# Effects of Land Treatments on Erosion and Vegetation on Range Lands in Parts of Arizona and New Mexico

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Water and soil conservation are natural partners in the wise use of our range resources. Abundant research and management results have made this clear; yet water utilization, accelerated soil erosion and low herbage production remain serious resource problems on public and private range lands throughout the 11 western States.

Prior to enactment of the Taylor Grazing Act in 1934, overgrazing by domestic livestock, coupled with recurrent droughts and occasional floods, caused extensive range deterioration. As a means of combating this, Civilian Conservation Corps personnel were early assigned to these western range areas where conservation measures were critically needed. Two such areas were the upper Gila and upper Mimbres River basins in Arizona and New Mexico, where a large number of men were employed in a variety of range improvement programs during the years 1934 through 1942.

Potential for wide application of these practices to other depleted range areas prompted the U. S. Geological Survey to evaluate these efforts. This paper describes various structures employed and results obtained on seven treatment sites examined in Arizona and New Mexico.

## Related Literature

The use of mechanical structures to improve plant production on arid lands is not new. Structures similar to some described in this report were used by the Phoenicians in the Negev Desert 3,000 to 4,000 years ago (Lowdermilk, 1960). Intricate rock water spreaders were used by the Nebataens in the Negev Desert 2,000 years ago (Evenari and Koller, 1956). In an area with four inches annual precipitation the Nebataens used water spreaders for the production of grain, fruit, vegetables, and forage.

There have been several reports of successful range water

**Table 1. General locations of treatment sites, sizes, altitudes, types of erosion, kinds of vegetation, and soil textures.**

| Treatment site, location, size | Altitude (feet) | Types of erosion and vegetation | Soil texture |
|---|---|---|---|
| Fort Thomas, Wash., 2 miles south of Fort Thomas, Arizona. 260 acres. | 2,800-3,000 | Gullying and sheet erosion on valley floor. Creosote bush *(Larrea tridentata* (D.C.) Coville). | Fine sand to silt and clay |
| Indian Gardens, 5 miles northwest of Pima, Arizona. 500 acres. | 2,500-3,150 | Sheet erosion and minor gully erosion. Creosote bush. | Pebbly, sandy loam |
| Freeman Flat, 2 miles southwest of Safford, Arizona. 600 acres. | 2,500-3,000 | Deep axial gully and heavy sheet erosion in alluvial valley. Fourwing saltbush *(Atriplex canescens* (Pursh) Nutt.)-Desert saltbush *(A. polycarpa* (Toor.) Watts) | Silt loan |
| Whitlock Valley, 20 miles southwest of Duncan, Arizona. 600 acres. | 3,500-5,000 | Sheet erosion with discontinuous gully in alluvial valley. Creosote bush-tobosa grass *(Hilaria mutica* (Buckl.) Benth.) | Sandy loam |
| Blackfield, Wash., 3 miles south of Duncan, Arizona. 1,200 acres. | 3,800-4,000 | Deep but discontinuous gully and extensive sheet erosion in alluvial valley. Tobosa grass-alkali sacaton *(Sporobolus airoides* Torr.) | Sandy loam |
| Rodeo site, 5 miles north of Rodeo, New Mexico. 950 acres. | 4,200-4,300 | Sheet erosion and barren slicks on outer edge of large alluvial fan. Mormon tea *(Ephedra sp)* tobosa grass. | Sandy |
| Silver City site, near Silver City, New Mexico. Approximately 2,000 acres. | 5,600-6,500 | Extensive gullying and sheet erosion. Blue grama *(Bouteloua gracilis* (H.B.K.) Lag.-juniper *(Juniperus osteosperma* (Torr.) Little). | Silt loan |

spreaders in the United States and Canada (Semple and Allred, 1937; Miles, 1944; Hubbell and Gardner, 1944, 1950; Hubbard and Smoliak, 1953; Branson, 1956; Mooney, 1956; and Houston, 1960). Other successful, as well as unsuccessful, water spreaders not yet reported upon have been constructed on arid lands of the West. Ten years of results on semidesert range land near Las Cruces, New Mexico revealed that five types of structures, including brush spreaders similar to those described below, did not increase forage production (Valentine, 1947). Failure of the treatments in New Mexico was attributed to the sandy soil, which prevented runoff and failed to store enough moisture to permit improvement in plant growth.

Gully control structures were installed in Colorado by the Civilian Conservation Corps at about the same time that work was done in the Gila and Membres River basins. A report on these structures (Heede, 1960) contains photographs showing types of structures used and their effects at the end of 20 to 25 years along with recommendations for future gully control work.

## Treatment Areas

The location, size, altitude, type of erosion, vegetation, and soil texture for each of the areas selected for study in 1947 are presented in Table 1. A wide range of environmental conditions were represented among the seven treatment sites. Altitudes ranged from 2,500 to 6,500 feet and soil texture varied from clayey to sandy. Vegetation included desert shrub types, desert grassland, and juniper woodland.

Each of the areas was used exclusively for grazing and no forested or cultivated lands were involved. About half of the land is privately owned, the remainder is public domain. Table 2 gives the lowest, highest, and average annual precipitation amounts recorded at three stations near the study areas for the 1905-1960 period. The yearly precipitation pattern for all three localities is characterized by two wet seasons, one extending from November through March created by cyclonic conditions, the other largely a series of high-intensity convective storms occurring in late summer. The latter rainy period produces most of the runoff and erosion.

## Treatments and Evaluation Methods

The Civilian Conservation Corps was created during the depression in the 1930's to provide work for the unemployed. Early emphasis was on creating jobs as much as on specific physical accomplishments. Conservation on the arid range lands presented new problems, and there was little precedent or experience for guidance in design of structures and programs. Because of the pressures for creating jobs, there was seldom sufficient time to investigate, compare, and weigh the merits of either the programs or the many structures built. A certain number of failures in the structures, both structural and functional, were to be expected under these conditions.

The ample supply of labor combined with dispersion of activities encouraged the use of structures that could be built by hand or with light implements using mostly local construction materials. Such structures fit in with the philosophy of conservation treatment then believed to be suitable for these lands, and expressed in the popular slogan of the day, "Keep the raindrop where it falls." Because erosion and lack of plant growth were considered directly attributable to low infiltration and rapid runoff of rainfall, the obvious means of correction was to reverse the process by substituting a mechanical means of slowing down runoff and increasing soil moisture storage. A system of contour spreader dikes designed to utilize runoff water appeared to comply with all such needs. Such a system could be built by hand of local material, could increase stored soil moisture on the upstream side of the dikes for use by vegetation, and, if properly constructed, would slow down the runoff and distribute it evenly across the land, thus preventing water concentration in a few eroding channels.

Water spreaders used in this program were of several different designs. Where abundant, rock was the common building material. Loose rock spreaders consisted of random-sized stones piled in windrows three to four feet wide and four to eight inches high (Figure 1-A). In the hand-placed rock spreaders (Figure 1-B), carefully selected rocks were keyed together into shallow trenches, without a matrix, but with special care to keep the upper surface and upslope edge of each dike as uniform as possible. Spreaders made of brush were used extensively. Most were anchored either by rock and earth or by tying with wire secured to suitable anchors. A representative example is shown in Figure 2-A. Another type was constructed of fine mesh hog wire a few inches high, supported by cable anchored to metal posts as shown in Figure 2-B. Cement worm spreaders (Figure 2-C) were used extensively in one locality.

**Table 2. Minimum, maximum, and annual precipitation at Safford, Arizona, Rodeo and Silver City, New Mexico, based on 56 years of record, 1905-1960.**

| | Safford, Ariz. | Rodeo, N. Mex. | Silver City, N. Mex. |
|---|---|---|---|
| | (Inches) | | |
| Minimum | 3.0 | 5.0 | 6.8 |
| Maximum | 17.3 | 21.8 | 26.2 |
| Annual | 8.5 | 10.5 | 16.2 |

FIGURE 1. A. Loose rock spreader showing deterioration shortly after construction. Rodeo area, New Mexico.

B. Hand-placed rock spreader showing no deterioration 5 years after installation.

The various spreaders were placed on contour at intervals of 50 to 100 feet on slopes ranging from 10 to 200 feet per mile. Little effort was made to vary the spacing or heights of the spreaders in accordance with the slope or soil texture although generally the distance between structures was shortened in areas subject to heavy runoff, such as below points of diversion from channels.

In addition to the spreaders, several other kinds of structures were used in the treatment program, some appurtenant to the spreading operation, others designed primarily for erosion abatement. Dams were built to divert water out of the larger channels across the spreading system and, in a few localities, retarding reservoirs were constructed to regulate flood flows. Erosion control structures such as check dams, masonry drops, groins, and channel stabilizers were installed to prevent the further deepening, widening, and advancement of gullied channels.

Diversion and retarding dams were built of loose earth using carryalls and bulldozers. Check dams, drops, barriers, and groins were hand built of dry or cemented rubble with some being wrapped with woven wire for added stability.

## Results and Discussion

Treatment appraisal recognized two aspects of the conservation measures, structural stability and functional response. Erosion abatement and vegetation response, especially an increase in usable forage through recovery of existing plant communities or establishment of species new to the sites, were considered the major purposes of the treatments. A companion function was the trapping of sediment, which would otherwise be deposited in channels or reservoirs downstream. Consideration of structural stability could not be separated completely from an evaluation of functional results, since the failure or success of one structure could seriously affect the operation of other parts of an erosion control or spreader system.

### Structural Stability

As shown in Table 3, more than half of the structures have been unstable, with the highest percentage of failures occurring in the loose rock, rock and brush, and rock rubble structures. The relatively low number of failures in the earthfill dams is somewhat misleading as the examination showed that all of the retarding dams and most of the diversion structures located on the larger channels have failed, leaving intact and still operating only the smaller structures located on minor channels. Because of these failures, more than half and possibly as many as two-thirds of the structures no longer have any influence on runoff. Doubtless this condition was one of the major causes for the gen-

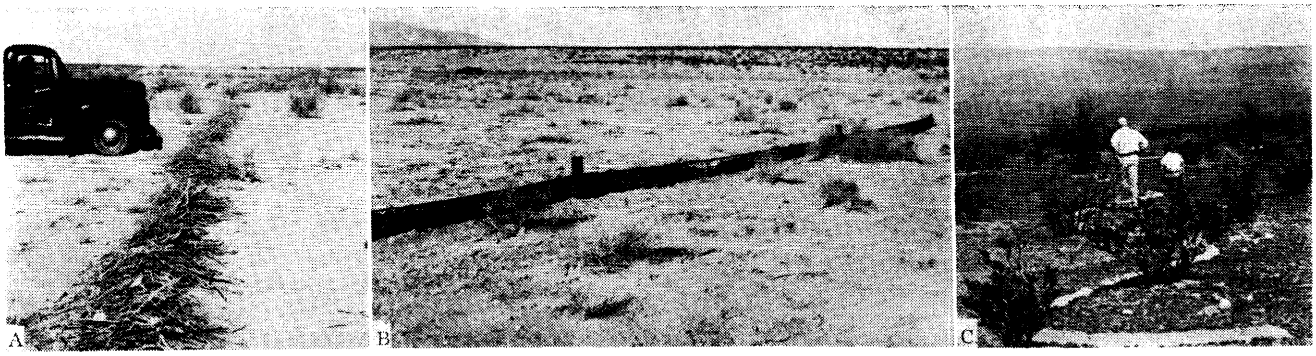


FIGURE 2. A. One of the few remaining brush spreaders on Freeman Flat in 1949.
B. Typical spreader of hog wire supported by cable and posts. Freeman Flat, 1949.
C. A "cement worm" water spreader near Fort Thomas, Arizona (1961). Little change in vegetation or sediment entrapment is apparent.

eral lack of range improvement. However some areas containing intact structures, which have operated as anticipated, likewise exhibit little vegetation recovery.

The 1961 observations disclosed that deterioration and some new failures in structures had occurred since the 1949 appraisal. However, these failures were of minor importance in the over-all functioning of the spreaders as most of the key control structures had failed and become inoperative by 1949.

Reason for failures in the earth-fill structures can, in general, be attributed to the low construction standards as there was seldom any moisture control or compaction other than that offered by the construction equipment. The result was a high percentage of failures by breaching or piping. Additional damage can be traced to inadequate or poorly protected spillways.

Where check dams, drop structures, barriers, and groins were located on good foundation material the percentage of failures was small, but where they were placed on uncompacted or poorly prepared alluvium the great majority have failed. The percentage of failures in structures designed to protect gully banks and head cuts is so high that it raises serious doubt as to the advisability of ever using this type of treatment unless the foundation and approach section are carefully prepared. The tendency of water to seep behind or under the rigid structures, thus initiating piping and other types of subsurface erosion, is so well displayed that cause of failure of the structure is immediately apparent. Proper treatment could prevent this seepage, but the expense would, in most instances, be prohibitive in such programs.

The loose rock spreaders were easily breached in a short period. The percentage of failures in the hand-placed types was much lower. "Cement worms" were effective in catching small amounts of sediment, but water plunging over the downslope side resulted in under-cutting and was the cause of occasional failures. These were often placed on vegetation types such as creosote bush that generally have low forage production potential. Although effective in catching sediment, brush spreaders proved highly vulnerable both to natural rot and to accidental and incendiary fire. Most of the brush spreaders disappeared within a few years.

All of the wire spreaders were still in place in 1961, twenty-five years after construction. Gradual rusting of the wires and cables and some undercutting was apparent in a number of the structures examined in 1961.

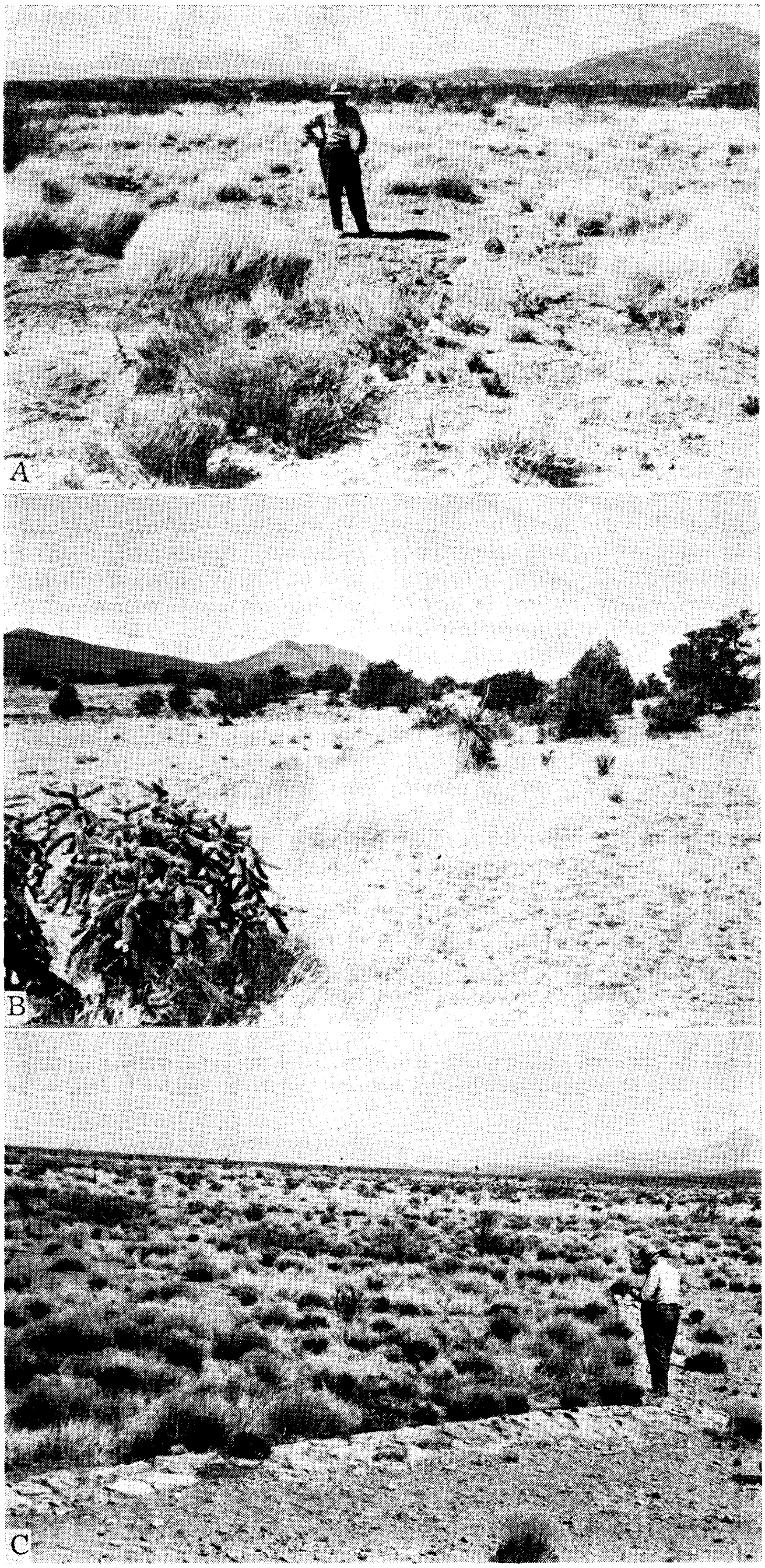
### Sediment Trapped By Structures

Table 3 gives the volume of sediment caught by the structures and, although this is a substantial amount, it will be noted

**Table 3. Data on conservation structures used in land treatment. Upper Gila and Mimbres River basins, Arizona and New Mexico. Examination 1947-49.**

| Type of Structure | No. of structures | No. of breached structures | Percent structural failures | Vol. of material in structures (Cu. Yds.) | Vol. of sediment caught by structures (Cu. Yds.) |
|---|---|---|---|---|---|
| Earthfill dams | 123 | 22 | 18 | 84,300 | 21,000 |
| Wire and cable spreaders | 41 | 8 | 19 | — | 7,900 |
| Hand-placed rock spreaders | 208 | 62 | 30 | 4,400 | 6,550 |
| Cement worm spreaders | 20 | 8 | 40 | 320 | 410 |
| Rock rubble structures[1] | 24 | 16 | 67 | 240 | 60 |
| Loose rock spreaders | 433 | 361 | 83 | 8,650 | 6,050 |
| Rock and brush and wire and brush spreaders | 50 | 42 | 84 | 1,000 | 1,520 |
| | 899 | 519 | | | |

[1]Includes check dams, gully plugs, headcut drop structures, stream bed control structures, rock groins.



that when compared with the volume of material used in building the structures the quantities are not impressive. This demonstrates the low efficiency of the structures in controlling sediment movement and emphasizes again that the primary function of structures of this type should be stimulation of vegetative recovery.

No detailed measurements of sediment deposition were attempted in 1961, but observations indicated that in some localities a net loss in deposition had occurred due to additional deterioration of the structures and the attendant erosion of previously deposited materials. In general, such erosion was not serious and it probably had little, if any, influence on the over-all functioning of the structures.

**Vegetation Responses**

Observations made in 1949 over the major parts of each of the 7 treated areas showed a uniform lack of vegetation recovery. A slight increase in plant growth had occurred in a few places where water had been caught and stored for a time, as in small reservoirs or in deep borrow pits near structures, but in some localities the treatments had little, if any, effect on perennial grasses or shrubs. Annual forbs grew better on the sediment caught by the spreaders than on the natural soil but new establishment of perennial grasses was not sufficient to trap additional sediment.

Conditions in 1961 showed some improvement over 1949 with regard to vegetation. In general the improvements were most pronounced where the structures still exerted some control on runoff and plants received extra water through spreading or impounding. Best results were achieved in the areas of higher elevation (Silver City, Rodeo, and Whitlock Valley), but some local improvement was also evident at Free-

FIGURE 3. A. Buried rock spreader with good growth of tobosa grass in overlying sediment. Whitlock Valley, 1961. (Previous page)

B. Excellent recovery of range grass at rock spreader. Silver City, 1961.

C. Well defined effect of rock spreader on tobosa grass. Rodeo area, 1961.

man Flat and Indian Gardens. Figure 3-A shows the recent growth in part of the spread area in Whitlock Valley. Figures 3-B and C show similar improved conditions in parts of the Silver City and Rodeo areas, respectively. In 1949 each of these areas was almost barren. Figure 4 shows the conditions on one of the spreaders in Indian Gardens in 1961 (view A) as contrasted with an adjacent area where spreaders had not been constructed (view B). Figure 4-A shows the same area as Figure 1-A, taken in 1949.

Structural failure apparently was not responsible for the lack of improvement on areas above cable and wire spreader dikes. Field observations indicated that the low dikes (10 to 12 inches) formed by the wire spreaders, which were 200 to 400 feet apart, had little effect on detention and infiltration of water for plant use. Earth dikes that detained water and caused increased infiltration resulted in improved plant responses (Figure 5-A). Where water was ponded for extended periods (Figure 5-B) undesirable phreatophytes such as seep-willow *(Baccharis glutinosa* Pers.), mesquite *(Prosopia juliflora* (Swartz) D.C.), and tamarix *(Tamarix pentandra* Pall.) utilized the available water.

Reasons for the improved conditions in 1961 compared to 1949 are not clear since no new structures had been added nor had any repairs been made on the old ones during the intervening period. The region, in general received above normal precipitation in 1957 and 1958. Precipitation in 1959 and 1960 was well below normal, although this drought was not as severe as the one extending from 1945 through 1948 when during four successive years the annual precipitation ranged from 1.86 to 5.39 inches below the long-term average. The intensity and distribution of rains in the immediate vicinity of the treated areas during the period 1950-60 may have been more favorable for plant growth, but information on this feature is not available. Grazing also appears to have had an important influence on recovery as it was noted that the most pronounced improvement had occurred where livestock had been excluded or grazing was light. This was particularly evident in the Whitlock, Rodeo, and Silver City areas as seen in Figure 3. Adjacent heavily grazed pastures in these areas showed little improvement, indicating that grazing use may be the controlling feature in stimulating range recovery.

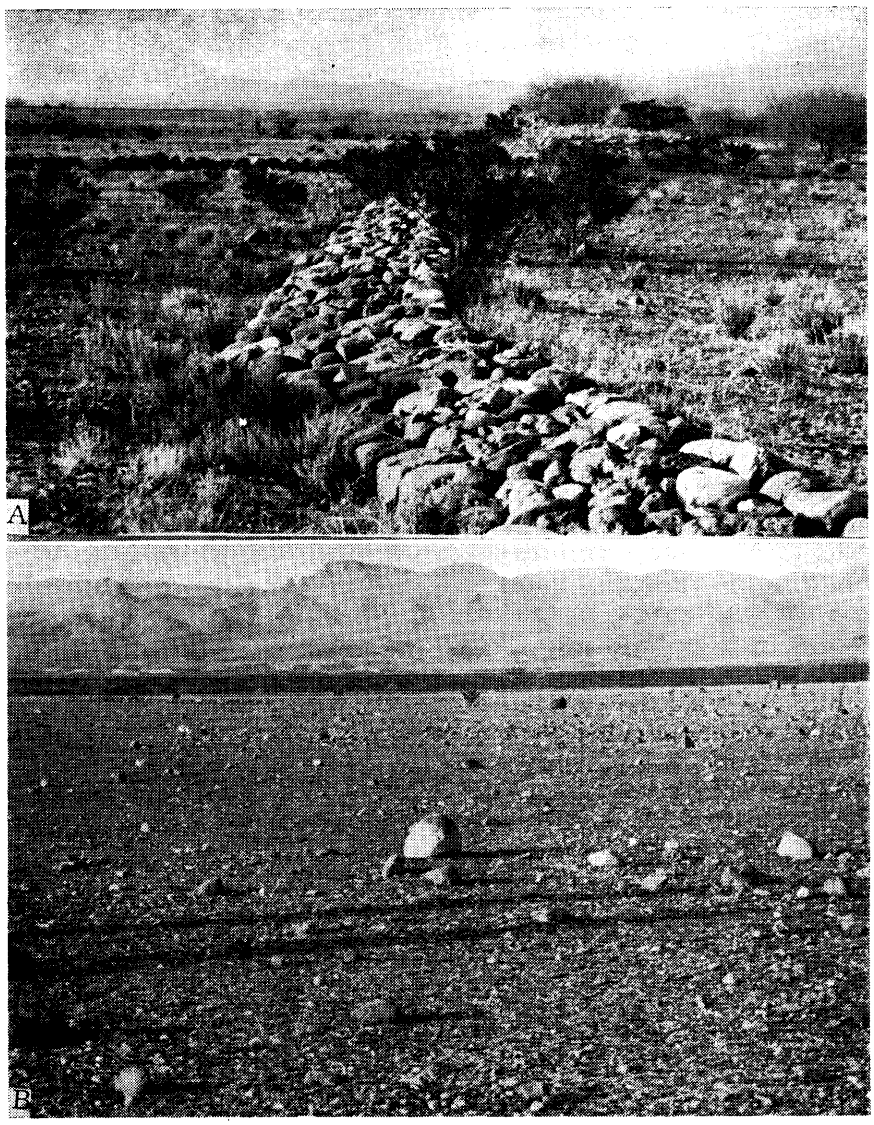


FIGURE 4. A. Vegetative recovery in vicinity of a hand-placed rock spreader. Indian Gardens, 1961. Compare with 1-A, approximately the same locality in 1949.

B. Shows very sparse vegetation below spread area. Indian Gardens, 1961.

**Summary**

Appraisals were made in 1949 and 1961 by the U. S. Geological Survey of land treatment measures constructed by the Civilian Conservation Corps in the mid-1930's in the upper Gila River and Membres River basins in

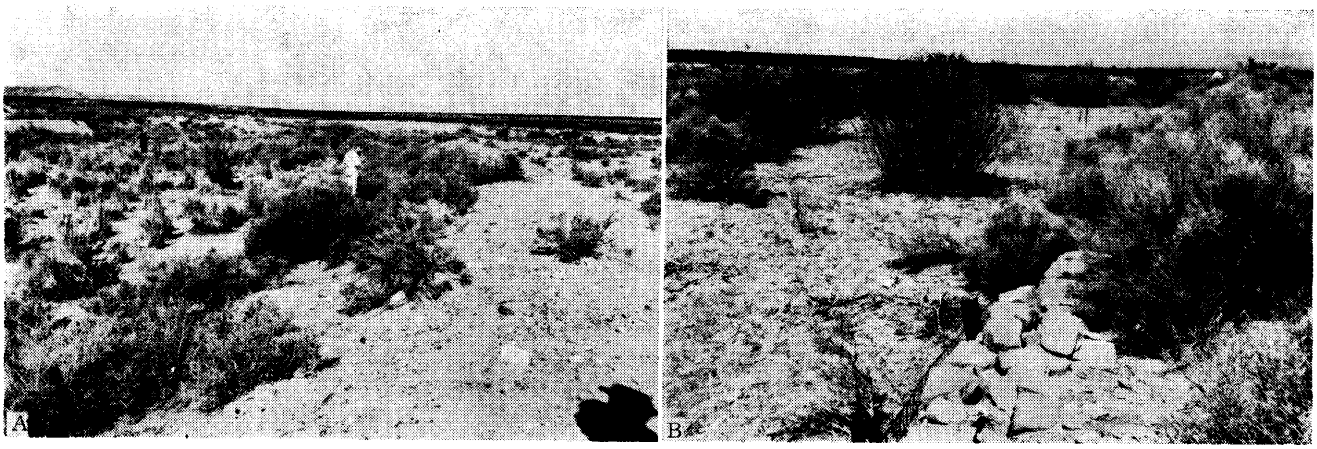



FIGURE 5. A. Increased vegetation above an earth dike. Freeman Flat, 1961. Locality gets some additional water from upstream sources. The grass to the left is alkali sacaton.

B. Seep-willow growing above dike where water has been ponded for long periods. Freeman Flat, 1961.

Arizona and New Mexico. The purpose of the appraisals was to determine the effectiveness of the structures in terms of vegetation improvement, longevity of structures, and quantities of sediment retained by the structures.

Treatments applied included earth-fill dams, earth dike water spreaders, loose rock spreaders, hand-placed rock spreaders, brush spreaders, "cement worm" spreaders, cable and wire spreaders and rock-rubble gully-control structures.

More than half of the structures were breached within a few years after construction. The highest percentage of failures occurred in the loose rock spreaders, brush and rock spreaders, and rock-rubble structures. The cable and wire spreaders generally remained intact but failed to cause vegetation improvement apparently due to inadequate detention and infiltration of water. Where earth dikes were not breached and water reached the spreader system there was improvement in vegetation even in the driest areas at lower altitudes. Few failures occurred in the hand-placed rock spreaders, but significant response to the treatment was mainly limited to the higher rainfall areas. Brush spreaders were generally ineffective in producing vegetation improvement but reduced sheet erosion slightly. "Cement worm" spreaders were generally ineffective in bringing about vegetation improvement or reducing sediment movement due to their limited capacity for moisture and sediment retention.

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