Notes:

J2X Filename:

Number of radii measured:

J2X Series Id:

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

04 - 01 - Inclined, rings above. Burned.
00 - Narrow.
99 - The dark wood. Burned.
77 - Narrow, rings. Burned.
97 - 96 - Narrow.
95 - New.
94 - Wide, faint center boundary.
93 - New.
Big Bend - Ring Reading Notes

Ring Reader: Df - Td

Reading Date:

Site ID: MxLhbn

Collection Date: Feb. 2008

Tree/Hole ID: 283

Slab ID: 28r

Ring Counts/Notes:

J2X Filename:

Number of radii measured:

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

07-01. Trellis, gusseted
09 - End - Burned
99 - Narrow - Burned, difficult to discern
98 - Narrow Burned
97 - And 5 wide - Burned
96 - Narrow - Burned, color 2ng & way
95 - and
94 - and
93 - end
Pitch very small

93.07 - Burned after 95
Big Bend - Ring Reading Notes

Ring Reader: JK

Reading Date: 

Site ID: 24

Collection Date: Feb. 2008

Tree/Hole ID: 293

Slab ID: 29

Ring Counts/Notes:

J2X Filename:

Number of radii measured:

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: 
Stop Year: 
Proportion:

Start Year:
Stop Year:
Proportion:

Start Year:
Stop Year:
Proportion:

Wood Anatomy Change Notes:

07 - 48 - Undecipherable Buried
97 - Med.
49 - Narrow
95 - Med / Wide
46 - Medium / Narrow
43 - Med to wide
93 - Burial off 05
**Big Bend - Ring Reading Notes**

Ring Reader: T.J.R.  
Reading Date: 4/1/08

Site ID: Castolon - Big Bend (CS)  
Collection Date: Feb. 2008

Tree/Hole ID: J2X-11139  
Slab ID: GS

**Ring Counts/Notes:**

*J2X Filename: CS28 J2X, TXT*

Number of radii measured: 2

*J2X Series Id:*

Proportion of circumference with secondary growth:

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**Wood Anatomy Change Notes:**

07 - Width: 2.0
06 - 4-5 claret rings on outer edge from previous winter reach growth
05 - Inside of 05 appears false but transition appears to be more clear. Inner bark here becomes thick of
04 - Some faint claret banding on inside and outside of ring
03 - Inner rings appear false on radial side, not appear to change, however very apparent clear demarcation
02 - 1.5 cm wide, however, 4-5 late rings within
01-07
Big Bend - Ring Reading Notes

Ring Reader: mjrshr
Reading Date: 04/08

Site ID: Castleran Big Bend
Collection Date: Feb, 2008

Tree/Hole ID: Tor-willow
Slab ID: Slab 1.1

Ring Counts/Notes:

J2X Filename: C 5 2P2X.txt
Number of radii measured: 2
J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: 2001 - 2007

07 - wide, face knot, big and outer edge,
06 - narrower than 07 and ~3 late rings on outside of 06
05 - inside of the opinion plus but gets closer downstream - looks a distinctive change in vessel ring narrows.
04 - inner edge tight in places.
03 - inside edge opinion plus two a no distinctive change in vessel change, becomes more discerning.
02 - wider
01 - point radius, says threshold. Also, a round stem of another opinion present, above ring.

Pith cracked.
Big Bend - Ring Reading Notes

Ring Reader: DD + JR  
Reading Date: 4/28

Site ID: Castle - Big Bend  
Collection Date: Feb, 2008

Tree/Hole ID: JX willow  
Slab ID: 2

Ring Counts/Notes:

J2X Filename: CS28J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion: 

Start Year:  
Stop Year:  
Proportion: 

Start Year:  
Stop Year:  
Proportion: 

Wood Anatomy Change Notes: 2001-2007

07-widest rings  
06 - narrow - #5  
05 - ring appears bottle in one of 6 sections  
04 - wide without rings  
03 - rings appear where it is  
02 - wide, no rings at all  
01 - wide, no rings at all  
00 - white rings all present
Big Bend - Ring Reading Notes

Ring Reader: 33-58

Reading Date: 4/1/08

Site ID: 33-58 - Big Bend

Collection Date: Feb, 2008

Tree/Hole ID: 33-58-005

Slab ID: 3 - NoID E8

Ring Counts/Notes:

J2X Filename: C528J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: _______  Stop Year: _______  Proportion: _______

Start Year: _______  Stop Year: _______  Proportion: _______

Start Year: _______  Stop Year: _______  Proportion: _______

Wood Anatomy Change Notes: 2001-2007

01. Wide - starting to look new place.
06. 3. False rings still present on outer edge of ring.
05. Rather clear new although some transition in spots. Narrower.
04. Wide.
02. Coat at Boundary of 02/03. Narrowly, almost wider.
01. False Rings. 3.8 plus on outer forming at 01/02 Boundary.
Big Bend - Ring Reading Notes

Ring Reader: DD JR  
Reading Date: 4/1/08

Site ID: Castleton - Big Bend  
Collection Date: Feb. 2008

Tree/Hole ID: 4yz1111  
Slab ID: 5 EP  

Ring Counts/Notes:

J2X Filename: C528J2X.txt

Number of radii measured: 2

J2X Series Id: __________________________

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes: 2001 - 2007

07 : inner
06 : fiber rings still present on outer edge; 5 pellets; other present, often 05 remainder.
05 : appears definite adenomatous
04 : fiber ring on outer edge, white
03 : three - branch branching in 04/05 becoming - appear to be on additional site with 06 remainder
02 : contains what looks like an additional 04
01 : fiber rings still present
Big Bend - Ring Reading Notes

Ring Reader: DROXK

Reading Date: 4/10/07

Site ID: Control - Big Bend

Collection Date: Feb. 2008

Tree/Hole ID: T02_1218_03

Slab ID: 00 A31 - F7/16

Ring Counts/Notes:

J2X Filename: CS2P2J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes:

2001 - 2007

01 - wide - slightly porous
06 - slightly porous - Faded rings still present on outer edge
05 - prisms of new ring on bottom
041 - Faded ring on outer edge, 03 - thin
02 - wide
01 - Faded rings still present, w/ pitch
Big Bend - Ring Reading Notes

Ring Reader: 2B + 1B  
Reading Date: 4/1/08

Site ID:  nest - Big bend  
Collection Date: Feb. 2008

Tree/Hole ID: 732  
Slab ID: 8  

Ring Counts/Notes:

J2X Filename: CS2BJ2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  
Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes:  
2001-2007

07-08 - Wide + upper 05  
05 - Broad + upper 04  
04 - Wide  
03 - Narrow rings present throughout  
02 - Wide  
01 - Narrow rings present throughout width.
### Big Bend - Ring Reading Notes

<table>
<thead>
<tr>
<th>Ring Reader: DD + TR</th>
<th>Reading Date: 4/16/08</th>
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<tbody>
<tr>
<td>Site ID: Redbud Big Red</td>
<td>Collection Date: Feb. 2008</td>
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<tr>
<td>Tree/Hole ID: 722-112612</td>
<td>Slab ID: 1B4, 2B4</td>
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**Ring Counts/Notes:**

- **J2X Filename:** C2P7J2X,7X4

- **Number of radii measured:** 2

**J2X Series Id:**

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<th>Proportion of circumference with secondary growth:</th>
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<tbody>
<tr>
<td>Start Year:</td>
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<td>Start Year:</td>
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</tbody>
</table>

**Wood Anatomy Change Notes:** 2001-2007

- 01: 05 - False rings throughout, wide of pitch
- 04 - Wide
- 03 - Narrow
- 02 - Wide
- 01 - False rings throughout, wide of pitch
Big Bend - Ring Reading Notes

Ring Reader: DD+TE  
Reading Date: 6/26

Site ID:  
Collection Date: Feb. 2008

Tree/Hole ID:  
Slab ID: 11  
23.

Ring Counts/Notes:

J2X Filename: CS28J2X.EXT

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes: 2001-2007

04-07: with Daniel
04-05: 02/07 03-01 05-07 06-07 08-01 06-07
03-10 02-01 04-02 06-07 07-01 08-07
01-07/27 02/07
Big Bend - Ring Reading Notes

Ring Reader: 58  
Reading Date:  

Site ID:  
Collection Date: Feb. 2008  

Tree/Hole ID:  
Slab ID: 14 163 72  

Ring Counts/Notes:  

J2X Filename: C5T2T2K,TXT  

Number of radii measured: 2  

J2X Series Id:  

Proportion of circumference with secondary growth:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes: 2001 - 2007  

01 - 05 - completed  
04 - 05 - Burned > Burned after 03  
03 - 05 - Slightly more-pulp was burned after 01  
01 - Sake rings throughout: w/pitch
Big Bend - Ring Reading Notes

Ring Reader: test
Reading Date: 4/1/08

Site ID: test
Collection Date: Feb. 2008

Tree/Hole ID: test
Slab ID: test

Ring Counts/Notes:

J2X Filename: CS28J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

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<tr>
<th>Start Year</th>
<th>Stop Year</th>
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</table>

Wood Anatomy Change Notes: 2001-2007

01. 08: Compression
03. Difficult to scan due to burials
16. Shows signs of burial

Burial after 01
01. until 1/8/89
Big Bend - Ring Reading Notes

Ring Reader: DJSJR  
Reading Date: 4/15/85

Site ID:  
Collection Date: Feb. 2008

Tree/Hole ID: 
Slab ID: 12 100 1/2

Ring Counts/Notes:

J2X Filename: CS2J2X,CX

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes:  2001 - 2002

Everything Burns after 01
Radii A - Cleaner through 003.
- Path Still Present.
Big Bend - Ring Reading Notes

Ring Reader: [Name]  
Reading Date: [Date]

Site ID: [Site ID]  
Collection Date: Feb. 2008

Tree/Hole ID: [Tree/Hole ID]  
Slab ID: [Slab ID]

Ring Counts/Notes:

J2X Filename: cs2pj2x.2xt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: ____  Stop Year: ____  Proportion: ____
Start Year: ____  Stop Year: ____  Proportion: ____
Start Year: ____  Stop Year: ____  Proportion: ____

Wood Anatomy Change Notes: 2001-2004

- Everything burns after 01
- 01-02 are 0.8-0.9 difficult to identify late rings
- Pith still present
- Measure 1st year only
Big Bend - Ring Reading Notes

Ring Reader: JIR, ____________________ Reading Date: ____________________

Site ID: Castlock ____________________ Collection Date: Feb. 2008

Tree/Hole ID: 28 ____________________ Slab ID: 21 ____________________

Ring Counts/Notes:

J2X Filename: cs28j2x.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: _______ Stop Year: _______ Proportion: _______

Start Year: _______ Stop Year: _______ Proportion: _______

Start Year: _______ Stop Year: _______ Proportion: _______

Wood Anatomy Change Notes:


pith present.
- burial after 2001 - center
Big Bend - Ring Reading Notes

Ring Reader:  D.D. & J.R.  

Reading Date:  4  

Site ID: Castolah  

Collection Date: Feb. 2008  

Tree/Hole ID: 28  

Slab ID: 21-1  

Ring Counts/Notes:

J2X Filename: CS28J2X_EXT  

Number of radii measured:  2  

J2X Series Id:  

Proportion of circumference with secondary growth:

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Start Year:  
Stop Year:  
Proportion:  

Wood Anatomy Change Notes: 2000 - 2003  
- Center = 2000 width  
- Additional center year seen here, may have been on premium ale, but too crooked to see well.  
- Burial after 2000.  
- 2003 very compressed, band discernible.
Big Bend - Ring Reading Notes

Ring Reader: DB + 5R ______________________ Reading Date: 4/1/98

Site ID: Est. 10x ______________________ Collection Date: Feb. 2008

Tree/Hole ID: 12x :: 251 (a) ______________________ Slab ID: 22

Ring Counts/Notes:

J2X Filename: c52pj2x.txt

Number of radii measured: 2

J2X Series Id: ______________________

Proportion of circumference with secondary growth:

Start Year: ______ Stop Year: ______ Proportion: ______

Start Year: ______ Stop Year: ______ Proportion: ______

Start Year: ______ Stop Year: ______ Proportion: ______

Wood Anatomy Change Notes: (2000 - 2002)

appears to be a new ring present in 2000

- Everything weird after 2001
- Pith still present
- CA - 02 = measure only
- 2003 not clear enough to measure - compressed
Big Bend - Ring Reading Notes

Ring Reader: D.J. Tidwell
Reading Date: 4/16

Site ID: Cablon
Collection Date: Feb. 2008

Tree/Hole ID: 7/4-11/16
Slab ID: 24

Ring Counts/Notes:

J2X Filename: CS28J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:
Start Year: Stop Year: Proportion:

Wood Anatomy Change Notes: (1999-2001)

Everything went off in 01; some Renew signs in 01.
- New zone - 1999 center
- Pith present
Big Bend - Ring Reading Notes

Ring Reader: 991178  Reading Date: 4/1/08

Site ID: 06-06178  Collection Date: Feb, 2008

Tree/Hole ID: 10535/11056  Slab ID: 25

Ring Counts/Notes:

J2X Filename: CS28J2X.txt

Number of radii measured: 2

J2X Series Id:

Proportion of circumference with secondary growth:

Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:
Start Year:  Stop Year:  Proportion:

Wood Anatomy Change Notes: (1999-2000)

- center-1999
- earliest/oldest ring in middle (??)
- all annual after 00.

- Still pith round
**Big Bend - Ring Reading Notes**

**Ring Reader:** J.K.                                                                 **Reading Date:**

**Site ID:** Castolon                                                            **Collection Date:** Feb. 2008

**Tree/Hole ID:** T 28                                                           **Slab ID:** 26

**Ring Counts/Notes:**

**J2X Filename:** CS 28 J2X.txt

**Number of radii measured:** 2

**J2X Series Id:**

**Proportion of circumference with secondary growth:**

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

Start Year: Stop Year: Proportion:

**Wood Anatomy Change Notes:** (1999 - 2000)

- center still present.
- pith still present.
Big Bend - Ring Reading Notes

Ring Reader: IL. ____________________  Reading Date: ____________

Site ID: Castolon ____________________  Collection Date: Feb. 2008

Tree/Hole ID: T28 ____________________  Slab ID: 28 ____________

Ring Counts/Notes:

J2X Filename: CS28J2X.txt ____________

Number of radii measured: 2 ____________

J2X Series Id: _______________________

Proportion of circumference with secondary growth:

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Wood Anatomy Change Notes:

- end of tree center - 1999
- with present
- burned after '99
- potential estate year is 1999.
B1 & BEND - Castolon - Trees 28

(willow)

4/1/2008

J. Rock

Page 1 of 3

335

(r=12.5cm)

CS: 28.0

(r=6cm)

CS: 28.65

(r=7cm)

CS: 28.10

(r=10cm)

CS: 28.11

(r=8cm)

CS: 28.12

(r=14cm)

CS: 28.2

(r=7cm)

CS: 28.3

(r=6cm)

CS: 28.4

(r=4cm)

CS: 28.5

(r=4.5cm)

CS: 28.6

(r=5cm)

CS: 28.7
Big Bend - Castolon

Tree 28 (willow)

<table>
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<tr>
<th>Section</th>
<th>Image</th>
<th>CS</th>
<th>Reil</th>
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<tr>
<td>(7 cm)</td>
<td>![Image]</td>
<td>CS.28.8</td>
<td>( \frac{E_6}{E_3} )</td>
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<tr>
<td>(5 cm)</td>
<td>![Image]</td>
<td>CS.28.9</td>
<td>( \frac{E_5}{E_4} )</td>
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<tr>
<td>(20 cm)</td>
<td>![Image]</td>
<td>CS.28.10</td>
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<tr>
<td>(10 cm)</td>
<td>![Image]</td>
<td>CS.28.11</td>
<td>( \frac{E_4}{E_3} )</td>
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<tr>
<td>(5-17 cm)</td>
<td>![Image]</td>
<td>CS.28.12</td>
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<tr>
<td>(2-3.5 cm)</td>
<td>![Image]</td>
<td>CS.28.13</td>
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<td>(5 cm)</td>
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