# WORK REPORT

## CONSERVATION SURVEY

Land Management Unit 3.

Navajo Project

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the time, but will be incorporated
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## Soil and Erosion Report of Land Management Unit 3

Land Management Unit Number 3 is located in the extreme western portion of the Navajo Indian Reservation. It lies within Coconino County, Arizona; approximately between 35°45' and 36°45' parallels of latitude and 111° and 112° meridians of longitude. The south portion of the Unit is rectangular in shape, but the north portion forms a narrow wedge extending northward to Lee's Ferry, located on the Colorado River. The river forms the northwest boundary, not only of this Unit but also of the Navajo Indian Reservation. The east boundary of the Unit is very irregular, touching or following such natural landmarks as Echo Cliffs, in the north portion, Crooked Ridge, Preston Mesa, Little Mesa, Cow Springs Wash, Blue Canyon, and Dinnebito Wash. From a point on the Little Colorado River, known locally as Black Falls, the boundary follows the south and west boundary of the Navajo Indian Reservation to the confluence of the Little Colorado and Colorado Rivers. The Unit embraces approximately 1,735,000 acres or 2,789 square miles.

U. S. Highway 89 extends north and south through the central portion of the Unit for a distance of approximately 85 miles. Other important roads branching from this highway are: (1) The main highway leading west to the Grand Canyon National Park leaving 89 at Cameron, located on the Little Colorado River. (2) The main road leading northeastward to Tuba City and Kayenta. (3) The Tuba City-Hotevilla road leading southeast from Tuba City. The latter is located in the central portion of the Unit. The entire Unit is accessible by secondary roads and truck trails.



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Physiographic Features:

The main physiographic features of Unit 3 are: Gray Mountain and the deep gorge of the Little Colorado River in the southwestern; steep, rugged canyon walls in the western; Shadow Mountain and extensive rough broken "badlands" in the central: Echo Cliffs and Kaibito Mesa in the northern; and Coal Mine and Blue Canyons and Moencopi Plateau in the eastern portions of the Unit. Stony outcrops and steep mesa escarpments are common to all parts of the Unit, but numerous broad smooth gently sloping or rolling uplands and valleys dominate the southwestern and western portions. The northeastern and eastern portions are characterized by an upland, plateau or mesa topography, the surface of which is characteristically hummocky.

The steep character of the terrain is conducive to rapid runoff, especially during the rainy season in late summer. Torrential storms falling on relatively impervious soils have resulted in excessive erosion, both on the rugged slopes and also on the alluvial soil deposits below the steep escarpments. Extensive areas, located in the central part of the Unit, are practically barren of soil cover.

With the exception of relatively flat mesa tops in the eastern and northeastern portions, the Unit is well or excessively drained. Practically all surface drainage leads to the Little Colorado River which traverses the southwestern portion of the Unit. The Moencopi drainage system, which empties into the Little Colorado River near Cameron, drains the central and northeastern parts of the Unit. A very minor portion of the Unit is drained by small intermittent streams which empty directly into the Colorado River. Drainage from the extreme eastern border



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reaches the Little Colorado River through the Dinnebito Wash.

Climate:

The lowest elevation, 3200 feet, is at Lee's Ferry in the extreme northern portion, and the highest, 7000 feet, on Gray Mountain in the southwestern portion. Climatic conditions vary considerably between the extremes in elevation, but the Unit, as a whole, is semi-arid or arid. Tuba City has an elevation of 4500 feet. Available climatilogical data over a 29 year period (1897-1930) at this place indicate that the average annual precipitation is 6.9 inches. Extreme years occurred in 1906 and 1924, with an annual precipitation of 12.57 and 1.58, respectively. The mean annual temperature is 54°. The maximum is 108°, and the minimum -15°. The average frost free growing season is 179 days, from April 22 to September 19. The climate of this Unit is characterized by a high percentage of clear days, low rainfall and humidity, and very little snow. The rate of evaporation and transpiration is very high as a result of hot summer days, and high spring and fall southwest winds. These conditions, in a large measure, account for the sparse native vegetation over most of the Unit, and for the fact that very little dry land farming is practiced.

Agricultural History and Present Land Use:

The land in Unit 3 is primarily adapted to grazing. Forestry and agriculture are of minor importance. Properly utilized, the area is capable of producing considerable quantity and variety of native browse and grass, but the Unit is typical of the Reservation as a whole in that soil and native vegetation is in a depreciated state, in most cases the result of improper range use.



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Agricultural development is limited not only by precipitation, but also by a lack of soil adapted to that purpose. Approximately 1100 acres are under irrigation at Moencopi Village near Tuba City from an Indian Service diversion dam located on Moencopi Wash. Another small area at Moenave is irrigated from springs, located along the base of Kaibito Mesa.

Historical data are not available, but probably some irrigation has been carried on here since the Mormon Pioneers entered this country about 1870. Some wind and water erosion has been incurred as a result of improper agronomic and irrigation practices. More significant, from a soils point of view, is the fact that valuable farm land at Moencopi farms has become impregnated with, and abandoned because of, harmful quantities of alkali. It would seem advisable, in view of the limited area of good agricultural land in this section, to initiate alkali investigations on this area for the purpose of discovering its cause, present status, and feasible methods of protection and reclamation of valuable agricultural land.

Approximately 1000 acres of land, located on top of Moencopi Plateau, is flood irrigated at the present time. An additional 200 acres is included in scattered dry farms in this same section. Removal of native vegetation on those sandy soils has resulted in severe wind erosion. The present condition warrants the attention of the agronomist to consider methods of effective control.

## Soils

The soils of Unit 3 are derived from reddish-brown Morrison and Wingate sandstone in the eastern and northeastern portions; reddish-brown or maroon Chinle and Moenkopi shale in the central; and grayish-brown



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Kiabab limestone in the western portion of the Unit. Soils derived from igneous rock occur in the extreme southern part of the Unit. These parent materials have imparted to the soils different characteristics which influence their productive capacity and susceptibility to erosion. For example, those derived from sandstone are very susceptible to wind erosion; those derived from shale are more susceptible to water erosion; but those developed from limestone and igneous rock are little effected by any form of erosion, due to the stabilizing effect of the vegetative cover.

In addition to origin, the soils of this Unit have been classified, systematically, according to mode of formation, chemical composition, stage of soil development, and surface texture. Using these criteria, the soils of the Unit have been placed in 15 series embracing 23 types. Other miscellaneous land classes include rough, broken and stony geologic materials, and riverwash. In this survey, the soils are also classified according to land use, slope, and erosion.

The main purpose of such a classification is to determine, as far as possible, the productive capacity of the soil under present land use. Further, to determine the need for, and the adaptability of these soils to an improved land use program. In this latter classification, the soils have been grouped into five land classes, according to range adaptation or quality from a range point of view. These five land class groups are briefly described. Their location is shown on the land class map.

Factors Considered in Grouping Soils:

Soil moisture is probably the chief limiting factor in forage production; therefore, in grouping soils according to range adaptation, soil conditions which influence moisture relationships are given special emphasis. Factors thus considered important are: slope, erosion, permeability, water-holding capacity, and alkali content.



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Group A Soils (excellent range soils) consist of those having: moderate slope (generally less than five per cent), less than 25 per cent of the top soil removed by erosion, occasional shallow gullies, permeable surface soil, deep, moderately heavy textured subsoil providing good waterholding capacity, and an alkali content which does not preclude the growth of desirable native vegetation.

Group B soils (good range soils) consist of those having: a slope generally between 5 and 15 per cent, between 25 and 75 per cent of the top soil removed by erosion, occasional shallow gullies, moderate permeability and waterholding capacity, and an alkali content which does not affect the type of native vegetation.

Group C soils (fair range soils) consist of those having steep slopes (generally between 15 and 30 per cent), over 75 per cent of the top soil removed by erosion, frequent shallow or occasional deep gullies, fair permeability and waterholding capacity, and an alkali content sufficiently high to affect the type of native vegetation, resulting in a lower carrying capacity.

Group D soils (poor range soils) consist of those having more than 30 per cent slope, soil cover essentially destroyed by erosion, low permeability and waterholding capacity, and an alkali content sufficiently high to affect not only the type but the amount of native vegetation.

Land class E (worthless range areas) consists of geologic outcrops of sandstone and shale supporting practically no vegetative cover.

Note: Any one of the above factors may serve to place a given soil in the next lower class.

Group A

This group consists of soils having excellent range qualities. As mentioned above, they are deep, permeable, slightly eroded, and have a



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low alkali content. The native vegetation consists largely of blue gramma and big sage. In most places, the vegetative cover is sufficient to provide ample protection to the friable surface soil. Isolated small areas where the vegetative cover has been damaged by heavy grazing, resulting in noticeable accelerated sheet and gully erosion, can be corrected by controlled grazing. These soils will respond quickly, in terms of increased vegetative growth, to a land management program.

The several soil series and types placed in this group, together with their soil characteristics, are presented in Table I. Of those which qualify in this group, the types in the Kiabab and Springerville series are the most important from the standpoint of area. These soils, developed from basaltic igneous rock and Kiabab limestone, are mapped extensively in the western portion of the Unit. In some places, the soil cover is broken by frequent stony outcrops, probably the result of natural geologic erosion. Extensive areas of these soil areas were separated out and placed in a lower class because of the shallow intermittent soil cover.

Improvement Program Feasible from Soils Standpoint:

The slight sheet and gully erosion on Group A soils can, in most cases, be effectively controlled by regulated grazing, although a few isolated head gullies may require mechanical treatment for immediate results. In that event, these soils may be regarded as adaptable material for structural purposes. If the slope is not too steep, Dinnebito sandy loam, by reason of its geographic location along the base of foot hills and escarpments, is best adapted for water spreading purposes. With water available for irrigation, the soils of this series are also adapted to agricultural development.



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Precautions:

A good grass cover renders these soils more resistant to erosion than those of other groups, but there is evidence that accelerated erosion is starting in some places, probably the result of present grazing methods. A good grass sod is not only important to protect the surface soil from erosion, but also to check the rate of runoff, thereby resulting in a greater amount of water absorbed by the soil. To that extent, the plant cover serves to improve soil moisture conditions. The destruction of native vegetative cover as the result of developing land for agricultural purposes should be compensated for, as far as possible, by artificial plant cover and other erosion control devices to protect the soil from undue wind erosion. The sandy loam soils are usually best adapted to Navajo farming. These soil types are also the most susceptible to wind erosion.



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CHARACTERISTICS OF SOILS INCLUDED IN CLASS A - RANGE SOILS

| Soil Type | Nos. on Map | General Location | Erosion | | | | % Slope | Permeability | Water Holding Capacity | Alkali |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water | | Wind | | | | | |
| | | | Sheet | Gully | Removals | Accum. | | | | |
| Todilto sandy loam | 21.7 | Scattered Areas in Eastern Portion of Unit | 0 | 0 | Slight | 0"-6" | 0-3 | Permeable | High | Low |
| Springerville Clay Loam | 25.13 | Southwest portion of Unit - near Grey Mountain | Slight | Occasional | 0 | 0 | 3-10 | " | " | " |
| Kiabab sandy loam | 43.7 | Northwest part of Unit. Near Little Colorado | " | " | Slight | 0 | 3-10 | " | " | " |
| Bonito clay loam | 75.13 | West of Cedar Ridge Trading Post | " | " | 0 | 0 | 0-3 | " | " | " |
| Dinnebito sandy loam | 76.7 | Southeast portion of Unit. | " | 0 | 0 | 12-36" | 0-3 | " | " | " |
| Dinnebito clay loam | 76.13 | " | " | 0 | Slight | 6-12" | 0-3 | " | " | " |
| Hunt sandy loam | 60.7 | North central portion of Unit. | " | Occasional | 0 | 0-6" | 0-3 | " | " | " |
| Shavano sandy loam | 42.7 | North central portion of Unit | " | " | 0 | 0 | 3-10 | " | " | " |

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CHARACTERISTICS OF SOILS INCLUDED IN CLASS A - RANGE SOILS

| Soil Type | Nos. on Map | General Location | Erosion | | | | % Slope | Permeability | Water Holding Capacity | Alkali |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water | | Wind | | | | | |
| | | | Sheet | Gully | Removals | Accum. | | | | |
| Todilto sandy loam | 21.7 | Scattered Areas in Eastern Portion of Unit | 0 | 0 | Slight | 0"-6" | 0-3 | Permeable | High | Low |
| Springerville Clay Loam | 25.13 | Southwest portion of Unit - near Grey Mountain | Slight | Occasional | 0 | 0 | 3-10 | " | " | " |
| Kiabab sandy loam | 43.7 | Northwest part of Unit. Near Little Colorado | " | " | Slight | 0 | 3-10 | " | " | " |
| Bonito clay loam | 75.13 | West of Cedar Ridge Trading Post | " | " | 0 | 0 | 0-3 | " | " | " |
| Dinnebito sandy loam | 76.7 | Southeast portion of Unit. | " | 0 | 0 | 12-36" | 0-3 | " | " | " |
| Dinnebito clay loam | 76.13 | " | " | 0 | Slight | 6-12" | 0-3 | " | " | " |
| Hunt sandy loam | 60.7 | North central portion of Unit. | " | Occasional | 0 | 0-6" | 0-3 | " | " | " |
| Shavano sandy loam | 42.7 | North central portion of Unit | " | " | 0 | 0 | 3-10 | " | " | " |

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## Group B.

This group consists of soils having good range qualities, but for reasons specified above do not meet the requirements of Group A. Erosion is usually more advanced on these soils. For that reason, control measures are more timely. But, more significant is the fact that the soil cover is not seriously damaged as yet. The soils of this group are of such quality as to make erosion work feasible and worth while. The soils of this group will respond to a land management program.

The soil series and types placed in this group are presented in Table II. The Todilto series is the most important from the standpoint of area. This series, developed from Morrison and Wingate sandstone, occurs extensively in the eastern and northeastern portions of the Unit. The soil is characterized by a light, usually a loamy sand, surface texture, and unless protected by a good vegetative cover, is very susceptible to wind erosion. Wind hummocks and drift sand are common topographic features. The native vegetation consists of blue gramma, Mormon tea, yellow brush, and Spanish dagger.

### Improvement Program Feasible from a Soils Standpoint:

In general, a range management program will serve to correct the damage from soil erosion on this soil group. These soils, however, probably will not respond as quickly to such a program as those of Group A. To obtain most effective results, a larger proportion of these soils will require mechanical treatment or intensive erosion work. This would apply especially to sheet and gully erosion on some alluvial soils, such as the Hunt and Dinnebito series. In some places the total exclusion of all livestock by fencing might be justifiable.



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Precautions:

As mentioned above, Todilto loamy sand is subject to wind erosion. A maximum vegetative cover should be developed and maintained. Gully erosion, if allowed to continue at its present rate on certain alluvial soils, will eventually render otherwise potentially good agricultural or range land worthless.



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CHARACTERISTICS OF SOILS INCLUDED IN CLASS B - RANGE LANDS

| Soil Type | Nos. on Map | General Location | Erosion | | | | % Slope | Permeability | Water Holding Capacity | Alkali |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water | | Wind | | | | | |
| | | | Sheet | Gully | Removals | Accum. | | | | |
| Todilto loamy sand | 21.7 | Eastern part of Unit | Slight | Occa-sion-al | Moder-ate | 12-36" | 0-3 | Permeable | Moderate-ly high | Low |
| Dinnebito sandy loam | 76.7 | South of Blue Canyon | Slight | 0 | " | 6-12" | 0-3 | " | High | " |
| Hunt clay loam | 60.13 | In valley along Moencopi Wash | " | Occa-sion-al | Slight | 0-6" | 0-3 | " | " | " |
| Kaibab sandy loam | 43.7 | Southwest part of Unit | Mod. | " | " | 0-6" | 10-25 | " | Moderate-ly high | " |
| Cameron clay loam | 79.13 | In valleys in south-west part of Unit. | " | " | " | 0 | 0-3 | " | " | " |



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## Group C.

Group C soils are those having a fair or relatively low productive capacity. Low productive capacity may be natural or it may be the result of accelerated erosion due to misuse of the land, such as overgrazing. Any one or more of the following factors may be the reason for placing a given soil in this group: (1) low permeability, (2) low water-holding capacity, (3) rough, broken or stony land, (4) accelerated erosion, or (5) high alkali content.

All or part of the types in the following soil series have been placed in this group: Moenoopi, Dennehotso, Tolani, Concho, Todilto, Tees Nos Pos, and Gila. (See Table III.) Types in the first three are derived from Chinle and Moenkopi shales, located in the central portion of the area. These soils, especially the heavier textured soil types, have a high rate of run-off which makes them unusually susceptible to water erosion. The rate of run-off is governed largely by topography, but also by a relatively impervious surface soil, and a lack of vegetative cover. Heavy grazing is, as usual, an important factor contributing to the latter con-dition, but in this case, low permeability as it affects soil moisture is also an important factor.

The alkali content and dispersion of the surface soil is frequently high in soils derived from shales. Water penetration is low in a dispersed soil, and a high alkali content gives certain relatively non-palatable, ineffective erosion control vegetation a natural advantage over other vegetation having a higher carrying capacity. Greasewood and salt bush are the main vegetative types on most of the soil types placed in this group. An exception is Todilto loamy sand, mapped northeast of Tuba City. This soil has been placed in Group C because



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of severe wind erosion. The typical erosion condition here is represented by small sand dunes which range from 36 to 72 inches in height. Some large active sand dunes also occur.

Improvement Program Feasible from Soils Standpoint:

In considering the soils of this group from the standpoint of a land improvement program, two factors should not be overlooked; (1) The serious need of soil conservation where accelerated erosion has reached a severe stage, and, (2) The limitations of such a soil improvement program. The latter has reference to soil areas which are so badly depleted that mechanical work is impracticable, and also to extensive areas on which erosion is largely the result of a natural geologic process. In this case, a very shallow, intermittent soil cover would offer very definite limitations to an improvement program. (See map, Class C land with rough, broken and stony symbol, 19S and 19B.) Range improvement will also be limited by soils having total salt content sufficiently high as to favor vegetation with a low carrying capacity.

Soils placed in this group as a result of accelerated erosion represent what might be referred to as a critical stage of erosion because of the need for immediate action to save the soil areas from passing into a veritable waste land. In some places, conservation should consist not only of restricted grazing, but also of mechanical treatment. This soil group is important from a land management standpoint because of the possibility of doing a great deal of good, on the one hand, and the probability of not doing sufficient good to warrant the required expenditure of labor and materials, because of natural soil limitations on the other.



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**Precautions:**

Soils of the Moencopi, Dennehotso, Hunt, and Concho series frequently have a high clay content and an alkali content which results in a dispersed soil condition. The use of these soil materials for structural purposes is dependent upon approval after laboratory analyses to determine the degree of dispersion. An intensive alkali investigation should usually be made before attempting to reseed or develop these soils for agricultural purposes. The soils of this group, because of erosion, will not respond readily to a land improvement program. In some isolated places, it might be impossible to establish a soil cover sufficient to support a vegetative cover. It is advised that grazing be restricted accordingly.



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CHARACTERISTICS OF SOILS INCLUDED IN CLASS C - RANGE LANDS

| Soil Type | Nos. on Map | General Location | Erosion | | | | Slope | Permeability | Water Holding Capacity | Alkali |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water | | Wind | | | | | |
| | | | Sheet | Gully | Removals | Accum. | | | | |
| Concho Clay | 55.16 | In valley of Cow Springs Wash | Mod. | Occa-sion-al | Mod. | 12-24" | 0-3" | Impermeable | High | Mod. Low |
| Denehotso clay | 57.16 | Area northeast of Red Lake | Slight | B Class | 0 | 0 | 0-3 | " | " | " |
| Denehotso sandy loam | 57.7 | Area northeast of Moenave Dem. Area | " | EROSION | | | 0-3 | Permeable | Low | " |
| Moencopi sandy loam | 46.7 | South end of Unit | Slight | Occa-sion-al | Mod. | 12-24" | 0-3 | " | " | Low |
| Moencopi sandy loam | 46.7 | Central Portion | Mod. | " | Slight | 0-6 | | Non-Permeable | High | Mod. |
| Tolani sandy loam | 68.7 | Along Little Colorado, S. end of Unit | Slight | " | Mod. | 24-36" | 0-3 | Permeable | Low | Low |
| Gila clay loam | 70.13 | Along Colorado in Extension from Unit5 | " | " | " | 0-6" | 0-3 | " | Mod. High | Mod. Low |
| Tees Nos Pos sandy loam | 71.7 | South of River in western portion | Se-vere | " | Slight | 0-6 | 3-10 | " | " | " |
| Kaibab sandy loam | 43.7 | Western portion | Rough - Stony | | | | | " | Low | Low |
| Todilto Loamy sand | 21.2 | Eastern part of Unit | 0 | Occa-sion-al | Mod. | 36-72" | 3-10 | " | Mod. High | Low |

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## Group D.

The soils placed in this group have many characteristics in common with those placed in Group C. However, they are less permeable, may have a higher alkali content, affecting not only the type but the amount of vegetation, or these soils might be more severely eroded. In this Unit, this group is composed largely of rough stony and broken land with an intermittent, shallow soil cover (see Table IV). The vegetative cover is sparse, and consists mostly of salt bush.

### Land Improvement Program Feasible from a Soils Standpoint.

Group D soils are very limited in their adaptability to a land improvement program, for muchof the area consists of raw shales and very thin soil on which erosion is largely geologic. A program of restricted grazing is recommended, although it must be kept in mind that bare shales and the shallow soils on them are very slow to develop a vegetative cover.

Costly mechanical treatment is not practical unless for the purpose of protecting better soils.

### Precautions:

The same precaution with reference to the quality of the soil for structural and reseeding purposes applies here as in case of Group C.



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CHARACTERISTICS OF SOILS INCLUDED IN CLASS D - RANGE SOILS

| Soil Type | Nos. on Map | General Location | Erosion | | | | % Slope | Permeability | Water Holding Capacity | Alkali |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water | | Wind | | | | | |
| | | | Sheet | Gully | Removals | Accum. | | | | |
| Moencopi clay loam | 46.13 | Central and south part of Unit | Se-vere | Freq. | 0 | 0 | 10-20 | Permeable | Mod. High | Low |
| Moencopi clay | 46.16 | Central and south parts | " | Freq. | 0 | 0 | 20-40 | Impermeable | High | Mod. High |
| Todilto loamy sand | 21.1 | Eastern portion | Slight | Occa-sion-al | Very Severe | 36-72 | 10-20 | Permeable | Low | Low |
| Rough Broken | 19B | Scattered generally over Unit. | Se-vere | Freq. | 0 | 0 | 20-40 | Impermeable | High | Mod. High |

CHARACTERISTICS OF SOILS INCLUDED IN CLASS E - RANGE SOILS

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rough Stony | 19S | Scattered generally over Unit | G E O L O G I C | | | | 40% | Impermeable | Low | Low |
| Rough Broken | 19B | " | | | | | " | " | " | " |

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Agricultural Soils:

No attempt was made in this survey to group soils on a basis of their agricultural adaptability. Consequently, in a discussion of agricultural soils reference will be made to soil series and types. In so doing, an appraisal will be made of their characteristics from an agricultural point of view.

Agricultural soils, on this Unit, are limited to alluvial deposits along Moencopi Wash and the Little Colorado River. The most important farming area is located at Moencopi Village, near Tuba City. Local soil accumulations from the Todilto series, located on Moencopi Plateau, may be appropriated for agricultural use with some hazards from uncertain rainfall and wind erosion.

The alluvial soil types which are more or less adapted to agricultural development are grouped in the following series: The Dennehotso, Hunt, Concho, Dinnebito, Gila and Cameron. Each of these soils will be briefly considered from the standpoint of agricultural use.

Types in the Dennehotso, Hunt and Tolani series have many things in common. In the first place, they are all derived from Chinle and Moenkopi shales. Soils from that origin frequently have a high clay and alkali content, resulting in a dispersed soil. The topography is level or gently sloping with the surface invariably broken by wind hummocks and sand drifts, varying from 12 to 36 inches in height. The latter materially increase the subjugation costs of these soils for agricultural development. The native vegetation consists of greasewood, salt bush, and sacaton grass. These soils occur along the Moencopi Wash and secondary drainages from Moencopi Village, near Tuba City, Southwest to Cameron.



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Types in the Dennehotso series have a deep friable subsoil which gives these soils an advantage over the soils in the other two series from an agricultural point of view. The sandy loam and clay loam types are usually classed as A grade agricultural land, provided the alkali content does not exceed .2 of one per cent. They comprise about _____ acres of Unit 3.

Types in the Hunt series differ from those in the Dinnehotso in agricultural adaptation by the frequent occurence of heavy, impervious strata which result in poor subdrainage. This is very significant because, as montioned above, these soils derived from Chinle shale contain appreciable quantities of alkali salts. Unless sub-drainage is adequate to facilitate free movement of water and some leaching of salts, the soils are not adapted to agricultural use. Hunt sandy loam is rated B or C agricultural land, but the heavier types are not normally adapted to irrigation. There are approximately _____ acres of Hunt sandy loam.

Types in the Tolani series consist of recent alluvial overwash, usually deposited upon one of the types in the other series just mentioned. The soil is shallow and light in texture, and consequently, very susceptible to wind erosion. The salt content is probably lower than in the types in the other two series, the subsoil is usually open and friable, but severe wind and water erosion reduces its agricultural value to C class. _____ acres are mapped in this Unit.

Gila Series: Soils in this series occur along the Little Colorado River bottom, southeast of Cameron. They are favorably located from the standpoint of water for irrigation purposes. The texture, both on the surface and in the subsoil, is predominantly light. This soil is approved for agricultural development provided the alkali content or a high groundwater table does not prohibit its use. In view of the limited amount of



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soils which are adapted to agricultural purposes in this Unit it is advised that consideration be given the possibility of some development on types of this soil series. The Gila series comprise _____ acres of Unit 3.

Concho Series: Types in the Concho series are distributed along the Koencopi drainage from Tonalea Trading Post, south to the mouth of Blue Canyon. The topography is level to hummocky. The subsoil is heavy and often impervious. The surface soil is often highly dispersed by the physical action of certain salts on the usual high colloid content. The vegetation consists of greasewood.

Soils of this series have about the same agricultural qualities as those in the series described above. The sandy loam and clay loam types have similar adaptation. Their adaptation, however, is dependent upon the alkali content in the root zone and upon the clay content of the subsoil. Heavy concentrations of alkali is almost certain unless good subdrainage is facilitated by an open and friable subsoil. The soils of this series should be investigated carefully from that standpoint prior to costly agricultural development. They are usually classified as Group C or D non-agricultural land, because of the danger of alkali concentrations under irrigation. In all the Concho series comprises _____ acres.

Types in the Dinnebito series, located in the southeastern portion, and in the Cameron Series, located in the southwestern portion of the Unit, are good or excellent range soils. Their development for agricultural use depends upon the development of an adequate supply of irrigation water.

Alkali:

Sufficient has already been said to suggest that soil alkali is a



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very important factor limiting the value of the soils of this Unit for reseeding, structural, and agricultural purposes. It occurs in all the soils derived in part from shales, or, in other words, in types of the Moencopi, Concho, Hunt, Dinnehotso, and Tolani series. It is also concentrated, in the vicinity of Tuba City, in soils of the Todilto series. The reason for its concentration here, as well as other places, is the presence of a relatively impervious substratum consisting of Wingate sandstone, which, together with low rainfall, prevents the leaching of salts to lower depths, or from the soil.

Concentrations of alkali salts on cultivated lands which warrant special consideration at this time are those which occur on Moencopi farms. The alkali results presented in the following table are of soil samples taken from this area. The results show alkali concentrations too high for the tolerance of most cultivated plants.

In another part of this report it has been suggested that an alkali investigation be made of this area at an early date. Justification for such an investigation is found in the obvious need to find practicable ways and means of preventing alkali affected areas from spreading to productive agricultural land. This would necessitate discovering the cause or combination of causes which have produced the present condition. Such an investigation might also determine, at least from a soils point of view, a feasible method of reclaiming this alkali land for agricultural use.

Summary of Erosion:

Extremes in erosion conditions obtaining on Unit 3 vary from the slightly affected types in the Kaibab and Springerville series to the severely eroded Todilto, Hunt and Tolani types, some areas of which



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are essentially destroyed. Soil and climate both contribute to an environment which is fundamentally conducive to erosion. Low rainfall makes for a sparse vegetation. Heavy impervious soils, especially those with a steep topography, intensify the effect of this climatic factor. Torrential thunder storms, common to this section in late summer, further increase the destructiveness of water erosion through rapid run-off.

High southwest winds are probably the most destructive erosion agent in this Unit. With the exception of some of the grass lands, mentioned above, the entire Unit is affected to some degree by this agent. Wind erosion is most severe on the light-textured alluvial soils and the Todilto types. As previously mentioned, wind hummocks range generally from 12 to 36 inches in height, but they are much higher in some localities. Active sand dunes are common northeast of Tuba City.

Corrective measures from a soils standpoint would probably justify the extreme in land management policy and practice. This covers the Unit as a whole. Focal points or critical areas will certainly warrant absolute exclusion of livestock during the growing season. Mechanical treatment is necessary to supplement and make these measures most effective. Mechanical treatment would probably be most effective on restricted water sheds and alluvial valleys adjacent to and within areas indicated on the map as types in the Toland and Hunt series. In this manner, especially if water spreading is feasible, certain chamise and sacaton grass soils, seriously depleted of grass cover at the present time, could be made very productive of native vegetation.

There is some need for flood control work on valuable farm land adjacent to Moenoopi Wash. It is suggested that flood control should consist of, (1) A comprehensive land management program on the upper



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watershed of Black Mesa, involving both water retention and spreading as well as controlled grazing, and (2) Mechanical work at strategic points along the main channel in the vicinity of Moencopi Farms. A more intensive soil and erosion investigation will be necessary on areas proposed for agricultural development or intensive erosion control work, to determine more specifically the soil and erosion problems involved.



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TABLE V. RESULTS OF ALKALI ANALYSIS OF SOIL SAMPLES COLLECTED FROM MOENKOPI FARMING AREA, TUBA CITY, ARIZONA

Collected 12/28/36 by Ray H. Korr.

| Lab. No. | Field No. | Total Salts | P.P.M.* $Na_2CO_3$ | Mechanical Analysis Sand % | Silt % | Clay % | Pot. Dispersion |
|---|---|---|---|---|---|---|---|
| 3676 | 1-A-1 | .06 | Trace | | | | |
| 3677 | 2-A1 | 1.09 | 2300 | | | | |
| 3678 | 2-A-2 | .16 | 375 | | | | |
| 3679 | 1-A-3 | .02 | Trace | | | | |
| 3680 | 3-A-1 | .17 | 0 | | | | |
| 3681 | 3-A-2 | .28 | 0 | | | | |
| 3682 | 3-A-3 | .33 | 488 | | | | |
| 3683 | 4-A-1 | 3.00 | Trace | | | | |
| 3684 | 4-A-2 | 3.00 | " | | | | |
| 3685 | 5-A-1 | 1.11 | 329 | | | | |
| 3686 | 5-A-2 | .145 | 116 | | | | |
| 3687 | 6-A-1 | .80 | 2374 | | | | |
| 3688 | 7-A-1 | 1.23 | 774 | | | | |
| 3689 | 7-A-2 | 2.00 | 1272 | | | | |
| 3690 | | | | 32.6 | 49.2 | 18.2 | |
| 3691 | | | | 78.1 | 12.9 | 9.0 | 45.7 |
| 3692 | | | | 82.1 | 8.4 | 9.5 | 18.8 |
| 3693 | | | | 84.3 | 9.4 | 6.3 | |
| 3694 | | | | 83.1 | 7.1 | 9.0 | |
| 3695 | | | | 76.9 | 9.7 | 13.4 | |
| 3696 | | | | 75.9 | 6.2 | 17.9 | |

*P.P.M. Parts per million. 100 p.p.m. = 0.01%



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Tuba City - Soil Samples
Collected 3/1/37

Collected by:
Ray H. Kerr and
L. A. Hill

TABLE VI.

| Lab. No. | Field No. | Pct. Total Salts | P.P.M.* $Na_2CO_3$ |
|---|---|---|---|
| 3854 | 1A-1 | 3.0+ | 31 |
| 3855 | 1A-2 | 1.28 | Trace |
| 3856 | 1A-3 | 1.35 | 83 |
| 3857 | 2A-1 | .12 | 0 |
| 3858 | 2A-2 | .17 | 0 |
| 3859 | 2A-3 | .17 | 0 |
| 3860 | 3A-1 | .68 | Trace |
| 3861 | 3A-2 | .21 | 0 |
| 3862 | 3A-3 | .16 | 0 |
| 3863 | 4A-1 | .56 | 0 |
| 3864 | 4A-2 | .14 | 52 |
| 3865 | 4A-3 | .14 | 229 |
| 3866 | S1-11-03 | .09 | 0 |
| 3867 | S1-11-03 | .07 | 0 |
| 3868 | S1-11-03 | .11 | 0 |
| 3869 | S2-11-03 | 3.0+ | 0 |
| 3870 | S2-11-03 | 1.06 | 208 |
| 3871 | S2-11-03 | 1.11 | 0 |
| 3872 | S3-11-03 | .15 | 0 |
| 3873 | S3-11-03 | .105 | 0 |
| 3874 | S3-11-03 | .10 | Trace |
| 3875 | S4-11-03 | 3.0+ | 0 |
| 3876 | S4-11-03 | 1.9 | Trace |
| 3877 | S4-11-03 | 1.7 | 166 |
| 3878 | S5-11-03 | .33 | 0 |
| 3879 | S5-11-03 | .19 | 0 |
| 3880 | S5-11-03 | .23 | 0 |

*P.P.M. = parts per million.



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