Neal W. Ackerly received his doctorate in anthropology from Arizona State University in 1986. In the mid-1980s, he directed a number of projects focusing on the dynamics of prehistoric irrigation systems in central Arizona. Working in New Mexico over the past ten years, he has documented historical interactions between small- and large-scale irrigators and the rivers on which they depend. His studies encompass large federal irrigation projects (EBID, MRGCD) as well as smaller community acequia systems in the Mimbres, Ruidoso, Peñasco, and Velarde areas. Among other efforts, he recently prepared an overview of the historical development of irrigation systems across New Mexico.

The Evolution of the Rio Grande

I appreciate Tom Bahr's invitation to speak with you this morning about the evolution of the Rio Grande basin. As you might guess from the paper title, what I want to present, in an abbreviated fashion, is just a smattering of historical information about how the Rio Grande basin has changed since it was first viewed by Spanish explorers.

However, Tom should probably have subtitled this talk something along the lines of "All the stuff that we think we know, but are not quite certain about." Why all the uncertainty? It is not that the historical record lacks information about the Rio Grande. Instead, historical records have simply not been examined in sufficient detail to allow us to develop a comprehensive overview of the evolution of the Rio Grande.

In my very short time at the podium, I want to focus on only a small set of issues. These include a brief consideration of long-term fluctuations in runoff, the changing character of the river channel, and the character of vegetation communities along the banks of the Rio Grande. These issues were important in the past and remain important to water-users even today.

The Rio Grande as we view it today has been subject to manifold impacts whose origins can be traced back more than 400 years. Some of these impacts are due to naturally occurring fluctuations in the environment, while others are more directly linked to man's activities. In some cases, man's activities have made worse the tenuous environmental conditions that normally prevail in arid environments.

One interesting aspect of the Rio Grande basin are long-term fluctuations in flows or discharges. While these numbers are a bit out of date, covering only the period 1895-1969, they indicate that the annual discharge at San Marcial was 569,063 acre-feet, while the annual discharge at El Paso was 943,211 acre-feet. At the same time, the standard deviations in river flow are so high (398,868 and 578,143, respectively) that average river flows are estimated to have fluctuated between 616,737 - 521,389 acre-feet at San Marcial and between 874,110 - 1,012,312 acre-feet at El Paso 95% of the time during the last century. Figures 1-3 make clear that the flow of the Rio Grande varied annually, but it is equally clear that these flows varied seasonally. As a consequence, main stem flow of the Rio Grande, rather than remaining constant throughout much of the year, more closely resembles a pulsed flow with alternating periods of increased discharge followed by periods of relatively low discharge.

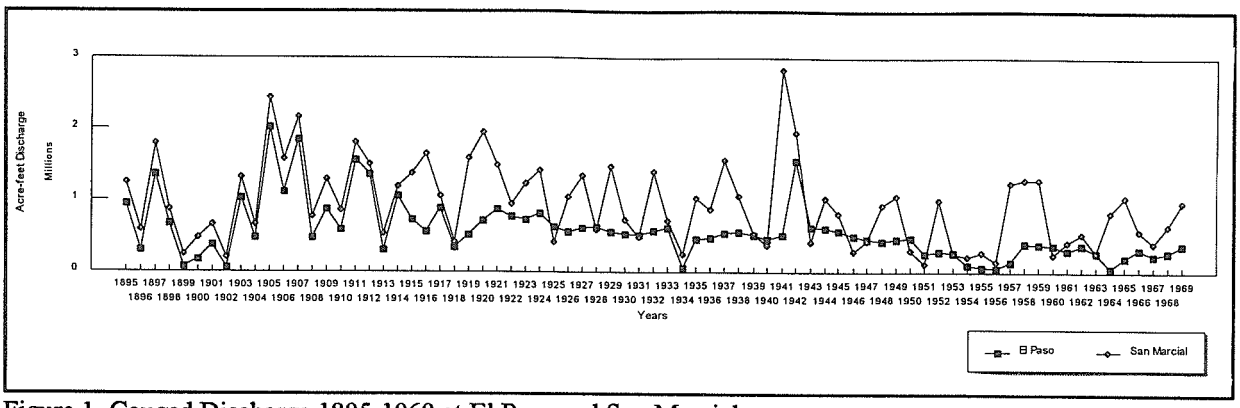

Figure 1. Gauged Discharge 1895-1969 at El Paso and San Marcial

Further, gauging stations have been present since 1887 and provide at best only a glimpse of long-term annual fluctuations in the Rio Grande's discharge. It is important to understand how the river's flow varies over much longer periods of time simply because today we are trying to plan and allocate waters from a river basin whose discharge characteristics are highly variable.

Tree-ring records provide much longer time frames for examining climate fluctuations, while reconstructed drought severity indices lend support to the notion that there has been considerable environmental variability since 1700. Palmer Drought Severity Indices (PSDI) indicate moderate droughts in 16 of 278 years, severe droughts in 20 of 278 years, and extreme droughts in 5 of 278 years. Severe to extreme droughts therefore occur on average once every 10 years. Moderate to extreme droughts occur on average about once every 7 years.

It is harder to calibrate these reconstructions so that you can determine when the flow of the Rio Grande was sharply reduced or ceased altogether. Nevertheless, historic narratives, while spotty, largely confirm these fluctuations. Quoting Baron Alexander von Humbolt (1811(2):312): "The inhabitants of the Paso del Norte [El Paso, TX] have preserved the recollection of a very extraordinary event which took place in 1752. The whole bed of the river became dry all of a sudden for more than thirty leagues [78 miles] above, and twenty leagues [52 miles] below the Paso [for several weeks]." In 1760, Bishop Tamarón commented that the town of Tomé was the best in the kingdom, at least in part because the Rio Grande "keeps flowing there." The fact that this town was situated based on this factor implies that this was not the case in other parts of the basin, that is, that surface flows periodically disappeared along the river's length. In Josiah Gregg's narrative of his 1844 traverse down the length of the Rio Grande he commented in passing near Valverde that "the best lands of the settlements remain unfruitful for want of water" (Gregg 1933 (reprint):269).

In his report on the 1850-1853 U.S. - Mexico Boundary Survey, John Bartlett commented (Personal Narrative of Explorations and Incidents 1965 (reprint):186-188):

> "The freshets that take place are owing to the melting of snows in the Rocky Mountains. These are not of yearly occurrence; for during the summers of 1851 and '52, there were none. The river not only did not swell or overflow its banks, but in the former year it became quite dry near El Paso, all the water being transferred to the acequias. . .I was told by a gentleman at San Eleazario [sic], twenty-five miles below El Paso, that the summer of 1852 was the first one in five years where there had been sufficient water to irrigate all the lands of that vicinity which had been put under cultivation."

This implies that the river had been extraordinarily low or even dry (see below) each summer between 1847-1851. Remember, at this time the San Luis Valley of Colorado had barely been settled, Colorado was not using water from the Rio Grande in substantial amounts, and the Mesilla Valley had been occupied for less than a decade.

Similarly, W.W. Follett's (1898) publication "Equitable Distribution of Waters of the Rio Grande" contains the comment:

> "A. That the river went dry many years before the large use of water in Colorado began. The records show that in 1851 it [the Rio Grande] was dry as far north as Socorro, N. Mex. Again in 1860 or 1861 it was dry in the Mesilla Valley, and 1879 was the driest year of record prior to 1889, the flow ceasing nearly or quite as far north

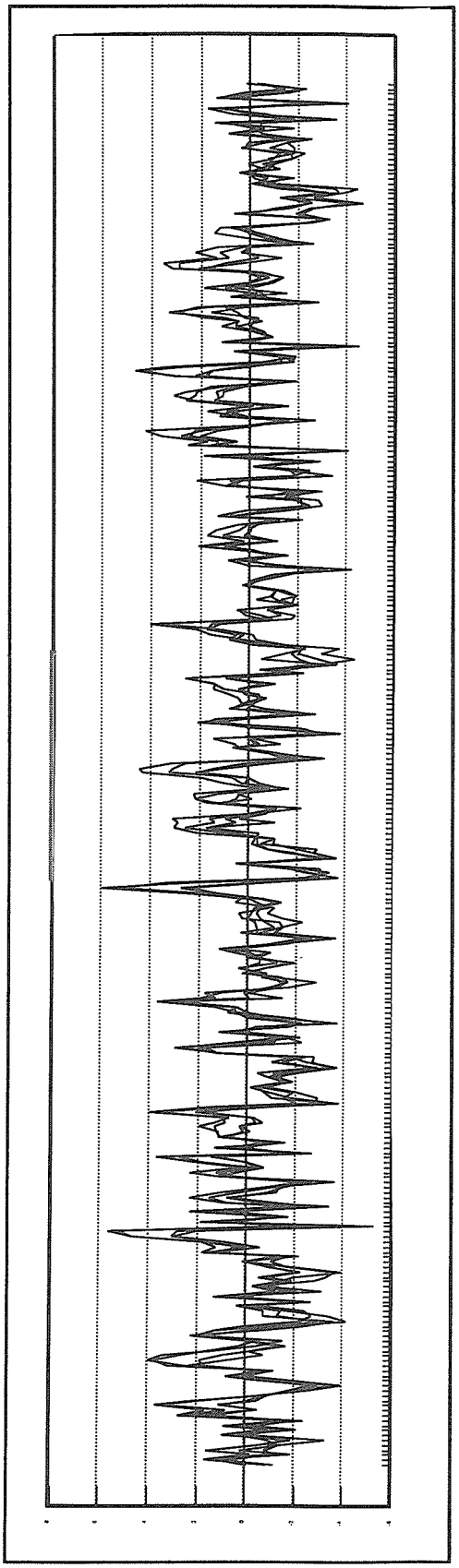

Figure 2. Reconstructed Palmer Drought Severity Indices, Years 1700-1978

as Albuquerque. In 1889 it was dry for over four months at El Paso, and this dry river was continuous farther north than Albuquerque" (Pg. 100).

"C. In 1889, for instance, the records show a large volume of water in the river at Del Norte [Colorado] and the channel dry from Albuquerque southward, while in 1894, with a very small amount in the river in the San Luis, it did not go dry at Albuquerque, but was dry thirty days for a long distance below there, and was not dry for any length of time in the Mesilla Valley" (Pg. 100).

The technical name for what is being described here is an "exotic" river in which flows typically diminish with distance from headwaters and/or ones in which surface flows periodically disappear beneath the bed of the river, only to reappear some distance downstream when (typically) impermeable subsurface dikes force water up toward the surface of the river's bed.

In short, the Rio Grande did not always flow every year and certainly did not flow in the same amounts from year to year. Equally important, not all portions of the Rio Grande contained water even during the same year; instead, surface flows ceased in some parts of the river while other parts of the river continued to have surface water.

A second aspect of the character of the Rio Grande revolves around flooding and avulsive changes in channel locations. What is perhaps ironic is that the correlation between annual discharge and maximum flood events is relatively low. Gauging station data from San Marcial, above Elephant Butte Dam, shows that only about 56% of the variability in flood magnitudes can be attributed to annual discharge ($r = 0.7491$). In other words, floods occur not only in high discharge years, but in years when discharge is quite low. In short, you could get flooded even in the midst of a drought due, probably, to localized high-intensity rainfall events.

Flooding is important in the region's ecology since, prior to channelization and damming of the Rio Grande, it was responsible for causing avulsive changes in channel locations. In short, the main channel of the Rio Grande simply moved. . .sometimes by as much as two miles. If you doubt the accuracy and impact of such channel changes, just ask old-timers in Mesilla which side of the river the town used to be on.

Associated with avulsive channel changes were the formation of oxbow cutoffs and oxbow lakes. For example, there are relatively few people in Las Cruces who know about, much less could locate, Lake Considine. Early observers often commented that the Rio Grande contained numerous sloughs and oxbow lakes.

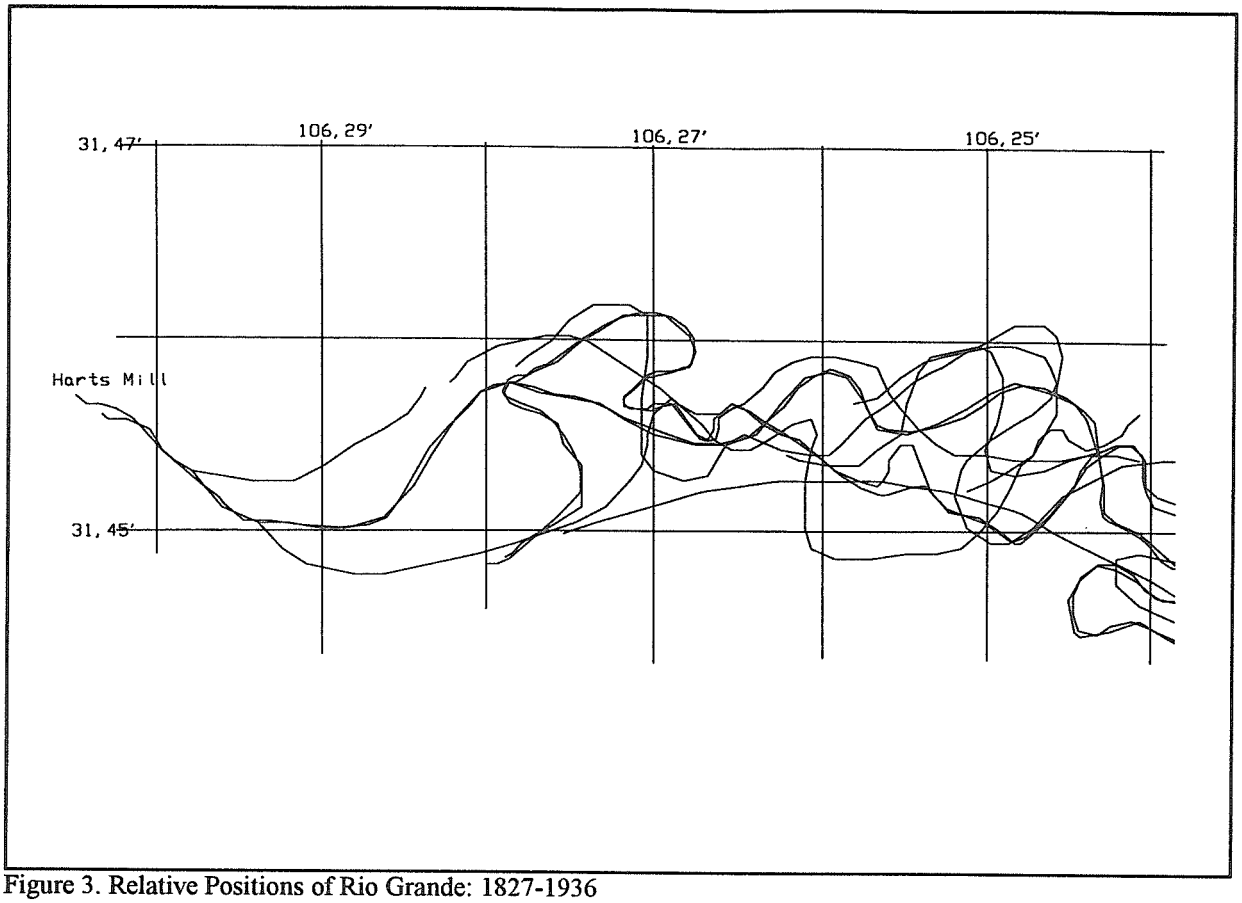

Figure 3. Relative Positions of Rio Grande: 1827-1936

1582: This [La Cienega Grande south of El Paso] is formed by the Turbio [Rio Grande] river when it overflows its banks. . .We named this site Los Charcos de Canutillo because there were numerous reeds and large marshes and pools with quantities of fish close by the river (Hammond and Rey 1966 (reprint):169).

1582: . . .we traveled upstream [south of El Paso] another four days and came upon large numbers of people who lived near several lakes through which the Rio del Norte flows. . .and many varieties of fish which abound in those lakes (Hammond and Rey 1966 (reprint):218).

1583: We set out from this place [Elephant Butte] on the thirty-first of January and went four leagues [north] to a marsh which we named El Mal Pais (Hammond and Rey 1966 (reprint):72-73).

1626: It has likewise many rivers in which are fish of great abundance; and great sloughs and particularly the Rio del Norte (Ayer 1916 (reprint):36-37).

1773: . . .but the river [Rio Grande] abounds in fish, known as rock fish, although some call it bream. Other delicious kinds are the corazon and the anguila [eels], all of more than medium size. The anguilas are found more often in the ponds formed by the overflow of the river than in its channel (Hackett 1942:507-508).

Even as late as 1850, Bartlett camped along a mile-long lake at San Diego crossing, near modern-day Hatch. All evidence of this lake is now gone.

The channel itself appears to have varied as much as the flows that came down it. Vintage reports again suggest that the Rio Grande's channel was not particularly impressive:

1626: And it is called the Rio Bravo [Rio Grande] and must have a width of one shot of an arquebuse (Ayer 1916 (reprint):71).

March 7, 1805: We crossed the Rio del Norte, a little below the village of Albuquerque where it was 400 yards wide, but not more than three feet deep and excellent fording (Coues 1965 (reprint): 401).

September 26-30, 1846: We crossed the Rio Grande del Norte at Albuquerque, its width was about twenty-five yards, and its deepest part just up to the hubs of the wheels. It is low at present, but at no time, we learned, is its rise excessive--scarcely exceeding one or two feet. (Emory, Notes of a Military Reconnoissance, 1951 (reprint):79).

October 9, 1846: We are now 203 miles [downstream] from Santa Fé, measured along the river. A cross section of it [Rio Grande] at this point is 118 feet wide, with a mean depth of 14 inches, flowing over large round pebbles, making it unsuitable for navigation with any kind of boats (Emory, op. cit.: 91).

1846: At Albuquerque we forded the river, which is about two feet deep and twenty-five yards wide (Cooke, Narrative, 1952:39).

1850: . . . the opinion entertained was very decided that loaded boats would not be able to make the passage in safety, even at the highest stage of water--at low water it would be perfectly impracticable (McCall, 1968 (reprint):91).

In short, the Rio Grande did not always flow every year and certainly did not flow in the same amounts from year to year. Equally important, not all portions of the Rio Grande contained water even during the same year...
Neal Ackerly

1850: The river near the town [El Paso] varies in width from 300 to 600 feet. It is muddy and sluggish except during freshets. . . (Bartlett, Boundary Commission Report, 1965 (reprint):186).

November 7, 1853: At Pajarito the river bottom is wide and low as at Albuquerque. The distance between them [Isleta Pueblo and Pajarito] is about eight hundred feet. The bed of the river is sandy, and the depth of water three to four feet (Foreman 1941 (reprint):109).

November 13, 1853: The river here [near Albuquerque] is full of sand bars. At one place we plucked a reed, "arundo phragmites", and without difficulty threw it across the river, which at that place was no more than 50 feet wide to the bar, but the water is now very low (Möllhausen, 1858:65-100).

1860: The Rio Grande at the confluence of the Rio Galisteo is "nearly 300 yards wide, but it is very shallow, and runs mostly over a bed of moving sand. . ." (Domenech 1860:196).

October 3, 1878: Where the river was gauged at Palomas [near T or C] the width is 465 feet, and the greatest depth only 2.1 feet. At Ft. Selden the width is 368 feet and the greatest depth but 2.2 feet (Wheeler 1880:248).

Accordingly, the historic character of the Rio Grande appears to have consisted of continuously changing channels, sometimes narrow and braided and other times not. The floodplain of the Rio Grande contained oxbow lakes that simultaneously formed refuges for many animal species during periods of low flow and breeding grounds for other species, notably insects, that contributed greatly to the region's reputation as a malarial wasteland. Anybody wondering why Ft. Selden was established need only read correspondence files to find that one of the more important factors was to get soldiers away from marshes containing malarial mosquitos.

It logically follows that riparian plants and animals along the Rio Grande must have been adapted to pronounced fluctuations in water availability, both seasonally and annually. Gallery cottonwood forests were common as far north as Albuquerque, but began to disappear shortly after the arrival of the Spanish. For example, the Bosque Grande de San Francisco Xavier along the east site of the Rio Grande near Albuquerque began to disappear by the early 1700s, due in part to woodcutting (Scurlock 1998:185). Indeed, as early as 1692, Vargas found that Zia Pueblo had little or no firewood in the immediate vicinity.

The cumulative impact of wood use for fuel and construction was such that, by the 1840s, early American observers found that much of the area north and south of Albuquerque was without wood. In 1846, for example, both Wislizenus and Emory found few trees. Henry Turner, also in 1846, found that fuelwood was scarce to absent from San Felipe to Socorro, with only a few isolated cottonwood groves appearing from time to time. Abert, again in 1846, commented that "no wood is to be obtained within less than 9 or 10 miles of Albuquerque," again suggesting that the basin here was largely denuded. By 1849, Simpson observed that Albuquerque residents now had to travel as much as 25 miles to obtain fuelwood (McNitt 1964:152, 154). As a consequence, travelers routinely relied on so-called "Texas wood"—manure—for cooking when traversing through the Albuquerque region. The progressive denudation of the river's margins was probably among one of the more important factors contributing to flooding and sedimentation so notable during the late nineteenth and early twentieth centuries.

I don't normally discuss policy implications, not because I don't want to, but because nobody will pay my fees. Nevertheless, I want to close with a few thoughts about what the historical record suggests about approaches for managing water in the Rio Grande.

First, we cannot manage a system whose characteristics we don't understand and I don't believe for a second that we understand the hydrology of the Rio Grande. Gaging station data are simply too limited in terms of time depth to form a rational basis for allocating water for agricultural and M&I use. As the Palmer Drought Severity Indices show (Figure 2), long-term averages in the Rio Grande's discharge are almost meaningless in the face of such profound variability. We might be better advised to consider planning our water use based on the probabilities that water in given quantities will be available. This is more complex as a management strategy and necessarily requires greater time depth than the past century for long-term planning. In turn, this may require that we undertake an integrated project to define more precisely what these long-term probabilities are, perhaps relying on tree-ring data and historic records of the kind I have mentioned here.

Second, there will undoubtedly be years when there are "surpluses"–water in excess of the amounts required for agricultural, municipal and industrial users. Under these circumstances, we would be well advised to "bank" these surpluses, perhaps by committing ourselves to an integrated groundwater recharge program. For as sure as there are surpluses, there will be deficits. Just ask anybody who struggled through the 1950s drought.

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