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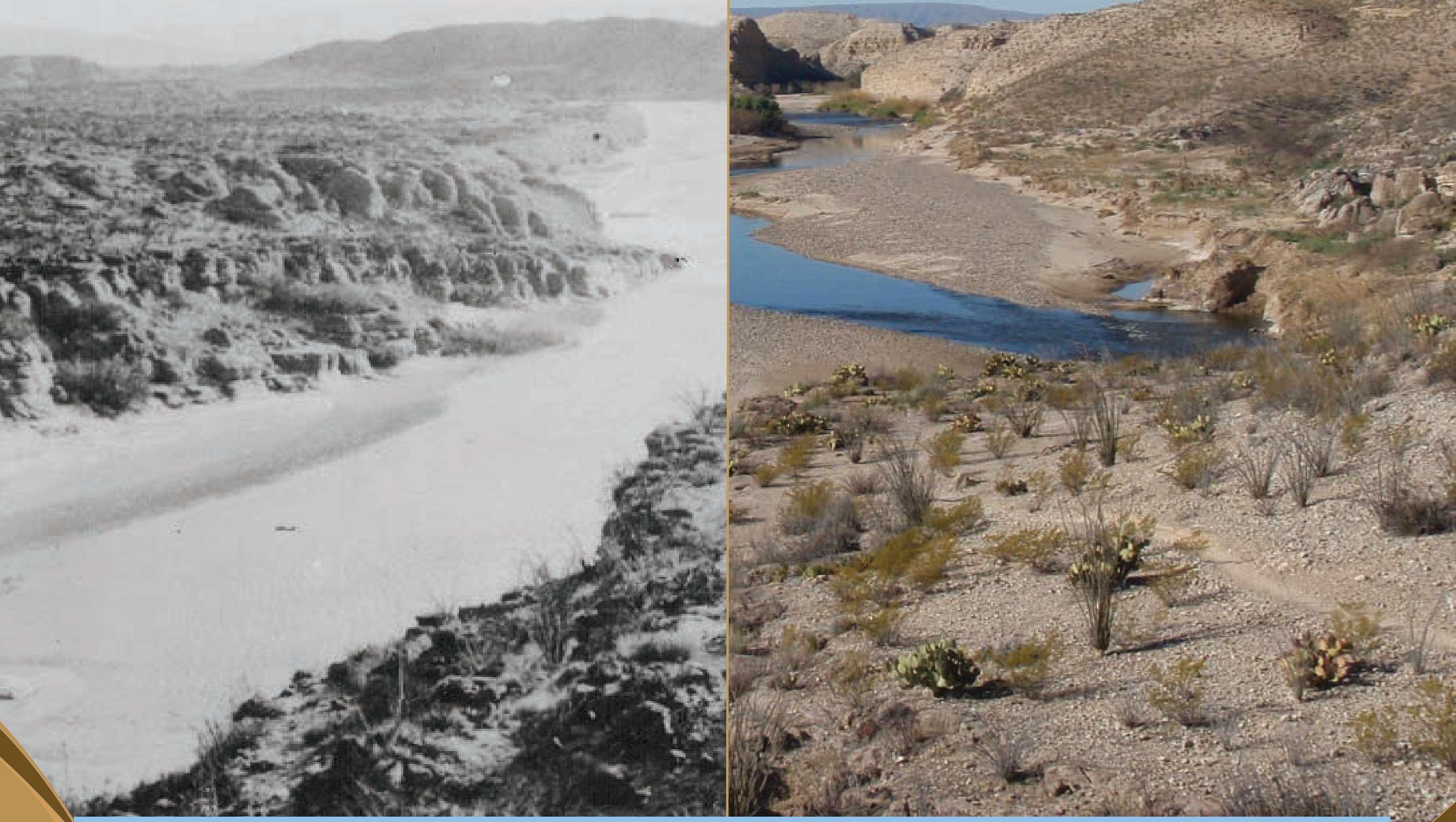
Prepared in cooperation with the National Park Service, Utah State University, Sul Ross State University, World Wildlife Fund, Alpine Test Services, Rio Grande Scientific Support Services, and RiversEdge West

A River of Change—The Rio Grande in the Big Bend Region



The Rio Grande in Hot Springs Canyon, Texas, Big Bend National Park. Left side image taken in 1901 by H.C. Oberholser, right side image taken in 2008 by David J. Dean, U.S. Geological Survey.

Introduction

The Big Bend region is located within the heart of the Chihuahan Desert of North America. Within this region, the Rio Grande, referred to as the Rio Bravo in Mexico, is the international border between the United States and Mexico. The area known as the Big Bend is named after the large northerly bend that the river makes before flowing southeast to the Gulf of Mexico. This region is environmentally protected by both countries. Although large binational conservation efforts exist, the physical and ecological characteristics of the river have been substantially altered. Changes in Rio Grande hydrology (the seasonality, magnitude, duration, and variability in streamflow) have resulted in the widespread physical transformation of the river, resulting in the loss of important habitat for native and endangered fish and increased flood risk. U.S. Geological Survey (USGS) scientists, in cooperation with many other government agencies, universities, and non-governmental organizations (NGOs), are working to better understand these changes to inform management of the Rio Grande.

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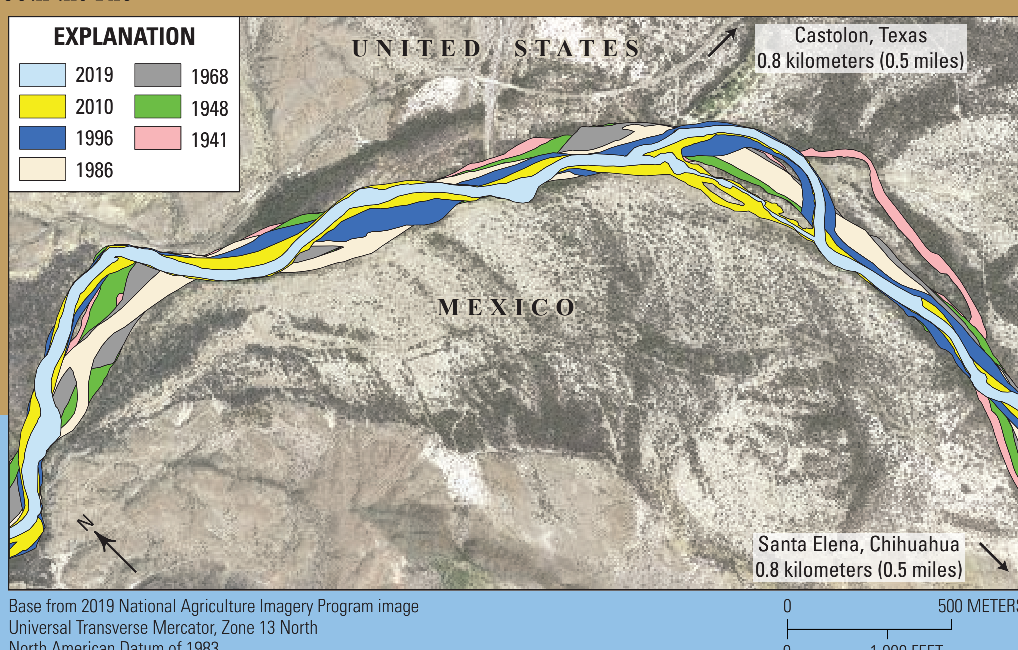
Regional map of the Rio Grande Basin (*A*) and map of the Big Bend Region (*B*). In *A*, the Rio Grande basin is shown by the dash-dot black line. In *B*, places numbered 1–6 refer to (1) Presidio, Texas, (2) Ojinaga, Chihuahua, (3) Castolon, Texas; (4) Santa Elena, Chihuahua; (5) Rio Grande Village, Texas; and (6) Boquillas, Coahuila.

Historical Changes in Hydrology

In the late 1800s, Rio Grande streamflow in the Big Bend region was dominated by two large flood pulses, a spring snowmelt pulse from the northern branch of the Rio Grande in Colorado and New Mexico, and a summer/fall monsoon pulse caused by rainfall in the Rio Conchos Basin in Chihuahua, which is a large Mexican tributary. These two pulses were approximately equal in magnitude, and high flows in the Big Bend segment of the Rio Grande occurred for nearly 6 months annually.

Diversions of streamflow from the northern branch of the Rio Grande (upstream from Presidio, Texas/Ojinaga, Chihuahua) dramatically increased in the late 1870s and large dams were constructed on both the Rio Grande and the Rio Conchos in the early and mid-1900s. Dam construction and management, combined with increased agricultural and consumptive water use, resulted in declines in both the total amount of streamflow and flood magnitude, with the largest declines occurring in the 1940s, during the onset of a regional drought. It was during this time of low streamflow and small floods that major changes to the Rio Grande channel and floodplain began to occur.

Photograph of the Rio Grande, looking upstream, approximately 20 kilometers downstream from Castolon, Texas, and Santa Elena, Chihuahua. Photograph by George Grant, National Park Service, 1936.



Historical channel boundaries of the Rio Grande near Castolon, Texas, in Big Bend National Park, and Santa Elena, Chihuahua, in the Cañon de Santa Elena Protected Area. Boundaries were delineated on historical aerial photographs.

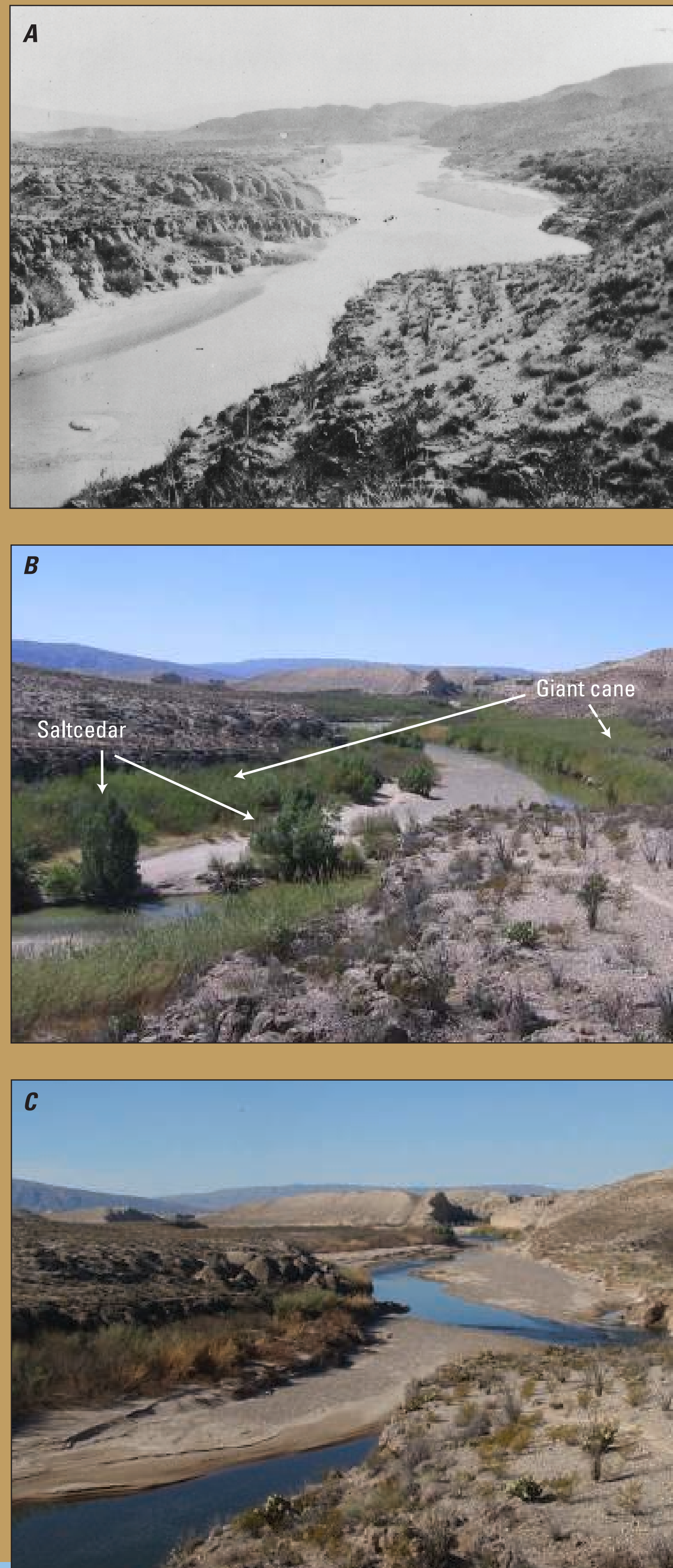
Channel Narrowing and Floodplain Expansion

In the Big Bend region, the Rio Grande flows through both wide valleys and narrow canyons. When not constrained in canyons, the channel of the Rio Grande in the late 1800s was wide, had multiple channels, and was prone to sudden changes in its course during large floods. As total streamflow and flood magnitude declined, the channel began to narrow. This narrowing occurred because ephemeral tributaries naturally supplied large amounts of sediment to the Rio Grande during flash floods, but there were fewer large, long-duration floods able to transport the large volume of tributary-supplied sediment downstream. When there are no large floods within the Rio Grande, much of this tributary-derived sediment accumulates within the channel and causes channel narrowing. When these sediment deposits are not eroded by large floods, vegetation grows on these surfaces and helps trap additional sediment. Over time, these new deposits evolve into floodplains. In the wide valleys of the Rio Grande, sediment deposition, vegetation establishment, and floodplain growth resulted in average reductions in channel width of approximately 50 percent since the 1940s. These processes resulted in the conversion of the Rio Grande from a wide, laterally unstable river with multiple channels and sparse riverside vegetation, to a laterally stable river with one channel and dense riverside vegetation.

The physical transformation of the Rio Grande has had important consequences. First, as channel narrowing occurred, many of the wide parts of the channel, where there was slow-moving water, have filled with sediment. These low-velocity habitats are important for the rearing and growth of native and endangered fish, and channel narrowing has had a negative effect on these important habitats. Second, there has been an increase in the number of floods that negatively impact riverside communities and historical sites, because the now narrow river can no longer convey floodwaters without spilling out of its channel.

Channel-Reset Floods

Occasional large floods, called channel-reset floods, can cause widespread erosion, thereby temporarily reversing the narrowing that occurs during years with small floods. Channel-reset floods are usually driven by large amounts of rainfall caused by tropical storms and hurricanes in the Rio Conchos Basin. These rainfall events can fill upstream reservoirs, requiring large dam releases that cause flooding downstream. A channel-reset flood in 2008 resulted in 26–52 percent channel enlargement in the wide valleys of the Rio Grande; however, rapid channel narrowing resumed shortly thereafter. In the early 1900s, floods of similar magnitude to channel-reset floods occurred approximately once every four years, which maintained a much wider channel during that period. Today, floods of this magnitude occur once every decade or two.



Photographs of the Rio Grande taken from the same location in Hot Springs Canyon, Texas, in Big Bend National Park. Photograph *A* was taken in 1901 by H.C. Oberholser. Photographs *B* and *C* were taken before and after the 2008 channel-reset flood, respectively. Note the much narrower width of the channel between *A* and *B*, the stands of nonnative vegetation (saltcedar and giant cane) in *B*, and the extensive widening caused by the 2008 channel reset flood in *C*. Photographs *B* and *C* by David J. Dean, U.S. Geological Survey.

Management of Sediment and Vegetation

Regional environmental managers in the United States and Mexico are exploring options to limit channel narrowing, the degradation of instream habitat, and the threat of increased flooding that occurs between channel-reset floods. Changes to channel and floodplain topography are measured regularly by USGS and National Park Service (NPS) scientists, in cooperation with many other partners. These surveys are conducted to determine the ongoing rate and magnitude of channel and floodplain change, and whether these changes vary between the wide valleys and canyon-bound reaches. The USGS also continuously measures sediment transport within the Rio Grande to quantify the amount of sediment eroded or deposited within the river during floods (https://www.gcmrc.gov/discharge_qw_sediment/). These measurements allow researchers to evaluate how the management of streamflow from upstream dams may be used to help reduce channel narrowing during low flow years. Sediment transport data and measurements of channel and floodplain topography indicate that large releases from upstream dams that last many weeks or longer can be effective at eroding sediment and creating new aquatic habitat. However, floods much larger than the typical dam releases are required to fully offset the accumulation of sediment in the channel.

Vegetation removal and other biocontrols may improve the ability of long-duration dam releases to cause channel widening. Nonnative vegetation, consisting of giant cane (*Arundo donax*) and saltcedar (*Tamarix spp.*) is being removed by the NPS, the State of Texas, and other NGOs in order to increase native plant biodiversity, and to encourage bank erosion during floods. Biocontrol measures, consisting of a wasp (the arundo wasp, *Tetramesa romana*) that is parasitic to giant cane and a beetle (the tamarisk beetle, *Diorhabda spp.*) that feeds on saltcedar leaves, have also been released to help control these nonnative plants. The long-term physical and ecological responses to these management efforts are currently being evaluated.

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Upstream view of the Rio Grande within Boquillas Canyon, taken by David J. Dean, U.S. Geological Survey.

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