THE RIO PUERCO - PAST, PRESENT, AND FUTURE

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The history of the Rio Puerco is one of man's inability to live in harmony with soil, topography, vegetation, and climate. Soil dislodgement and movement in the Rio Puerco may surpass that of any watershed in this country. It is estimated that between 600,000 and 800,000 acre-feet of soil has washed out of the Rio Puerco since 1885. Even now, this watershed which represents 28 percent of the contributing basin in the Upper Rio Grande in New Mexico produces about 45 percent of the measured sediment and only 4 percent of the water yield.

Sediment from the Rio Puerco results in considerable downstream damage through; (1) depletion of the capacity of Elephant Butte Reservoir, (2) aggradation of the Rio Grande channel, (3) increased maintenance of irrigation canals, ditches and drains, (4) detrimental deposition on lands and crops, (5) increased salinity, and (6) providing a favorable habitat for phreatophytes such as salt cedar between the mouth of the Puerco and the reservoir. Water consumed and wasted by non-beneficial phreatophytes in the Rio Grande was estimated at 240,000 acre-feet annually before the rehabilitation program of the Bureau of Reclamation.

These are current and continuing damages that are a threat to the future of downstream residents. They are in addition to the soil, vegetation, and other damages that have occurred on the Rio Puerco watershed itself. But with so much sediment coming from the Puerco, the main problem is how to control or prevent this sedimentation damage.

Description of Rio Puerco Watershed

The Rio Puerco is situated west of the Jemez mountains, Albuquerque, and Belen within 6 northwestern New Mexico counties (figure 1). It covers 3,900,000 acres, is irregular in outline, with approximate maximum dimensions of 125 miles from north to south, and 85 miles from east to west. The principal drainage, the Rio Puerco, rises in the western slopes of the San Pedro Mountains and takes a southerly course. It enters the Rio Grande about 2 miles north of La Joya and just east of Ladron Peak. The main tributaries from the west, rising along the Continental Divide, are the Rio San Jose and Chico Arroyo. The Rio Puerco currently is a permanent stream only through the upper few miles of its channel and its remaining part and all of its tributaries have intermittent or ephemeral flow.

Elevations range from 5,000 to 10,600 feet. Average annual precipitation varies from 8 inches near its mouth to about 25 inches on Mount Taylor and on San Pedro mountains. Three-fourths of the basin receives less than

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14 inches and only 5 percent of the drainage receives more than 20 inches annual precipitation.

Soils are derived predominantly from highly erodible sandstones and shales (mostly of Cretaceous origin) with the exception of 761,000 acres above McCartys on Rio San Jose where the surface is covered by lava flows. This latter area is not a source of flood and sediment to the main Rio Puerco and Rio Grande.

Soil Piping

A good portion of the soils in the Rio Puerco, particularly those developed from Upper Cretaceous shale are subject to "piping", a form of subterranean erosion. Cracks develop in the soil or parent material due to expansion and contraction that accompanies alternate wetting and drying. Water enters and concentrates in these cracks and eventually melts or disperses the surrounding soil and forms underground conduits or tunnels called "pipes". Also, holes formed by burrowing animals and other causes contribute to the development of this system of subsurface drainage (figure 2).

An important part of the high intensity rain that falls on the alluvium and nearby land slopes concentrates as runoff and enters these soil pipes. As the system of underground drainage develops, large quantities of runoff water may be quickly discharged into the gully system through soil pipes.

This method of waterflow delivery eventually results in the collapse of the overlying soil. It also causes sloughing or cave in of vertical gully walls following runoff producing rainstorms. Once a system of gullies has developed on these soils, control becomes difficult and costly.

This inherent characteristic of the geology and soil in the Rio Puerco has been an important contributing factor to past watershed deterioration, particularly gully formation, and must be fully recognized in a program of rehabilitation. Unfortunately, its importance has been noted only recently.

Vegetation

Vegetation in the Rio Puerco watershed is mostly pinon-juniper (Pinus edulis Engl. -Juniperous spp.) woodland and grassland about evenly divided. Sagebrush (Artemesia spp.) occupies from 3 to 4 percent of the watershed and forests an equal amount.

Historical records and reconnaissance surveys indicate that a good cover of grass mostly alkali sacaton (Sporobolus airoides Torr.), galleta (Hilaria jamesii (Torr.) Benth.) and blue grama (Bouteloua gracilis (H.B.K.) Lag.) was once present over much of the watershed. This was true even in the pinon-juniper as much of this woodland is the savanna type with widely spaced trees. Steep, rocky breaks and badland topography were no doubt always barren or sparsely vegetated and contributed high surface runoff which flooded the alluvium of the valleys (figure 3). Yet alkali sacaton and other grasses covered many steep slopes and pointed hilltops of Cretaceous shale origin (figure 4). Dead root crowns of alkali sacaton can now be found on uplands and steep slopes as well as valleys.

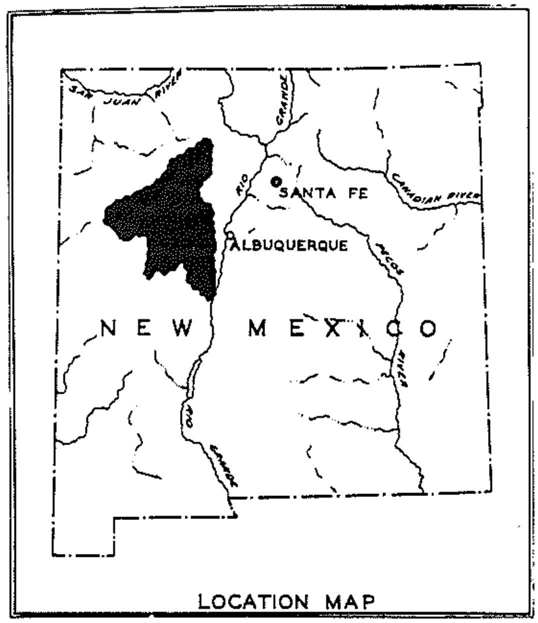

Figure 1. Rio Puerco watershed.

Figure 2A. Soil cracks develop on soil derived from Cretaceous shale (Menafee) after surface soil dries out. Presence of organic materials reduces the amount and size of cracks.

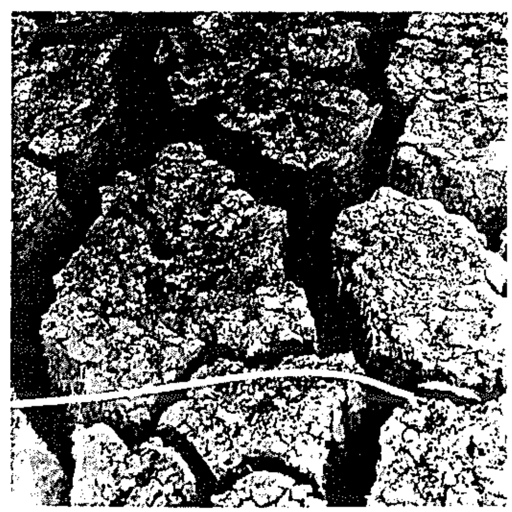

Figure 2B. Soil cracks are pronounced in dry sediment deposit derived from soils of Menafee shale origin.

The vegetation was in delicate balance with the erosive soils under the semiarid climate with recurrent droughts of long duration.

History of grazing

The coming of the Spaniards with their grazing animals may have upset this balance quite early. By 1750, thousands of sheep grazed out from the settlements on the Rio Puerco as there was little danger from Indians for a time after the Spaniards' return. Flocks were driven miles from the settlements and kept there for long periods. Many sheep wintered in the valley of the Rio Puerco where grass and brush afforded feed and protection. But by 1800, as a result of Indian attacks, herds were reduced to numbers that could be grazed near settlements. During this period, plant cover in more remote areas may have partially re-established itself. By 1855 there was little danger from marauding Indians and livestock herds built up and grazed at distances from settlements. For example, there were 185,000 sheep in Bernalillo County in 1850; 306,000 in 1860; and 583,000 in 1880.2/ Maximum numbers of livestock in the Rio Puerco were reached after 1880. According to Bryan (1928), destructive erosion followed in the period 1885-90.

Cutting of Main Stream Channel

Old records make no mention of accelerated erosion before the Spanish engaged in extensive livestock industry nor is there mention of the Rio Puerco channel being either wide or deep. Moreover, most of the early land surveys of section lines and grant boundaries beginning about 1855 recorded the width of the Puerco Channel, but few mentioned the channel depth. But in 1846, Abert (1848) found the Rio Puerco with vertical banks 10 or 12 feet high west of the village of Atrisco and about 30 feet high near the deserted settlement of Poblazon. Simpson (1852) in 1849 mentioned the presence of an entrenched channel when crossing the Puerco in the vicinity of the present village of San Luis. Streambanks of 20 to 30 feet had to be cut down to allow passage of the artillery. Four years later, in 1853, Whipple (1856) found the bed of the Rio Puerco about 100 feet wide and 18 feet below the alluvial valley near its confluence with the Rio San Jose. But later, in 1870, the flood plain was without a deep channel at Cabezon where a small bridge was used to cross the river (Bryan and Post - 1927). Likewise, in 1870 the channel was 8 feet deep at La Ventana whereas it is now approximately 50 feet in depth (Widdison, 1959). Thus, accounts of early travelers indicate the Rio Puerco was already entrenched at several places by the middle of the 19th century, but at other places the banks were low or inconspicuous. According to Bryan (1928) the Rio Puerco was, previous to the late eighties, an ephemeral stream with numerous floods of short duration, but occasionally of great magnitude. It flowed in a flood plain subject to overflow and had a discontinuous channel. In years of flood most of the valley floor was inundated and good crops of corn, wheat, and beans were raised.

Bryan and Post (1927) estimated the main discontinuous channel probably had a volume of about 17,000 acre-feet in 1885. A resurvey of the channel in 1939 by the Soil Conservation Service (1941) showed the volume to be 267,000

2/ Sheep numbers adjusted for changes in county boundaries to those existing in 1880.

acre-feet from below Cuba to its mouth.

The volume of tributary channels was estimated at 5500 acre-feet in 1885 and at 276,000 acre-feet in 1927 (Bryan and Post, 1927). It is considerably more today (figure 5).

Decline of Irrigation

Irrigated areas existed along the main Rio Puerco Valley from Los Cerros to the headwaters, being watered from small diversions in the discontinuous channel. As a result of the new deep channel forming from the mouth headward, Los Cerros, 34 miles upstream was abandoned about 1888. San Ignacio and San Francisco 62 and 73 miles upstream from the mouth were abandoned by 1896. Casa Salazar was abandoned in the late twenties and the last family recently moved out of Cabezon (figure 6).

Thus, the main cutting of the arroyo took place in the late eighties and as it proceeded headward, settlements were abandoned.

Of 16 villages and settlements along the main Puerco Valley only Regina, La Jara, Cuba and San Luis remain populated, while La Ventana has a single family. According to Harper, Cordova, and Oberg (1943) irrigated acreage from Casa Salazar to Cuba declined from 10,000 acres to 3,000 acres between 1880 and 1925. Irrigation along the main channel below Cuba ended with the destruction of the San Luis diversion dam by a large flood on July 25, 1951 (figure 7).

In 1939, more than 5,500 acres in the Upper Valley (above Cuba) were irrigated by 17 ditch systems. Much of the acreage and most of the ditches have been abandoned.

Rehabilitation and Research

Restoring a deteriorated watershed such as the Rio Puerco will be neither simple nor inexpensive. Many persons question whether this watershed can once again support a good cover of grass. For these and others may I suggest a visit to the Frank Bond Ranch. Here, winter grazing has been practiced for 36 years and a relatively good cover of grass can be found. (figure 8). Likewise, on the Howard Mayor Ranch, numerous gullies are healing and grass vegetation is improving under a soil and moisture conservation program and conservative grazing.

But on the Puerco, livestock control must be combined with vegetation and soil improvement and mechanical control of gullies. What types of vegetation, livestock, and mechanical control are needed for complete rehabilitation remains speculative. Much research and pilot testing is needed.

The Rocky Mountain Forest and Range Experiment Station is cooperating with the Bureau of Land Management and U. S. Geological Survey in the San Luis Experimental Watershed study. Three similar watersheds (338, 471, and 555 acres) are being calibrated to establish a relationship among precipitation, vegetation, surface runoff, and sediment inflow as measured at the reservoirs. Watersheds are individually fenced and cattle graze during a 5-month winter period beginning November 1-15 each year. Grazing use of the principal forage species has averaged 58 percent on alkali sacaton and 40 percent on gal-

Figure 3. Steep rocky sandstone and shale breaks on San Luis experimental watersheds (Menafee formation).

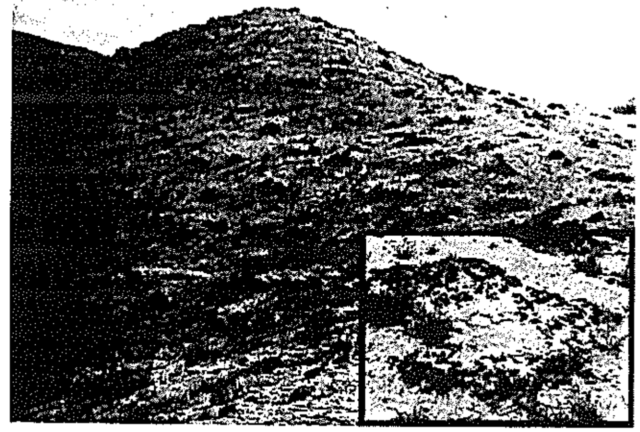

Figure 4. Mancos shale hill that once supported a good stand of alkali sacation. Note dead clumps of grass on slopes exceeding 40 percent.

Figure 5. Gully formation in tributary of Rio Puerco in 1954.

Figure 6. Abandoned village of Cabezon, 1952.

Figure 7A. San Luis Dam, 1938.

Figure 7B. Ruins of San Luis Dam, 1953.

leta during the past 6 years. This is considered heavy use of the key species alkali sacaton.

When watershed performance can be predicted for given rainstorms, the treatments on 2 watersheds will be altered and that on the 3rd watershed will remain unchanged to provide a climatic control. On one watershed, grazing intensity will be reduced to moderate (30% to 40%) use of alkali sacaton. Another watershed will receive moderate grazing use combined with a complete treatment of soil and vegetation, including control of gullies. Thus, we hope to learn what effect the soil and vegetation conservation treatments needed for full rehabilitation will have on water and sediment yield. Thus far, water yield as measured at the reservoirs has averaged about 5% of the annual precipitation. This is in agreement with runoff measured on the experimental watersheds on Montana Grant (Dortignac, 1956) and about 1.5% less water yield than from the nearby Cornfield Wash (23 sq. miles) as shown by a 5 year U. S. Geological Survey study (Kennon and Peterson, 1960). Water yield from pinon-juniper experimental watersheds at Mexican Springs averaged 4.5% of the annual precipitation.3/ This water yield and that from other pinon-juniper and lower lying lands is almost entirely surface runoff produced during high intensity rainstorms and is in marked contrast to soil water discharge from snow melting in the higher-lying Mt. Taylor and San Pedro mountains.

Annual sediment production on the San Luis experimental watersheds has averaged about three-fourths of an acre-foot per square mile. This is considerably less than on Cornfield Wash where 2.8 acre-feet per square mile has been measured. Most of the sediment comes from the extensive network of gullies. Re-measurement of soil elevation transect grids on this watershed in 1958, one year after establishment indicates an appreciable rate of aggradation on the alluvium near the bluffs. An average of 160 point elevation measurements shows about 1/4 inch soil deposition attributed to 7.05 inches precipitation, most of which (4 inches) fell in a 2-day storm in October 1957.

The 3 dams on the experimental watersheds were constructed above the heads of actively eroding gullies in 1951. These dams have halted the headward progress of cutting and are effective gully controls. This and other methods of controlling runoff, gullies, land slope erosion, and sediment have been and are currently used by the Bureau of Land Management in their soil and water conservation program on public domain lands. The Rocky Mountain Forest and Range Experiment Station is presently evaluating the effects of several mechanical treatments of soil and vegetation. One of these, soil pitting, is accomplished with the Calkins pitter.

The Calkins pitter leaves a pattern of small basins over the land surface.

This practice is being evaluated on 16 surface runoff plots, 310 square feet in size. During the first year, 9 summer rainstorms produced surface

3/ Dortignac, E. J. Water yield from pinon-juniper. Paper presented at the thirty-sixth annual meeting of Southwestern and Rocky Mountain Division of the American Association for the Advancement of Science at Alpine, Texas; May 1960.

runoff. Reduction in surface runoff caused by soil pitting varied from 10.5% on the south slope to 26% on the north aspect. Erosion was reduced from 19% to 16% during the first year.

Soil ripping is another mechanical treatment that is being evaluated by means of surface runoff plots (figure 9). During the first year, soil ripping with the Jayhawker (figure 10) eliminated practically all of the surface runoff (98%) and erosion during 12 rainstorms. There was no vegetation improvement on experimental plots. On seeded plots, alkali sacaton seedlings became established by late fall and survived the winter, but subsequently died during the prolonged spring and summer drought. (figure 11)

Though sagebrush is not extensive in the Rio Puerco, it has been chained or treated with the Marden brush cutter. But this implement may be used in the Rio Puerco for gully control (figure 12).

In view of the hazards of soil piping in the Rio Puerco, sloping and seeding gully sidewalls, or completely filling-in gullies may be necessary in many areas. Research should develop methods for refilling and vegetating the gullied channels that dissect practically all of the once productive valleys, if sediment is to be controlled. Also, research should evaluate any losses in water yield that might result from a complete program of rehabilitation and control of sediment.

LITERATURE CITED

Abert, J. W., 1848, Report of Lieut. J. W. Abert of his examination of New Mexico in the years 1846-47. House Ex. Doc. No. 41, 30th Congress, 1st Session, pp. 417-548, illus.

Bryan, Kirk, 1928, Historic evidence on changes in the channel of Rio Puerco, a tributary of the Rio Grande in New Mexico. Jour. Geol. 36: pp. 265-282, illus.

________ and Post, George M., 1927, Erosion and control of silt on the Rio Puerco, New Mexico. Report to Chief Engineer, Middle Rio Grande Conservancy District (Oct. 1927) pp. 174, illus. (Typewritten)

Dortignac, E. J., 1956, Watershed resources and problems of the Upper Rio Grande Basin. Rocky Mountain Forest and Range Experiment Station, pp. 107, illus.

Harper, Allen G., Cordova, Andrew R., and Oberg, Kalervo, 1943, Man and Resources in the Middle Rio Grande Valley. Univ. of New Mexico Press, Inter-Americana Studies II, pp. 156, illus.

Kennon, F. and Peterson, H. V., 1960, Hydrology of cornfield wash Sandoval County, New Mexico, 1951-55. Geological Survey Water-Supply Paper 1475-B prepared in cooperation with U. S. Bureau of Land Management, pp. 103, illus.

Simpson, James H., 1852, Journal of a military reconnaissance from Santa Fe, New Mexico to the Navajo country made with the troops under command of Brevet Lt. Col. John M. Washington, Chief 9th Military Dep't. and Governor of New Mexico, in 1849. (James H. Simpson, First Lt. Corps of Topographical Engineers) Lippincott, Grambo and Co., Phila., 140 pp., illus.

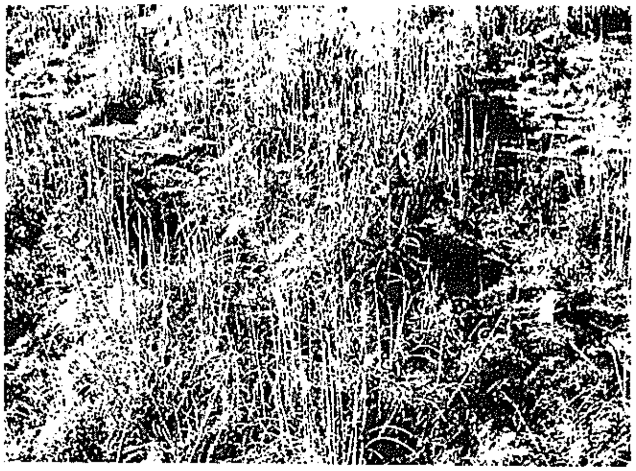

Figure 8. Stand of alkali sacaton on 15 percent slope on the Frank Bond Ranch. Soil derived from Upper Cretaceous shale.

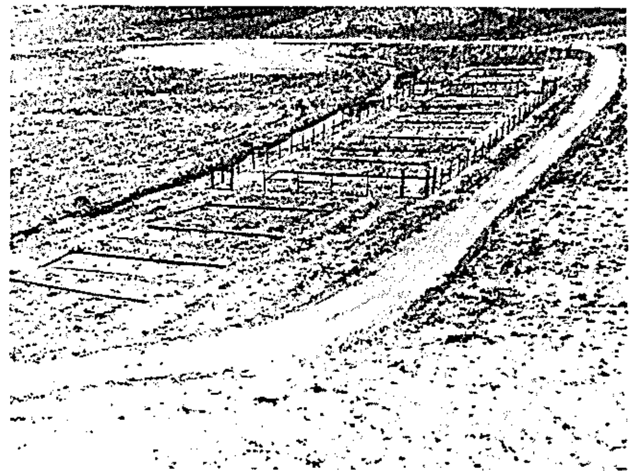

Figure 9. Surface runoff plots (each 10 x 30.5 feet) on upper slope of north aspect used to evaluate the effects of soil ripping. Soil derived from Mancos shale.

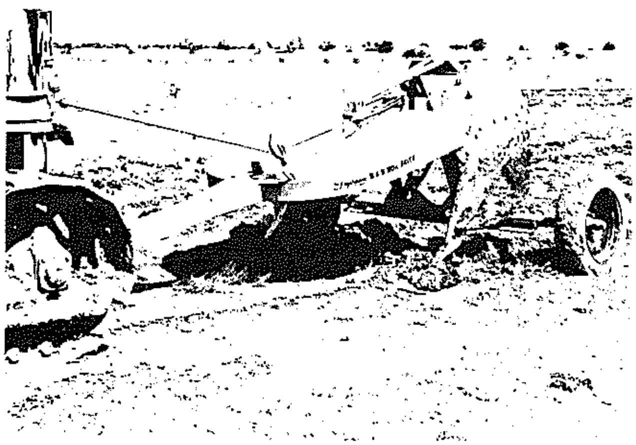

Figure 10A. Ripper is pulled by a D-8 tractor

Figure 10B. Land surface after treated with soil ripper. Depth of ripping 28 inches - soil derived from Upper Cretaceous shale.

Figure 11. Grass recovery one year after treatment with ripper - untreated on extreme left.

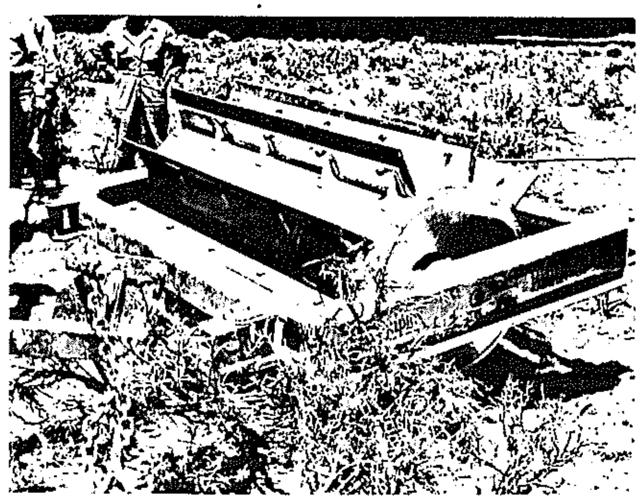

Figure 12. Eradicating sagebrush with a Marden Brush Cutter.

Whipple, A. W., 1856, Report on topographical features and character of the country, 77 pp., illus. From Reports of exploration and surveys to ascertain the most practical and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the Secretary of War. Vol. III U. S. Senate, 33rd Congress, 2nd Session, Ex. Doc. No. 78.

Widdison, Jerold Gwayn, 1959, Geography of Middle Rio Puerco Valley, New Mexico Historical Review, Vol. 34, pp. 248-284, illus.