

NAVAJO LAND PROBLEMS

J. W. Hoover

THE casual wanderer through the Navajo country cannot fail to be impressed by the seemingly illimitable spaces, so vast, so colorful, and so varied in form. The inhabitants are not much in evidence, for their widely scattered simple hogans, if not hidden away, blend easily with the landscape. Eastward from the Grand Canyon of the Colorado in Arizona, the Navajo realm stretches to the 108th meridian in New Mexico, and from the Little Colorado River northward to the San Juan River in Southern Utah. The solid block of Navajo reservation area includes 25,000 square miles or 16,000,000 acres. Nine states of the United States are smaller. The real Navajo country—the country occupied chiefly by Navajo—comes nearer to 28,000 square miles, an area larger than Ireland.

Incongruously this vast area set aside for the Navajo Indians, with a density of population of about two per square mile, is overcrowded, though it appears vacant.

The Indian population of the reservation area is estimated to include 46,000 or more Navajo, about 3,000 Hopi, and 100 Piute. The entire white population comprises not more than 2,000 traders, missionaries, teachers, and other government employees. About three-fifths of the Navajo live in Arizona and nearly all the rest in New Mexico, where the density reaches four per square mile. The few Piute live along the San Juan River. Though thinly spread, the population presses hard upon the sustenance power of the area, which has an average rainfall of hardly ten inches and a general paucity of resources. So the Navajo, as ever, clamors for more land, spilling over his

boundaries, and squatting or pasturing his flocks upon public domain or other unfenced lands, privately owned.

The crux of the problem lies in the fact that the Navajo has been increasing at a phenomenal rate, while there has been a corresponding decrease in the carrying power of the range. "The vanishing American," as an appellation for the native Indian, has been rendered obsolete by the fecund Navajo tribe, now the largest in the United States. The livestock of the Navajo have meanwhile been increasing at an even more rapid rate than the people.

In 1864, after repeated annoyances by Navajo bands, the tribe was subdued by Kit Carson, and the majority of the tribe, about 12,000, were assembled at Fort Sumner or Bosque Redondo, New Mexico, on the Pecos River. Sickness and disease, with four epidemics in one year, reduced them to 8,000. In 1868 the survivors were permitted to return to their former home. Here they were started out anew with two sheep apiece for every man, woman, and child. A reservation was set aside for them around Fort Defiance in 1870.

Gradually many of the Navajo drifted away to more distant and better pastures. By 1878 they were already clamoring for more land and the first extension was created, which has sustained more Navajo than Hopi. In 1884 the reservation was considerably extended, and except for a few small areas since added, the boundaries remained essentially the same until 1935, when 1,385 square miles, all in Arizona, were added. Actually these additions have merely confirmed the Indians' rights upon lands which they already occupied. Hence

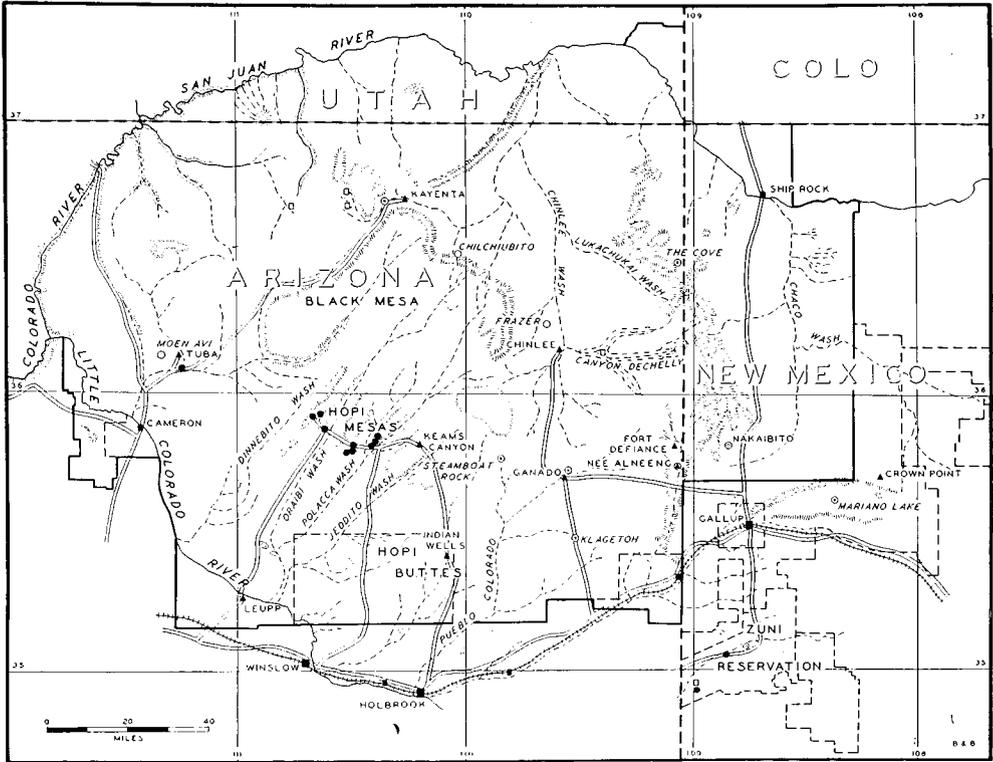


FIGURE 1.—Navajo Indian Reservation with boundaries as established in 1935, at which time 1,385 square miles were added in Arizona. Proposed additions indicated in New Mexico total more than 3,000 square miles. They still await ratification of the New Mexico state legislature.

they may not be considered as having provided in any degree for the expansion of the tribe. More than 3,000 square miles in New Mexico have been approved also by the federal government for addition to the reservation, but so far the legislature of New Mexico has failed to ratify.

The increase of population has far more than offset the areal additions to the reservation. The only real census of the Navajo in recent years was made in 1929 when they were computed at approximately 40,000. Estimates of the population at present range all the way from 45,000 to more than 50,000; 46,000 is a conservative estimate. Early estimates of Navajo population were inaccurate, and at first failed to include the considerable number who had never gone to Fort Sumner. Yet it would appear

that there has been about a four-fold increase since 1870. Geometric rate of increase shows no tapering off.

EARLY ESTIMATES OF NAVAJO POPULATION	
1872	9,114
1890	17,204
1900	20,000
1906	28,500

The language of the Navajo is Athapascan, so the stem of the tribe must have migrated from the north. Mixed origin is indicated in the tribal physical types which range from the squat solidity of the Pueblos to the tall, sinewy build of the tribes of the plains. Navajo culture reveals the same mixed character. The art of weaving, the outstanding tribal craft, came from the Pueblos, as did many of the Navajo ceremonials. Basketry is strongly Shoshonean. The hogans and also the pottery of the Navajo greatly resemble those of the Man-

dan of the plains. Puebloan somatic characteristics, and the art of weaving, came through the capture of women in raids upon the Pueblos. Also upon the return of the Spaniards, following the revolt of the Pueblos in the latter part of the seventeenth century, some of the pueblo people sought refuge among the Navajo.

A great change came to the Navajo in the years following 1630 with the acquisition of horses introduced by the Spaniards. With horses came rapidity of movement and the transformation of a comparatively peaceful local tribe into troublesome scourge, for now it was possible to attack the Spanish or Indian pueblos and depart like the wind before a counter attack could be launched.

The Navajo are superior physically and in other respects. White people living in the country quite generally appraise them more highly than other Indians. Their neighbors, the Hopi are more progressive, or appear so; but as village dwellers, having for centuries been subjected to the vices and unsani-

tary conditions of their tight villages, they are a small and inbred people. The Navajo are more reserved, more dignified, and more thoughtful, and the Hopi recognize them as a stronger race. The Navajo will not speak Hopi as they regard it an inferior language, but many Hopi speak Navajo in addition to their own tongue.

The healthy outdoor life and steady activity which goes with the care of their sheep has kept the Navajo strong and fit and has discouraged the spread of disease. The girls are better protected and sex morals are on a higher plane than with most tribes. In late years a large factor in the rate of increase has been lowered death rate, chiefly among infants, due to medical attention.

Many American and Mexican ranchers would rather have seen all the Indians driven back behind the old reservation lines than to see additions made to the reservation areas. These additions, which have been made or proposed, were mostly in the public domain, open to allotment by Indians, or to homesteading



FIGURE 2.—A Navajo family at home. The hogan is an example of one of several types. The manner of laying the logs indicates the white man's influence.



FIGURE 3.—Navajo flocks watering near Crown Point. The sheep are brought in to water every two or three days. In the vicinity of the water holes the forage is overgrazed or tramped out.

by others. They have also included much railroad land, since in order to encourage the building of the Atlantic and Pacific Railroad, now the Santa Fe, alternate sections of land were granted along the route extending back 50 miles. The railroad has been reluctant to release such of these lands as contain minerals, chiefly coal, or to make exchanges for them.

The added areas in Arizona, about 125 square miles west of the Little Colorado River, include approximately 936 square miles of the Hopi Butte country, east of the former Leupp reservation, and about 270 square miles along the New Mexico boundary which is traversed by the Santa Fe Railroad. The proposed New Mexico extensions are all to the southeast and include several detached areas; see Figure 1. The addition of these areas will leave little if any further areal expansion possible for the Navajo.

THE LAND

From the standpoint of utilization, the Navajo country is marginal land. The lower portions may well be classed as desert lands and the highest areas are rather sparsely covered with timber. But no appreciable area is so dry that it does not afford some meager forage, and none is so densely forested that it can not be used profitably for grazing.

The desert areas are less than 5,000 feet in elevation, near the Little Colorado and the San Juan Rivers. Truly barren areas are restricted to those parts which

have for ages been subjected to severe erosion by water or wind. They include the very colorful "Painted Desert" areas in the Chinlee Shales, best seen north of Holbrook and Adamana, and between Cameron and the Echo Cliffs; also the inaccessible Rainbow Plateau in the extreme northwest with its maze of canyons cut in red sandstone.

Less than one-third of the Navajo country has any forest cover. About 70 per cent of this is stunted pinon and cedar, mostly scattered, and of no timber value, beyond use for local fuel supply, and limited fence or other rough construction work. These areas can stand a minimum of disturbance. At present they are being reduced by cutting and close grazing, and they show virtually no reproduction of trees. The area of merchantable timber lands is estimated at 720,728 acres, which is about one-twentieth of the area of the reservation. The board footage is estimated to be 1,181,704,000 in Arizona, and 608,727,000 in New Mexico. These figures are mere estimates as no timber cruise has ever been made of the entire Navajo country. At least 98 per cent of the timber is yellow pine (*Pinus ponderosa*). Pinon pine (*Pinus edulis*) areas skirt the lower margins of the yellow pine forests. Although not classed as merchantable timber, their nuts are important as supplementing the Navajo food supply or income.

The major part of the country lies

within 5,000 and 7,000 feet elevation and is steppe land. Flat topped mesas rise between broad valleys or canyons cut in essentially horizontal sedimentary rock structures. Red and buff sandstones and sandy surfaces predominate.

VEGETATION ASSOCIATIONS

Locally, vegetation associations vary with soil and topographic situation and are indicators of their character. Scattered pinon and juniper commonly occur on the rocky mesas or ridges, with shrubs

here the soils are only slightly acid and contain considerable phosphorus. On the Defiance Plateau the soils are dominantly neutral.

Alkaline or saline soils occur along washes and on flats which collect surface water. Greasewood or chico (*Sarcobatus*) is the most conspicuous shrub on the alkaline areas. It furnishes good browse. Bluestem and shadscale grasses grow with it. On the saline soils, the same plants may occur, but large areas are also covered with saltbushes, spe-

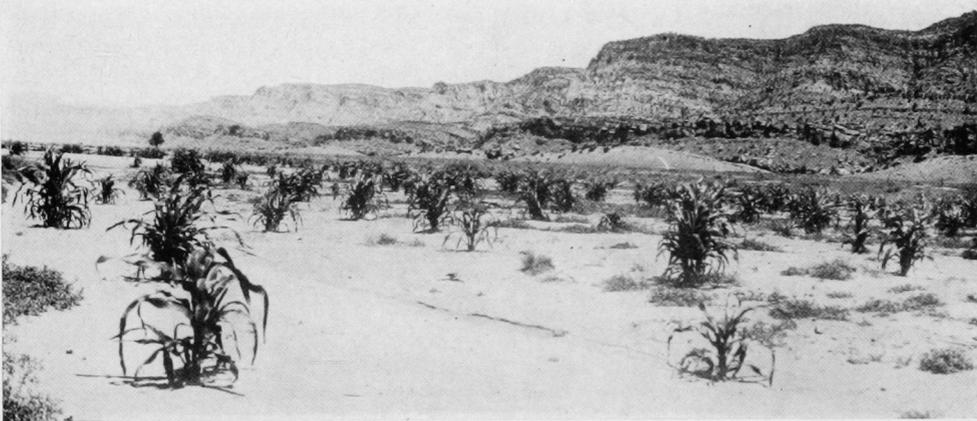


FIGURE 4.—Navajo cornfield in the Western Navajo Reservation. Navajo methods follow those of the Hopi, but in general they are less painstaking. The Echo Cliffs to the right are of bright red Jurassic sandstone. Flood water irrigation only.

and grasses on the lower slopes. Below the pinon and juniper, or extending into it, sagebrush (*Artemesia*) is the most conspicuous plant. If the soil is not too loose, the blue gamma grass, the best forage plant, grows abundantly if given opportunity. On the lower slopes having more compact soils mixed grasses occur with browse; the latter mostly *Happlepapus* and *Gutierrezia* (or snake-weed), which has no browse value, and increases with overgrazing.

A detailed soil survey of the reservation is under way. The soils may be generally classed as pedocals or lime accumulating. So far the only area found to be free of lime is on the top and west side of the Chuska Mountain. Even

cies of atroplex. The saltbushes are browsed to some extent for salting. Winter fat (*Eurotica*), another low, gray-green shrub, is an excellent fatter, valuable for winter forage when other plants are scarce, but unfortunately it does not grow abundantly. The dark green Russian thistle, conspicuous on many moderately alkaline or saline areas, has little forage value, but is eaten to some extent in the spring and early summer while young, if better forage becomes scant.

ECONOMIC ADJUSTMENTS OF THE NAVAJO TO THEIR LAND

The tragic bungling of the United States government for many years in

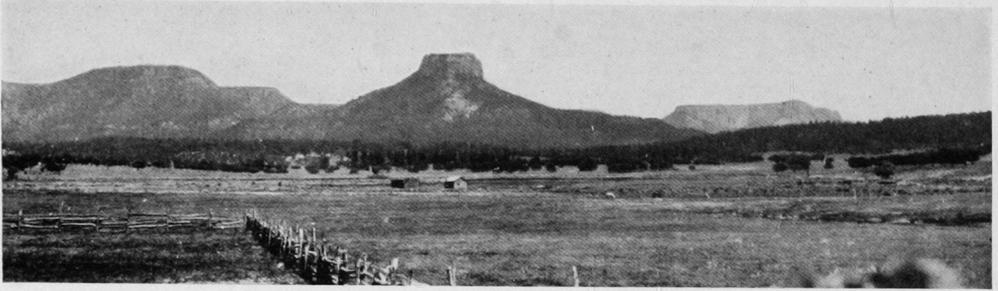


FIGURE 5.—Navajo farming community on the west flank of the Chuska mountain range where the Del Muerto stream emerges from the mountains. Ditch irrigation.

managing Navajo affairs was apparently due to ignorance in Washington concerning that part of the country. Upon their return from Fort Sumner in 1868, heads of families were expected to take up homesteads of 160 acres just as if the land were like the prairies of the Midwest. In the first years, emphasis was given to seeding and cultivation, though a small start was made with sheep and goats. For several years the Indians nearly starved while unsuccessfully trying to sow and reap from lands for which nature made no such provision. Gradually they withdrew from the wing of the government, and returned to the pastoral nomadism into which they had already become adjusted prior to their exile. Thus they became a self-supporting people regaining something of their former self-reliance. As they found satisfactory adjustment to the natural conditions of their land, they prospered with increase—sheep and goats, sons and daughters.

As the population has increased, the old unorganized wanderings in search of the fattest pastures have had to give way to more organized movements, or in many cases confinement to restricted circuits. Around the major highlands, the flocks are driven into the higher timber areas during the summer months and back again to the valleys. In other areas, drier and with less relief, the flocks are driven up in the winter, because then

only is water available (in the form of snow) in the higher areas.

Wherever possible the Navajo supplement their grazing industry with a little farming. From the standpoint of sustenance power, the land has been declining at an accelerating rate. Serious erosion of the Navajo lands has set in due to overstocking and overgrazing.

When first the Navajo began to practise livestock grazing, the demands upon the land were not intense. A satisfactory adjustment was worked out to meet the conditions of the area. But the dynamic factor of population increase has rendered their loose organization of land use inimical to the preservation of the range. Passive indifference toward the effects of denudation and depletion of forage resources has aided in lowering the productivity of the land. A finer balance must be struck between the numbers of stock grazing on the land, and its ability to produce forage, in order to avoid a material set-back of the Indians' livestock industry with attendant suffering and loss, even without further population increase.

THE PROBLEM OF EROSION

In the deterioration of the Navajo lands, erosion consequent to overgrazing, is the most serious factor. The chief damage is wrought in (1) removal of the soil and consequent destruction of land or lowering of its productive effi-

ciency; (2) increase in rapidity of runoff, which in turn accelerates the erosion process, and increases aridity; (3) lowering of the water table through lowering the bottoms of the drainage channels and rendering drainage more rapid and more complete. The amount of land completely destroyed for productive use in recent years is difficult to estimate, for the injury is relative rather than absolute in grazing areas. If the land were agricultural, much of the destruction would be complete. Reduction of productive value is very apparent and is quite general. Most conspicuous in their destructive growth are the systems of gullies which gash the country. Less noticeable, but no less insidious, are the effects of wind erosion and the more general sheet erosion.

Erosion has been noticeably accelerated in the last half century and has been greatest in the last twenty years. Streams which comparatively recently aggraded their canyon floors are now rapidly trenching their valley fill. Nu-

merous branch gullies have reached out from the deeply cut washes and have intersected the roadway.

Traces of old trails or roads may be found which once followed the valleys, but have had to be abandoned and moved farther up along the valley sides where it is rougher and stonier. Each season necessitates new detours to circumvent the heading of gullies. Instability of the banks due to undercutting of the alluvium discourages bridge building. Even on the main highways travel is often held up, as at Winslow, where the bridge across the Little Colorado was washed out three times during the summer of 1927. Even the Santa Fe Railway had to route its trains south over the Southern Pacific many times for as much as a week at a time on account of washed out bridges.

Into a few advanced major washes great quantities of water are at times poured from numerous tributary washes in all stages of development. Into the great Chaco Wash drain all the arroyos



FIGURE 6.—Young gully with vertical walls near Gallup, New Mexico. Note the large sections of the walls which have sloughed into the wash as the result of sapping.

of the Chaco Plateau in New Mexico. Also leading to the San Juan River are the washes of Chinli, Walker, and Lukachukai Creeks. In the south, the Tusayan Washes, chief of which are the Oraibi, Polacca, Dinnebito, and Jadito, together with the Pueblo Colorado Wash, drain to the Little Colorado.

As late as 1897, the Oraibi Wash was not more than 20 feet across and 12 feet deep at Oraibi according to Lorenzo Hubbel whose relatives have been traders in the country since that time. It now

a buckboard in 1914, but this became impossible about 15 years ago and the government had to put in a steel bridge.

The upper end of Laguna Creek formerly flowed through a series of small lakes, and was for this reason given its name by Kit Carson in 1863. The last lake was cut out in Laguna Canyon in 1900. On the other hand, the wash at Fort Defiance is said to have changed little since 1892, perhaps due to its emergence from a rocky canyon.

Ganado is called by the Indians "Luka



FIGURE 7.—Oraibi Wash several miles above Oraibi. Note sloughing of the bank where sapped due to meandering.

averages 150 to 300 feet wide and 30 to 35 feet deep. The Keams Canyon Wash, now about 25 feet deep, post-dates 1880. Its development necessitated moving the government experimental farm and the wash now goes through the middle of the old fields and cemetery. The head washes on the Black Mesa are still mostly narrow enough for the Indians to span with trees, but may be 30 or more feet deep. Until six or seven years ago, the Oraibi and Polacca Washes came together and emptied into a shallow lake before reaching the Little Colorado River; now both have cut arroyos all the way to the river. Between Indian Wells and Holbrook, the Teshbito Wash was easily crossed with

Entiel," meaning wide reeds. For, say the old Indians, the whole valley used to be covered with a heavy stand of reeds or tules, and there was just a small trickle of water passing through the reeds. Today the valley is gashed by the Pueblo Colorado Wash, mostly dry, but at times a raging torrent. No trace of the reeds remains, but instead there is a scant cover of snakeweed or greasewood, except where there are fields under irrigation.

CAUSAL FACTORS OF THE ACCELERATED EROSION

Most students of the problem find in the cultural changes of the Southwest, the reasons for the accelerated erosion of recent years. Prior to 1880, there

was no overgrazing of the Navajo country with its small Indian population. On bordering areas the Mexican people had cattle, sheep, and goats, but there was only a local market. The extensions of the Atlantic and Pacific Railroads through Arizona to the Colorado River by 1883 brought a great increase in the cattle business. Wells were drilled and cattle were put over the country. By 1890 the country was much overgrazed and the grass largely gone.

The Navajo are strikingly indifferent toward their land resources, having none of the peasant feeling and responsibility

secure some needed article from the hogan. A few do not bring the sheep back to corrals at night but practise bedding out. The larger herds are generally better managed.

A reduction in the amount of movement on the reservation would reduce somewhat the range destruction. Watering places are as yet too far apart and the flocks have to be driven long distances for water. Navajo herders do not recognize prior rights. They fail to regulate the use of springs and quarrel a great deal over the watering places. Hence many possible springs remain un-

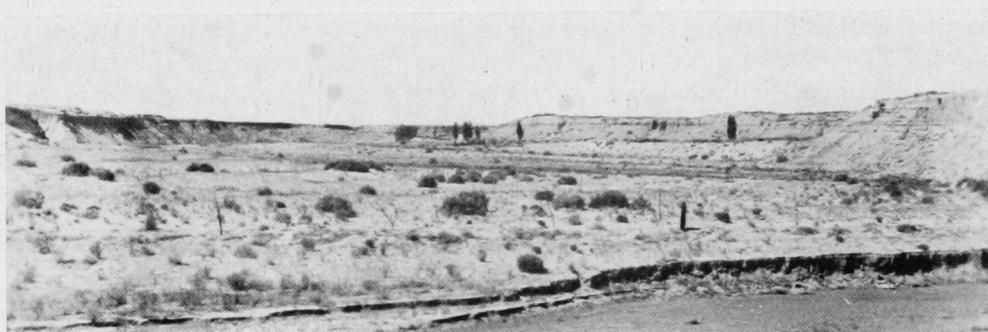


FIGURE 8.—The wide flat of the old Oraibi Wash representative of an advanced stage in arroyo development. The present Oraibi Wash has been cut in the alluvium of this older wash since 1880.

toward the land that goes with the sedentary Indians. Their destructive exploitation is the result largely of the grazing by an individual family of a convenient radius around the hogan and the return of the sheep and goats to the hogan every night. This results in overgrazing and tramping out the grass, irrespective of total numbers of grazing animals, and probably has done so from the very outset. The radius of the area grazed around the hogan may be as much as five miles but commonly is less. The distance depends upon the individual or family. The sheep are brought in every day and sometimes several times a day. The woman herder may also be weaving, and sometimes brings the sheep in unnecessarily during the day, in order to

developed for fear others will secure their use. The man with the large herds usually gets control and holds it when pastures are scarce. In the summer the sheep must be taken to the water every two days, in the winter every four days; perhaps 15 or 20 miles unless there is snow to eat. In the summer months the flocks are also occasionally brought from the highlands to the saline flats for salting by feeding on the saltbushes.

Many roadways in the Navajo country have been abandoned, for the ruts, directing the water of torrential rains, have been converted into gullies or arroyos. Horse and sheep trails also tend to start gullies. Not infrequently gullies run along the sides of the valleys instead of crossing the contours directly



FIGURE 9.—Dinnebito Wash. Early stage in the development of an arroyo flat. Note corn patch on small flat under the meander wall on opposite side.

to axial washes following the valley bottoms. The position of former trails is also sometimes indicated by gullies which follow the crests of the ridges. More Indians are securing wagons which is much worse for the range than the use of horses alone for transportation.

Kirk Bryan and H. E. Gregory have held to the idea that the present erosion may be incident to natural causes, perhaps slight climatic change. The major terraces of the Gila and other streams of the Southwest upwards of 75 feet in height are the result of alternate periods of erosion and deposition on a large scale. Remnants of smaller terraces suggest shorter cycles of alternate erosion and deposition within the larger ones; records of still shorter cycles may have been obliterated. Slight periodic fluctuations in climate might account for these terraces. Since the terracing as well as the present erosion is general through the arid southwest, it could hardly be due to diastrophic causes, as in this case the erosion would proceed from the margins of the uplifted area.

The record of rainfall for the few Navajo stations shows no progressive decrease. But Lorenzo Hubbel believes that overgrazing is insufficient to account

for the present erosion, and that although there has been just as much rainfall it has come at the wrong time; in general too late to make sufficient growth to hold the soil. Too few data have been kept and over too short a time to be conclusive. The increased meteorological observations begun in connection with the Navajo Erosion Control Project should clarify the problem if kept up long enough.

In view of the present tendencies to lowered productivity, and admitting the existence of earlier similar cycles of erosion in no remote period, it becomes a reasonable hypothesis that areas may have been abandoned in prehistoric times when erosion made them untenable. Thus we may eventually explain to a considerable extent, the mystery of many of the abandoned ruins throughout this region. Furthermore, the relatively dense populations of the regions in the past may have ushered in a series of processes akin to those of the present. A search for correlations between periods of human occupation and periods of erosion may prove fruitful. And if they are found to exist, the land will be seen to have within it the potentialities of healing itself.

Kirk Bryan found evidences of alternation of sedimentation and erosion on the Chaco River or Wash at Pueblo Bonito, New Mexico. Here the Chaco has cut an arroyo 24 to 30 feet deep since 1860. The alluvial deposits on the valley floor include remnants of pottery, charcoal, etc., to a depth of 21 feet, attesting to human occupation during this period of sedimentation. An ancient buried channel was traced for more than five miles. This older channel was evidently formed toward the close of the prehistoric occupation during which the great pueblos were built. Pieces of pottery of very late prehistoric date were found in the channel gravels, whereas

only pottery of ancient date was found at the same depths in the main valley fill. Bryan sees in this evidence of the fact that overgrazing is not the fundamental cause of the late rejuvenation of erosion in the southwest, as these prehistoric people did no grazing. However, archaeologists of the Southwest postulate a similar cycle of devastation through stripping of woody growth for construction and fuel, followed by accelerated run-off, lowered water table, reduced grass cover, and destructive erosion.

Prehistoric ruins dating back 2,000 years, are located in the vicinity of the Nakaibito Erosion Control Experiment

problem, the natural processes of erosion and sedimentation and also the natural balance between vegetation and animal life, must be given careful consideration.

Young gullies in the Navajo country are deep, narrow, and steep sided. Where the soil and mantle is clay without much stratification, they are likely to be V-shaped. But stratification of thin beds varying considerably in texture is conducive to vertical walls, even in the initial stage (see Figure 6). Such gullies tend to head by notch cutting, duplicating, when they run water, the conditions of receding falls in horizontal



FIGURE 10.—Bad lands between Cameron and Tuba. The bad lands are mostly in the easily eroded Chinle shales. Thin beds of sandstone and limestone act as binders holding the steep slopes. Owing to the brilliant colors such areas are called "Painted Desert."

Station, on the head of one of the three forks of the Chaco Wash. The extent of the ruins suggests a prehistoric population of perhaps as high as 10,000 in the valley of this wash, living by agriculture in an area where there is virtually none today. Later the Navajo cultivated the flats in the valley below the experiment station. But gullies came in with grazing, and now the main wash has been cut as deep as 50 feet. The gullies drained the ground water and the farms had to be moved farther and farther up the valley until now they have been pushed back to the head of the wash on the mountain divide.

In seeking a solution of the present

strata. More commonly the gully grows in part by the headward advance of a series of low notches until it finally divides into a number of small tributaries. These in turn may duplicate the form and processes of the main gully in miniature, leading into rills which grade into sheet erosion. Such erosion is encouraged in areas of sage or other shrubs which are without grassy cover. The lack of such cover is usually a stage in the process, following removal of the surface soil by sheet erosion incident to grazing, and consequent lowering of the water table. In grassy valley bottoms, the gully heading is usually more spectacular. As the gully enlarges, the

banks sag slightly under gravity, especially when pretty well saturated with water. Cracks develop, sometimes as much as 20 feet away. Rain wash entering these cracks enlarges them, and weakens the banks as it seeks its level in the wash. Only a small amount of flow may then be sufficient to sap the banks and cause large sections to slough or slump into the wash. (See Figures 6 and 7.) Much of this slumped material must await a large flood for transit. In the meantime it rests at the base of the steep sides.

On higher slopes silt deposits over the bedrock may be shallow, and even in larger valleys they are not generally so deep as in the arid basins of Arizona and southeastern California. So the valley may be cut to bedrock in places. The Oraibi wash is cut to bedrock about 16 miles above Oraibi and about the same distance below.

While actively widening, the gully banks are unstable, and are a serious handicap to transportation, even dangerous in time of flood. The water table is lowered and the surfaces above are drained of their moisture. In some cases there may be some compensation in a flow of water where the gullies are cut to seepage levels. By way of illustration, in the Oraibi and Dinnebito Washes the flow of water increased as they were cut down, but there has been little change in depth or in amount of water in late years. In the Oraibi Wash there is just a little permanent water at Oraibi, the amount of downwash reaching a maximum at 10 to 15 miles below the village. Increased seepage in the Dinnebito Wash has added materially to the number of springs and the Navajo have changed the name to To-dez-lini, meaning "many springs."

With an increasing number of tributary gullies, the axial washes find increasing difficulty in transportation of

the load over the ever-widening bottoms. High vertical silt walls are cut where the current swings to the side of the wash. On the opposite side, the banks gradually slough down and develop rounded continuous slopes. Small flats develop inside the meanders, and gradually the wash widens into a continuous flat. The Pueblo Colorado Wash is entering upon this stage. Above Oraibi, the present or recent wash is cut in the wide flat of an older one (Figure 8). Only in the occasional master floods would the flats be entirely submerged; then except for gradual or abrupt changes in the channel, they would have sediments added rather than removed. The flats may be more fertile than the lands above the bluffs and would be as moist at least as these higher lands ever were. Already small patches of corn are cultivated on the small incipient flats of the major Tusayan Washes (Figure 9). The hazards are hardly greater here than on the land above, where too the Indians find it necessary to shift their fields from year to year with shifting conditions.

Thus viewed, the future of the major washes should present less cause for alarm, since new land as good or better than the old may be built on the widening flats. However a still more advanced stage may be visioned, when the higher slopes of the land would be completely denuded of their soils, in most places thin at best. Then here, as in parts of North China today, the rains would splash against the bare rock mountain sides, and rush off down the gulches as if from bursting dams. Floods would rise suddenly, devastating the country, and subside almost as quickly leaving little or no moisture behind to keep things green.

By checking the run-off and gullying from the head, the banks should slough down to gentle slopes in the absence of the carrying power of the flash torrents.

In the Chinlee and Tusayan Washes drifting sands accumulate opposite the meander-cut bluffs. As an extreme case, Reservoir Canyon, near Tuba, was virtually obliterated by drifting sand. The natural vegetation, if given a chance will help bind the silt and sand drift. Surprising results have already been demonstrated at Nakaibito.

As suggested by Sauer, gravity movement in mass, taking place beneath the surface cover may be predominant in the movement of the mantle. This factor has been commonly overlooked owing to its inconspicuous character as compared to spectacular gullying. While such movement is normal in varying degrees to all slopes, it must be understood in its relation to destructive abnormal erosive processes.

As yet most of our observations on surface and soil denudation, in the Navajo country and elsewhere, have been cursory. Careful research is needed extending over a period of years. In his recommendations to the Science Advisory Board, Sauer has suggested a scientific approach for research in soil erosion.

REHABILITATION OF NAVAJO LANDS

The United States government is attacking the problem of rehabilitation of the Navajo lands and of checking destructive processes on them from several angles. The problem is seen to involve (1) checking of erosion by obstruction of free run-off of water; (2) restoration of the natural vegetation cover and the introduction of plants suited to check erosion; (3) rodent control; (4) reduction of Navajo stock; (5) better distribution of people and stock over the area; and (6) finding or providing other sources of income.

The leading agencies put to work are, in addition to United States Indian Service: (1) the Navajo Erosion Project,

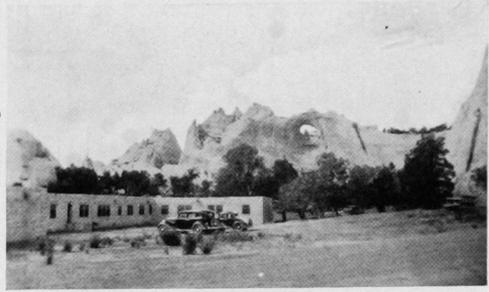


FIGURE 11.—“Nee Alneeng,” the new central agency for the Navajo, in picturesque surroundings. Note the “window” in the pink sandstone cliffs.

under the Department of Agriculture; (2) the Southwestern Station, Erosion and Plant Studies, under the Bureau of Plant Industry; (3) rodent control conducted by the Biological Survey, both of the latter under the Department of Agriculture; (4) Indian Emergency Conservation under the United States Indian Service.

Until recently the Navajo were governed from six distinct agencies located at Tuba, Keams Canyon, Leupp, and Fort Defiance in Arizona, and Ship Rock and Crown Point in New Mexico. On May 20, 1935, unification of the Navajo Reservation under a single agency was accomplished. The new central agency is located seven miles south of Fort Defiance and takes its name, Window Rock, from the natural window in the sandstone cliffs nearby (Figure 11). It is planned to make this the center of the social, artistic, and religious life of the Navajo as well as of their government. To date the Navajo do not show much appreciation of the capital being built for them, resenting somewhat too much government dictation.

THE NAVAJO EROSION CONTROL PROJECT

The Navajo service includes an experimental area of 67 square miles at Nakaibito or Mexican Springs, located 20 miles north of Gallup, together with

a number of demonstration areas as follows:

<i>Demonstration Areas</i>	<i>Acres Treated or Affected up to Nov. 1936</i>
Moen Ave., west of Tuba	10,508
Canyon Diablo, southwest of Leupp	4,864
Pete Springs	23,400
Kayenta	38,223
Chilchubito, northeast of the Black Mesa	16,586
Canyon de Chelly	3,137
Fraser, northwest of Chinlee	5,553
The Cove, ten miles west of Red Rock	29,376
Steamboat Canyon, midway between Keams Canyon and Ganado	25,000
Ganado, just northeast of Ganado	7,953
Klag-e-toh, 15 miles south of Ganado	3,900
Navajo Agency, at Window Rock	639
Chaco Canyon	3,000
Mariano Lake	7,005

Thirty-seven or more other projects are directed toward specific improvements and are classed as land management.

From the inception of the project and up to June 30, 1936, \$3,121,444 had been appropriated by the federal government for the Navajo Erosion Control Project. The Nakaibito area is intended to serve as a center of research for the reservation. It is roughly 20 miles long and five miles wide. Various methods of checking erosion are being tested. Grazing is also being studied from several angles, viz., intensity of grazing, seasonal use, and the number of sheep, goats or cattle that can be taken care of on given types of range and still recover their maximum efficiency of forage and ground cover.

The demonstration areas have also had to do considerable experimenting. Much of the first work at least was far too expensive to be warranted by the value of the land as a factor, but expensive examples on land of little value would appear to have little demonstrable value. Much of the first construction work was admittedly guess work awaiting the test of really heavy downpours. A heavy rain on the Nakaibito station on May 30, washed out more than 25 per cent of the small dams, but none have been washed out since. At any rate such washouts are not necessarily an indica-

tion of inefficiency if the obstructions are cheap enough.

Construction engineers, plant ecologists, and botanists, and meteorologists have been freely employed, but for the labor, Navajo have been employed exclusively. As the Navajo is unaccustomed to steady labor on schedule, and is unskilled in the type of construction so freely employed, some of the work has been inefficient both from the standpoint of amount and quality. In the beginning much rather aimless work was done just because the orders were to put the Indians upon the pay roll at once.

The total area of the experimental and demonstration projects is less than 200 square miles, which is hardly four-fifths of one per cent of the whole Navajo country. The intention is that these areas shall serve to demonstrate to the Navajo what can be done to check erosion and how, so that they will proceed to put these methods into practice throughout their reservation. The success of the undertaking therefore depends upon the Navajo, for the areas covered by the demonstration projects are trifling. In general the Navajo thinks only in terms of the present. Yet most of the headmen have caught the conservation idea and have pledged their coöperation. Such pledges are easy to make under the stimulus of substantial pay rolls; nevertheless they doubtless are based on good intentions.

In view of the size of the total area to be treated and the limited resources of the Indians upon whom the eventual success of the project will depend, such means must be found, presumably on the experimental area, and carried out on the demonstration areas, as have wide application with a minimum expenditure of labor and material. Such is the policy of the present administration at Nakaibito Experiment Station until lately under the direction of E. Musgrave. Any

system introduced must be self-operating and self-sustaining, for anything which requires attention is of little avail with the Navajo. Yet they are beginning to act some on suggestion.

UTILIZATION OF VEGETATION COVER

The protection and reseedling of suitable native plants and the introduction of others promise excellent results. Due to overgrazing in the Navajo country, the more palatable grasses have been replaced to some extent by the more

The Russian thistle is an illustration of an introduced plant which has altered the landscape of the Navajo country, as well as other semi-arid areas of the West. The plant was unwittingly brought into these parts, with hay it is believed, about seventeen years ago. By some authorities it has been reported as a pest because of its rapid spread and its slightly barbed brittle stems when mature. On the whole the plant is a benefit to the country. It is frequently the most abundant plant on saline and slightly alkaline soils,



FIGURE 12.—Navajo Indians at work on check dams in the Ganado Demonstration area. Summer of 1934.

hardy but less desirable species of plants. The best plants grow weaker from season to season as the result of the roots being trampled out and because they are grazed before the seeds have had a chance to mature. Seeding and planting of native species, although expensive, is generally worth while in badly eroded and depleted areas. The saltbushes may be used to advantage on saline or alkaline soils. They give variety to the forage and act as an over story for soil protection. Sage brush may be used on other soils to protect the soil, but it is low in forage value. However the blue grama grass produces heavy stands in the sage brush.

but is easily crowded out by other plants. It is found mostly on soils where scarcely anything else would grow, so with its dark green color it makes such areas more pleasing to the eye. It is commonly the first plant to take hold on disturbed surfaces, hence is not a very good soil binder. While young it has considerable value, and in droughts of early summer may be the only plant abundantly available. In midsummer it becomes hard and brittle and blows away as tumble weed to accumulate around clumps of shrubbery and to lodge in gullies. In dry years it is a great help in checking erosion as the dead stalks accumulate in the heads of young gullies

and become traps for sand and silt. Due to the short season of the thistle's growth, it affords no surface cover during a large part of the year.

Cottonwoods and willows, easily propagated, may be planted to good advantage in wash bottoms. From the cottonwoods planted at Chinlee, the seeds have been carried down the wash and the trees are scattered for many miles below. Formerly cottonwoods were more common along the washes. In years of severe drought the boughs had to be cut for forage. The tamarisk, introduced from Asiatic deserts, is transforming erosion and sedimentation processes along streams in the lower deserts and the Southwest and is being planted in a few places in the lower parts of the reservation. But it does not thrive in the higher areas with their more severe climate.

The timber margins of juniper and piñon have retreated considerably on the reservation because of the Indians' quest for fuel. Around the Hopi villages the valleys are denuded of wood and even the stems of the shadscale (*Atroplex*) are used for fuel. The Nakaibito Experiment Station is located in the juniper zone but only a few stunted specimens are found around it now. Cottonwoods once grew along the wash, then a stream, for some miles below the station, as is attested by old stumps and the memory of old Indians. One old one, and only one, is still growing below the station.

Cottonwood and segi willow, a low gray native willow of the Segi Mesa country, are being planted in the main wash at Nakaibito and are proving very effective in holding silt. The segi willow has a ramifying root system from which shoots grow and spread rapidly. It is thus hoped to restore the pristine condition of the valley, now nearly barren and gashed by a dry wash, to one of wooded or grassy slopes with a clear

stream flowing through groves of trees.

On the lower open areas several low wide dams have been put in and the water spread upon the land at a cost of about \$2.50 per acre; as the areas above the dams fill with silt, they will be planted to trees such as honey locust, which produces a seed for forage, ash, cottonwood, and Chinese elm. Eventually these areas can be cropped for wood. Effectiveness of the efforts at Nakaibito is indicated by the fact that during the past year, a rainy year, the run-off from the area was about 2,000 acre feet, whereas in the year before, a dry year, it was more than 4,000 acre feet. It is hoped that it will be reduced to zero this year.

RODENT CONTROL

Because of the low water content of the soil, the plants in general have very low vitality. Hence insects and rodents, ordinarily not important, become injurious and may cause death to the plants. Rusts also are killing the junipers.

Prairie dogs are the most numerous and destructive rodents on the range. One prairie dog will eat two times its own weight in a week. They eat the tops of the grass, then dig up the roots when the tops are gone. Around their villages they not only eat the forage but cut it off clean to give better vision. They will forage a radius of about one-fourth of a mile, using emergency holes. Estimates of the increase of erosion due to prairie dogs vary from 15 to 40 per cent. In general the Navajo cooperate with the Biological Survey in the work of eradicating prairie dogs, but some Indians are opposed to it because they use them for food.

The Navajo's corn field must run the hazards, not only of climate but also of prairie dogs, rats, and ravens. Strange devices are placed in the fields to scare them away; during the night they use

burning cedar bark which has been rubbed in the hands to make it inflammable.

REDUCTION OF NAVAJO FLOCKS

It follows as a matter of course that if the ills of Navajo land are largely the results of overgrazing, the Navajo flocks must be reduced if any real progress is to be made in restoring the land.

Dipping records for 1936 show a total of 1,080,706 sheep units. All stock is here included, each cow rating as four sheep units and each horse as five. The above sheep units thus included 459,285 grown sheep, 381,016 lambs, 122,847 goats, 17,887 cattle, and 29,162 horses. Range surveys show that the carrying capacity of the Reservation is between 550,000 and 600,000 sheep units. Stocking in excess of that figure will further deplete the vegetation and increase the losses due to erosion. The number of sheep and goats on the Reservation reached an all time peak in 1931 with 976,669 sheep and 345,242 goats. The reduction since then has amounted to 24.2 per cent of sheep and 68.8 per cent of goats.

Sheep and goats have been the life of the Navajo people. Anything that affects their sheep affects their life. They live with their sheep, are attached to them, and if there are not too many, they know them by name. Furthermore, the Navajo have been accustomed to think only of immediate wants and the idea of conservation is to them a new one. It is not strange then that the stock reduction program of the government is the one proposal which has met with considerable resistance.

The number of sheep per family has averaged about four or five hundred. Some of the poorer families do not have over 50 sheep and a few have as many as 2,000. The richest man in the vicinity of Ganado, still living in a primitive

hogan, owns 3,000. A Navajo family numbering not more than seven needs at least 150 sheep for bare existence, if dependent upon the product of the sheep alone. An average family numbers about eleven persons and has an income of about \$400.

Goats were once recommended to the Navajo. It now seems inconsistent to them that they should be asked to eliminate them in particular. The goats are of course especially bad for the range, but the Navajo learned to prefer them for meat because they remain fatter. They can sell the mohair for as high a price as the wool from sheep. Furthermore the goats are more intelligent and tractable than the sheep, and mixed with the sheep make them easier to manage. Reduction of stock has been carried on through purchases by the drought relief administration. The Indians have been paid from \$1.00 to \$3.00 for sheep and from \$1.00 to \$2.50 for goats, which is more than they would have received for the same classes in the open market. In addition to sheep and goats, the Indians still have many useless horses and ponies, although inroads have been made upon them for some time by government purchase and disposal. The Indians in some sections have been reluctant to dispose of them at the government prices of \$2.00 to \$2.50, preferring to use them for food.

COÖPERATIVE, PROTECTIVE, AND HIGHWAY PROJECTS

The demonstration areas are under fence with five-year coöperative agreements which give the government control of range management and stocking areas. Following a range rest period with the exclusion of all stock, the areas are restocked with Navajo owned sheep under government management. The Ganado area has been the first to be restocked. This year a 93 per cent lamb



FIGURE 13.—Silt catchment in rocky arroyo at the second Mesa of the Hopi Indian villages. Illustrates the painstaking efforts of the Hopi in the way of agricultural land utilization.

crop has been produced from it as compared with 60 per cent in the vicinity outside the area. The average weight of lambs this fall was 69 pounds as compared with 45 to 50 pounds outside the area, while ewes sheared twice as much wool. Range improvement has kept apace.

IMPROVEMENT OF NAVAJO STOCK

It is obvious that if the Navajo must reduce his flocks by about half, there must be some way made possible whereby he can keep his low standard of living at least at par. Will this be possible?

First, there is much room for improvement of the Navajo stock. The so called "Navajo Sheep" has long hair like wool which is well adapted to the hand spinning in their rugs and blankets, but yields a very poor fleece for commercial purposes. Their wool contains very little grease, and is easily washed by the Indian method, using yucca "soapweed" and cold water, instead of soap and warm water. Very little is known of the origin of the Navajo sheep, though evidently they are an evolution, without selection, from sheep in the first place obtained in raids upon Mexican and Pueblo Indian flocks. The sale of rugs several years ago amounted to \$750,000 a year. Hence a wool suitable for hand weaving is of prime importance. The

Indian Bureau has introduced Merino strains into the Navajo flocks because of the known high market value of the wool and the hardiness of the sheep. The Merino strain has not proved very satisfactory however, because the wool is a very short staple with a very sharp even crimp. This makes it desirable for machine weaving, but the spun yarn will not wash white by the Indian method. The grease catches quantities of dust and dirt making the wool unsuited to the desert environment.

The problem of improvement of Navajo stock is then to find a breed of sheep which has ability to get a living under adverse desert conditions, with a fine quality of wool, as long as possible, loose, not too highly crimped, and free from grease. In a word it should be suited to the Indian blanket weave, yet the surplus wool should be highly saleable. The stocky mutton type should also be striven for.

It has been suggested that since cattle are not so hard on the land as sheep it might be well to encourage the Navajo to shift from a sheep and wool economy to one of cattle grazing. Yet if we may judge by the conditions of southwestern tribes engaged chiefly in sheep breeding and those engaged in cattle raising, the sheep and wool industry has a far more wholesome effect upon the Indian. Sheep keep him continuously busily occupied, while cattle leave him idle for a large part of the year with income poorly distributed encouraging attendant vices and demoralization. So while cattle may be urged for the good of the land, the sheep must remain for the good of the Indian.

RECOURSE TO FARMING

The agricultural resources of the Navajo Reservation are far from exhausted. Irrigation has long been practised in a small way where streams

emerge from the Chuska Mountains and more recently where the Indian service has improved the water supply, as along the Paso Colorado Wash below Ganado, and in the Chinlee Valley. Small patches also are scattered over the reservation on which flood waters can be utilized. Here the Navajo crudely follow the methods of the Hopi. In general the Navajo is a poor farmer, for he dislikes the painstaking labor which the Pueblo Indians expend on no better land. Several thousands of Hopi succeed in making an independent living on less than 1,000 square miles of land no better than much of the surrounding Navajo Reservation. Hence if the Navajo could be brought to the Hopi methods and economy, their population problem might be solved—for some time at least. Furthermore, if the Navajo can be induced to extend the practices demonstrated on limited areas by the Navajo Erosion Control Project, the tillable areas may be greatly extended. At Nakaibito several hundred acres already have been made available for corn on the lower open flats as the result of spreading water from washes.

The Indians have developed the best drought resisting corn in existence. Twelve-inch ears commonly grow on 30-inch stalks, and often several ears to the stalk. On flood irrigated areas the yield may be as high as 20 bushels to the acre, or on ditch irrigated fields as high as 40 bushels (Figure 14). Fruit production should be encouraged also though it can be grown only locally. In Canyon de Chelly peach trees are growing on roots known to be 64 years old. Peaches are an important crop with the Hopi, but they have not been planted by the Navajo except in Canyon de Chelly. The use of vegetables also needs to be encouraged.

The Navajo is a good politician. So say those who are his neighbors. Hence



FIGURE 14.—Productive Navajo fields in the Tunitcha Mountains, upper end of the Nakaibito experimental area.

he is successful in receiving more attention and more benefits from the government than his proverbially stubborn Hopi neighbor, or other Indian tribes in general. He is noted as crafty in trade, and his art is not lost in his deals with Uncle Sam.

REMUNERATIVE EMPLOYMENT

According to the statement of the Commissioner of Indian Affairs, in the summer of 1934, twice as much was being spent by the government per capita for Navajo relief as for white relief. Employment was provided under the Indian Emergency Conservation Work. By the summer of 1935 the number of Navajo employed had been reduced to less than 1,500. The general wage paid by the government was \$44.00 per month or \$2.40 by the day for ordinary labor; some are paid higher. Others of the Navajo work for the Americans at good wages.

As income increases the standard of living goes up. Most Indians spend their earnings as they are received. Few save anything for the future except as they may invest in jewelry. Unfortunately most of those on pay roll are near towns which exploit the weaknesses of the Indian. Gallup, New Mexico, is surrounded by Navajo domain. Put upon the pay roll the average Navajo

begins with a first payment on a second-hand car and thenceforth becomes a slave to further installments and repair bills, and usually goes into debt. It is estimated that it will require at least three generations for them to learn the lessons of economy.

When the men began to receive wages, the women ceased to weave as many blankets, and they became more scarce. Formerly the man tightened his belt until the squaw had finished her blanket, but with her man on the pay roll the squaw waits for him to bring home the groceries. With decreased employment more blankets are again appearing on the market. Furthermore, under the encouragement of the Indian Service and schools and traders, the blankets are improving in quality. In a way outside employment helps to improve the quality of the blanket product, for when times are good only the more skilled weavers

work, but when times are bad, everybody who can, whether skilled or not, must needs weave.

Navajo weaving is a marginal industry which requires favorable circumstances to assure profitable activity. The economic returns are very low at present prices. At the Ship Rock Trading Co. a weaver was recently employed and observed as an experiment, and it was demonstrated that the weaver habitually weaves rugs for a market wage of five cents an hour. With exposure to the luxuries and conveniences of American life, how long may the Navajo women be expected to toil at the loom for a wage of five cents an hour? And when the government subsidized employment ceases, must the Navajo needs go back to the old life deprived of the luxuries for which he has cultivated a craving, to add another discontented element to our population?