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# CHANGES IN RIPARIAN VEGETATION IN THE SOUTHWESTERN UNITED STATES:
## Repeat Photography at Streamflow Gaging Stations

USGS GROUND WATER RESOURCES PROGRAM

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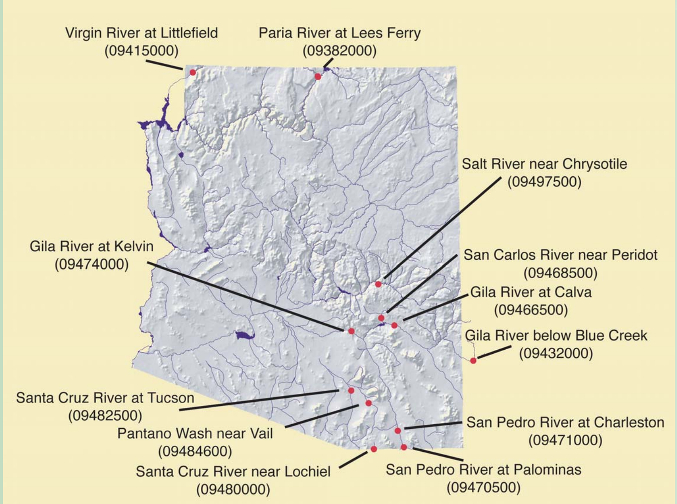
### INTRODUCTION




As part of the regular operation of surface-water gaging stations in Arizona, photographs are taken to document channel conditions. The photographs show many features of the channel that are important to accurate streamflow gaging, including shifts in channel thalwegs (the deepest point in the channel), changes in low-water controls, and changes in channel roughness. Photographs have been taken since gaging stations were first established in Arizona in the 1910s, and many photographs were taken in the 1920s and 1930s.

Now, these photographs provide an invaluable record for evaluating changes in the riverine environment of the major water courses in Arizona. Riparian vegetation in particular is highly valued because of its biodiversity, wildlife habitat, and ability to favorably alter water quality. The long-term status of riparian ecosystems in the southwestern United States is much debated. Water development is frequently blamed for decimation or elimination of riparian ecosystems. Floods may damage or destroy vegetation within channels, and changes in flood frequency may cause damage to floodplain structures, agricultural fields, and water- and irrigation-supply systems. Increases in channel roughness may create higher stages during floods, raising the possibility of increased frequency of flood damage.

The photography at gaging stations documents long-term changes in the riverine environments of Arizona. The images shown here are selected to illustrate the range of changes, which include large increases in native and non-native vegetation at most sites; complete elimination of riparian vegetation at some sites; and channel downcutting, lateral channel changes, and deposition of new fluvial terraces. The causes of many of the changes are not obvious. At some sites, riparian vegetation has increased despite the occurrence of large floods, flood control, or streamflow diversions. Despite the 20th century spread of tamarisk along the state's rivers, native species have increased as well. These photographs well illustrate the fact that Arizona's rivers have unstable channels and fast-changing riparian ecosystems, and management practices designed to protect Arizona's riparian ecosystems may benefit with this information.

### VIRGIN RIVER AT LITTLEFIELD (09415000)

(June 4, 1942). This downstream view from a bluff above the Virgin River shows the gaging station at Littlefield, Arizona, in the extreme northwestern part of Arizona. The channel was relatively wide and free of vegetation, with cottonwoods along river right (right side of the photo) and mesquites and tamarisks along river left. Although the river is used extensively for irrigation and domestic water supply, no dams have been built across the main channels (James Baumgartner, #3601).

(October 30, 2000). Despite several large floods in the intervening 58 years, including a January 1,1989, flood caused by the breaching of an off-channel dam upstream, riparian vegetation has increased in this reach. Most of the foreground vegetation is native, including cottonwood trees, arrowweed, mesquite, and catclaw. At lower right, a marsh containing reeds, cattails, and phragmites has developed. On river left, native coyote willow lines the bank, and a prominent zone of tamarisks with occasional cottonwood appears behind. The vertical bank at center is in a small floodplain terrace that developed after 1942 (Dominic Oldershaw, Stake 1727).

### PARIA RIVER AT LEES FERRY (09382000)

(ca. 1964-1968). In this upstream view, the photographer documented channel conditions in the reach just upstream from the gaging station. A small cottonwood tree appears at right center, just right of a relatively straight channel reach that undoubtedly was used for indirect-discharge estimates. The shrubs on both sides of the river are probably tamarisk, with other perennial shrubs on the broad floodplain at right (photographer unknown).

(January 19, 1984). The channel of the Paria River has changed significantly in this view. The cottonwood tree is gone, probably killed during one of the relatively small floods that have swept down the Paria River since the original photograph. The array of terraces suggests that considerable sediment has been stored along the floodplain on river left, probably during floods in 1980. Sediment has been removed from the floodplain on river right; note the near-vertical bank at left. The fence that once kept livestock out of the channel has been removed by erosion (Richard Hereford, Stake 1379).

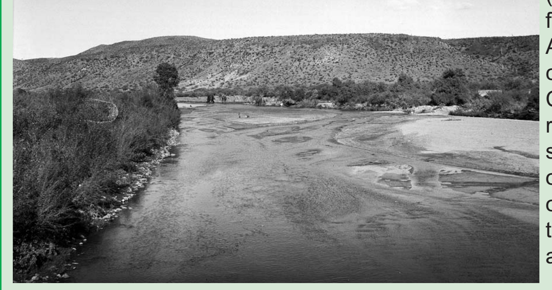
### SALT RIVER NEAR CHRYSOTILE (09497500)

(November 26, 1935). This upstream view from the old, two-lane bridge that crosses the Salt River in Salt River Canyon shows a relatively small discharge of 277 $ft^3/s$. Scattered native shrubs, including willows and brickellbush, appear to occupy the floodplain at right center. The road leading to Show Low, Arizona, appears as a one-lane cut through the hillslope at center (R.E. Cook, #2280).

(June 25, 1964). The water is low (about 97 $ft^3/s$), exposing the bedrock that forms the channel bed and the low-water control downstream from the gaging station. In the intervening 29 years, three floods with peaks of greater than 50,000 $ft^3/s$ passed through this reach. Tamarisk is interspersed with the native shrubs on the floodplain, and tamarisk lines river left, which was mostly devoid of woody vegetation in 1935. Palm trees (lower right), which are not native to this area, were planted as part of a roadside park well before this photograph was taken. The roadcut on the skyline has been widened (Raymond M. Turner).

(October 25, 2000). The water level is only slightly higher than in 1964. In the intervening 36 years, two floods exceeded 70,000 $ft^3/s$ and four have exceeded 50,000 $ft^3/s$. Despite these floods, riparian vegetation along the banks has increased, particularly non-native tamarisk. The palm trees have grown considerably (Dominic Oldershaw, Stake 363).

### SAN CARLOS RIVER NEAR PERIDOT (09468500)



(October 21, 1941). In this upstream view from the old bridge just south of San Carlos, Arizona, native shrubs and scattered cottonwoods line the wide channel. The San Carlos River near Peridot is a very difficult river to gage accurately because of a high sediment load and shifting channel. A flood of 40,600 $ft^3/s$ passed through this reach only 7 months before this photograph was taken, contributing to the scoured appearance of the channel (A.J.H., #3550).

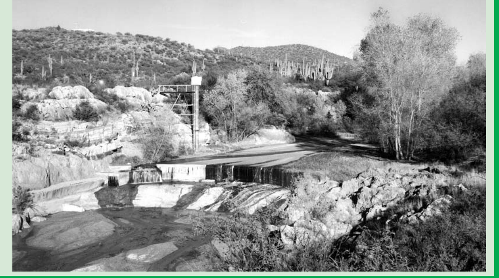
(June 4, 1964). The channel narrowed appreciably in the intervening 23 years, despite two floods exceeding 23,000 $ft^3/s$. Part of the reason may be the increase in non-native tamarisk trees, which appear along river left (right center). Native plants have also increased, including the willows at left. The San Carlos River was unregulated at this time except for diversions for irrigation (Raymond M. Turner).

(October 6, 2000). The San Carlos River became partially regulated by Talkalai Reservoir in 1979. The channel has shifted out of the view to the right and is narrower than it was in 1964. Most of the plants in the foreground, which is now a stable floodplain, are natives, including two species of willows, two species of brickellbush, and scattered mesquite and catclaw. Riparian vegetation has increased and the channel remains narrow despite a flood of 54,800 $ft^3/s$ in 1993, which is the flood of record for this gaging station (Dominic Oldershaw, Stake 333c).

### PANTANO WASH NEAR VAIL (09484600)

(October 30, 1961). Pantano Wash, a tributary of Rillito Creek southeast of Tucson, is perennial in this reach owing to a bedrock constriction with a concrete dam built within it. The stream is unregulated upstream from the gaging station; the concrete sill forms a weir that provides a low-water control for the gaging station. The flood of record, estimated to be 38,000 $ft^3/s$, occurred in 1958. The channel margins support mesquite (Garrett Anderson, #4658).

(November 28, 2000). In the 39 years between the photographs, the largest flood was 13,000 $ft^3/s$ in 1981. Cottonwood trees are now established near the low-water channel, and mesquites have grown up on the banks. The density of saguaros has also increased, particularly at right center (Dominic Oldershaw, Stake 2219).



### GILA RIVER AT CALVA (09466500)

(March 6, 1932). The Gila River was ravaged by floods in the 1910s and 1920s, including one flood estimated at 100,000 $ft^3/s$ in 1916. This upstream view from the railroad bridge at Calva shows a wide, braided channel. An open cottonwood gallery forest appears in the midground at left (channel right), and the low shrubs at right appear to be native willows (W.E. Dickinson, #1053).

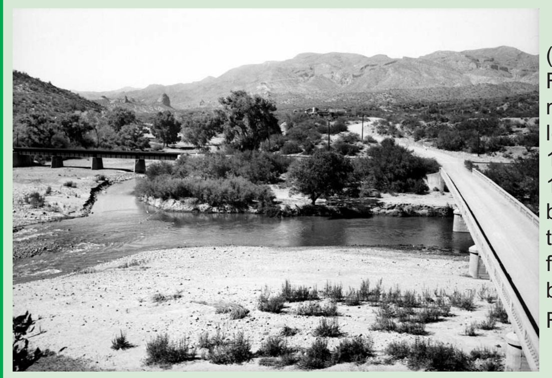
(June 18, 1964). In the intervening 32 years, the highest discharge through this reach was 27,900 $ft^3/s$ on October 1, 1941. Dense tamarisk has become established, creating a floodplain where the main channel once was. The channel has shifted to the right and is much smaller than it was in 1932 (Raymond M. Turner).

(October 17, 1973). To reduce evapotranspiration, phreatophytes (mostly tamarisk) were removed from this reach in 1970, and the floodplain was reseeded to native grasses. Those grasses are mostly gone at the time of this photograph, one year after a flood of 80,000 $ft^3/s$ passed through this reach. The small shrubs throughout the view are mostly tamarisks that are re-establishing in the reach (Raymond M. Turner).

(May 21, 1984). In October 1983, a flood of 150,000 $ft^3/s$ passed through this reach in the wake of Tropical Storm Octave. This flood followed one that peaked at 100,000 $ft^3/s$ in 1978. These floods shifted the channel back into the view, and driftwood racks appear throughout the foreground. Despite this flood, dense tamarisk appears on both floodplains (Raymond M. Turner).

(October 6, 2000). Except for withdrawals of domestic and irrigation water at low-head diversion dams, the Gila River is unregulated upstream from Calva. In January and February, 1993, three floods passed through this reach that exceeded 100,000 $ft^3/s$. Despite these floods, tamarisk has grown considerably, blocking the view of the river channel from this camera station. Despite the enormous effort at tamarisk removal and river restoration, the tamarisk has attained a higher biomass than it had in 1964. The channel has shifted from the right side to the left side of this view (Dominic Oldershaw, Stake 331a).

### GILA RIVER AT KELVIN (09474000)



(May 21, 1945). This view, from a hill on the south side of the Gila River, shows the bridge at Kelvin from which discharge measurements are made at high flows. The river flows from right to left in this view and is regulated by Coolidge Dam, completed in 1928. The largest historic flood at this station is 132,000 $ft^3/s$ in 1916, and three other annual flood peaks exceeded 40,000 $ft^3/s$ before 1945. Floods were less than 40,000 $ft^3/s$ for 15 years prior to this photograph. Tamarisk is becoming established in the foreground, and mesquite and cottonwood trees appear on the far bank. Mineral Creek, spanned by a railroad bridge, enters the Gila River at left (W.L. Heckler, #3709).

(October 2, 2000). The view is blocked by cottonwood trees, particularly at left and right with small trees in the foreground, and large tamarisk trees. This increase in riparian vegetation has occurred despite the fact that floods of 100,000 and 74,900 $ft^3/s$, in 1983 and 1993 respectively, passed through this reach (Dominic Oldershaw, Stake 430).

### GILA RIVER BELOW BLUE CREEK (09432000)

(July 23, 1931). The Gila River upstream from its juncture with Blue Creek near the Arizona-New Mexico border drains 3,203 $mi^2$ of rangeland and the Gila Wilderness. Just downstream from Blue Creek, the channel is somewhat confined within a bedrock canyon, but just upstream, as this view shows, the valley is relatively wide (James Baumgartner, #1501).

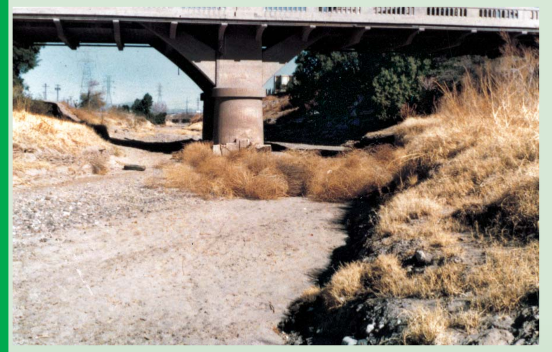
(June 11, 1964). By 1964, cottonwood trees had grown up along the banks of the river behind a lower ribbon of tamarisk trees. The channel position is the same despite a flood of 41,700 $ft^3/s$ in 1941 (Raymond M. Turner).

(October 5, 2000). The channel has shifted to the left, possibly during one of the four floods that exceeded 27,000 $ft^3/s$ between 1964 and 2000. The cottonwood gallery has been destroyed, and the channel is lined with tamarisk and coyote willows with scattered brickellbush (Dominic Oldershaw, Stake 346a).

### SANTA CRUZ RIVER AT TUCSON (09482500)

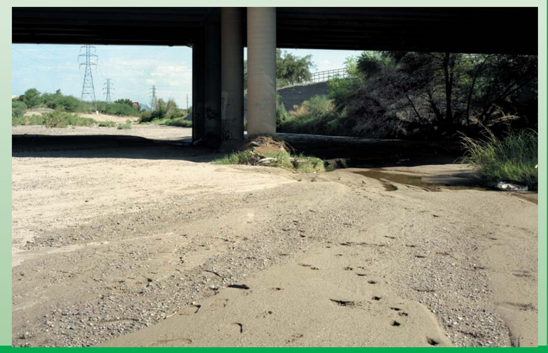
(November 22, 1930). This downstream view, taken from near the west abutment of the old Congress Street Bridge, shows the wide alluvial channel of the Santa Cruz River. At this time, the river flowed through a rural area, and cottonwood trees lined its banks. The relatively shallow arroyo began downcutting in 1878, and the 1914 flood of 15,000 $ft^3/s$ and 1917 flood of 7,500 $ft^3/s$ caused the most recent channel change before 1930 (photographer and number unknown).

(December 17, 1994). The channel of the Santa Cruz River is now confined by soil-cemented banks. The open gallery forest of cottonwood trees was destroyed by ground-water pumpage and development, and the channel reached its present depth between 1977 and 1983 (Dominic Oldershaw, Stake 3300).

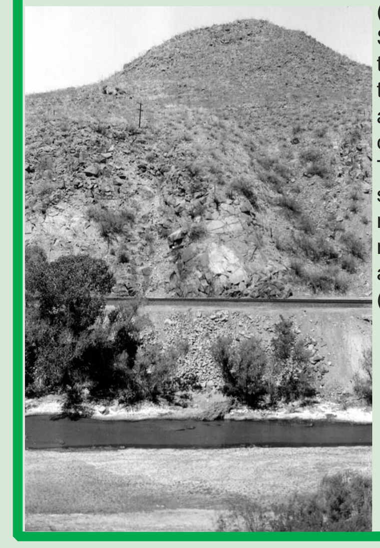


(February 3, 1964). This downstream view shows the approach to the gaging station at the Congress Street Bridge in Tucson. A relatively small channel became established within the arroyo walls in the middle part of the 20th century, when few significant floods occurred. Non-native athel tamarisk, a non-invasive species in Tucson, appear downstream from the bridge on channel right (photographer and number unknown).

(August 22, 2000). The bridge was replaced, but its roadway surface was at about the same elevation as the old one. Channel downcutting, which primarily occurred during the 1977 and 1983 floods (the latter had a peak discharge of 52,700 $ft^3/s$), has lowered the bed by up to 9 feet. Because of persistent problems with lateral channel change, soil cement now stabilizes the channel banks (Dominic Oldershaw, Stake 298).



### SAN PEDRO RIVER AT CHARLESTON (09471000)



(May 4, 1954). The gaging station for the San Pedro River at Charleston has one of the longest records in Arizona. In 1954, the gaging station was at this site, about a quarter mile downstream from the current station on the highway bridge. This view shows the cableway cross section used for discharge measurements. The view is to the east, and the river flows from right to left. The trees along the far bank are cottonwoods (C.A.B., #4251).

(July 29, 2000). Cottonwoods and willows, with scattered tamarisk, now block most of the view. The railroad on the opposite bank is still in operation (Dominic Oldershaw, Stake 296).

(May 24, 1939). This upstream view of the San Pedro River, from the bridge east of Palominas, looks over an open grassland towards mountains across the border in Mexico. Scattered cottonwood trees line the shallowly incised channel; vertical banks about 3 feet high appear in the midground at left. The 1926 flood was not measured at this site but had a discharge of 98,000 $ft^3/s$ downstream at Charleston (R.H. Monroe, #2503).

(January 23, 1981). This winter view shows small, defoliated cottonwoods and willows that block out most of the background. The channel is deeper, but the floodplain remains relatively free of woody plants. A flood of 22,000 $ft^3/s$ occurred in 1940, a flood of 16,500 $ft^3/s$ occurred in 1958, and another flood of 14,500 $ft^3/s$ occurred on October 9, 1977. Despite these floods, riparian vegetation has increased since 1939 (Raymond M. Turner).

### SAN PEDRO RIVER AT PALOMINAS (09470500)

(February 7, 1995). The main channel of the San Pedro River has narrowed, possibly in response to riparian vegetation and(or) earthwork. A dense thicket of trees--- mostly cottonwood---line its banks, and older trees have grown up to the right. The plants are leafless in this photo (Dominic Oldershaw).

(October 8, 2000). The cottonwoods and willows completely block the view. Despite a flood of 14,800 $ft^3/s$ in late October 2000, no changes occurred in the channel or riparian community. No woody non-native species at present in this reach (Dominic Oldershaw, Stake 1009).

### SANTA CRUZ RIVER NEAR LOCHIEL (09480000)

(June 1968). The gaging station at Lochiel measures flow in the Santa Cruz River before it enters Mexico. The river winds through the broad San Rafael Valley, a grassland, and the shallow channel had scattered cottonwood trees along it in 1968. This upstream view shows the gaging station and the low-water control (R.L.T., no number).

(October 8, 2000). The channel has meandered to the left despite a grade-control structure just downstream from the bridge. Cottonwoods have grown up throughout the view, and no woody non-native riparian species are present. The bed sediment in the reach has coarsened, increasing channel roughness (Dominic Oldershaw, Stake 1953).