A PROGRAM OF CONSERVATION FOR ARIZONA SCHOOLS GRADES 7-12

by

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A PROGRAM OF CONSERVATION FOR ARIZONA SCHOOLS GRADES 7-12

CHAPTER I

INTRODUCTION

Purpose of Study

The subject of this study is the conservation of the water, soil, minerals, timber and wild life in the state of Arizona. As applied to natural resources, the term "Conservation" is in no way to mean hoarding, but to mean a wise, well-planned use of those resources which this state needs in order to maintain a stable economy now, and in the future.

Arizona's economic existence is definitely drawn from the earth. The state is dependent upon basic industries. Our basic industries are in no way second hand, for there is very little manufacturing of materials that have to be sent into the state from other areas. Our basic industries are close to the earth and are not dependent upon material other than that which the land produces. Occupations such as farming, mining, lumbering and the development and use of water are good examples.

During the last few years, this state together with other states of the Union has been bombarded with a great deal of information on conservation. This material

has usually been delivered by groups or individuals stressing their own particular conservation problems. The purpose of this study is to present simply to the youth of the state the problems that are characteristic of this area. This explanation should point out the problems and responsibilities with which the citizens of the state are faced in the field of conservation so that steps can be taken toward the correction of wasteful practices as far as our natural resources are concerned. It should alert the readers to the recognition of danger areas and destructive practices that corrective steps may be taken before further permanent damage is done.

No matter how vast our resources seem to be, there is a limit to their productivity. A very good example of this is cited in the annual report of the Secretary of the Interior for 1945 (30:Vp), giving a list of metals which will not last at the present rate of consumption for longer than 35 years. Copper is included in this list, a matter of vital interest to the state of Arizona.

There is no substitute for long-term planning and conservation. It is true that it is difficult for an individual to plan during his lifetime for future generations, because it is also true that we are a short-sighted nation. Yet, conservation practices now in operation may

actually pay off in many cases for the very ones who first put them into practice. This is especially true in conservation of water and of soil.

Sources of Data or Information

In order to determine what has been done in the teaching of conservation in the high schools and junior high schools of the state, a questionnaire was sent to each school. Eighty-two per cent of the schools of Arizona participated by answering the questionnaire.

The answers to the questions asked show that the teaching of conservation varies from school to school with no two school systems using the same materials. Materials vary from U. S. Department of Agriculture bulletins to motion picture films. Two of the schools contacted did not teach conservation in any form. Most schools contacted taught it in conjunction with the science program although three schools use it as a social science unit.

In order to give a clearer picture of what is taught in the way of conservation throughout the state, the following results were tabulated:

44 schools teach water conservation

43 schools teach soil conservation

40 schools teach wildlife conservation

41 schools teach timber conservation

34 schools teach mineral conservation

A total of 51 schools were contacted and 43 per cent of this number believes there is a need for a text on conservation. Seventy-three per cent teach conservation in conjunction with other units.

The justification, therefore, for information as contained in this thesis exists in the need for consolidation of basic conservation facts. This information could be used by the teacher and the student alike. Within the Phoenix Public School system, a need also arose for the pooling of information from the many sources into a simple, usable form for teaching a unit on conservation.

In securing this information, and for anyone interested in the field, the following sources were found invaluable: Soil Conservation Service, State Land Commission, State Department of Library and Archives, Water Users Association, United States Forest Service, Arizona Resources Incorporated, and teachers in the public schools. This list is incomplete but represents some of the main sources of unwritten information used in this paper.

Limitations of Study

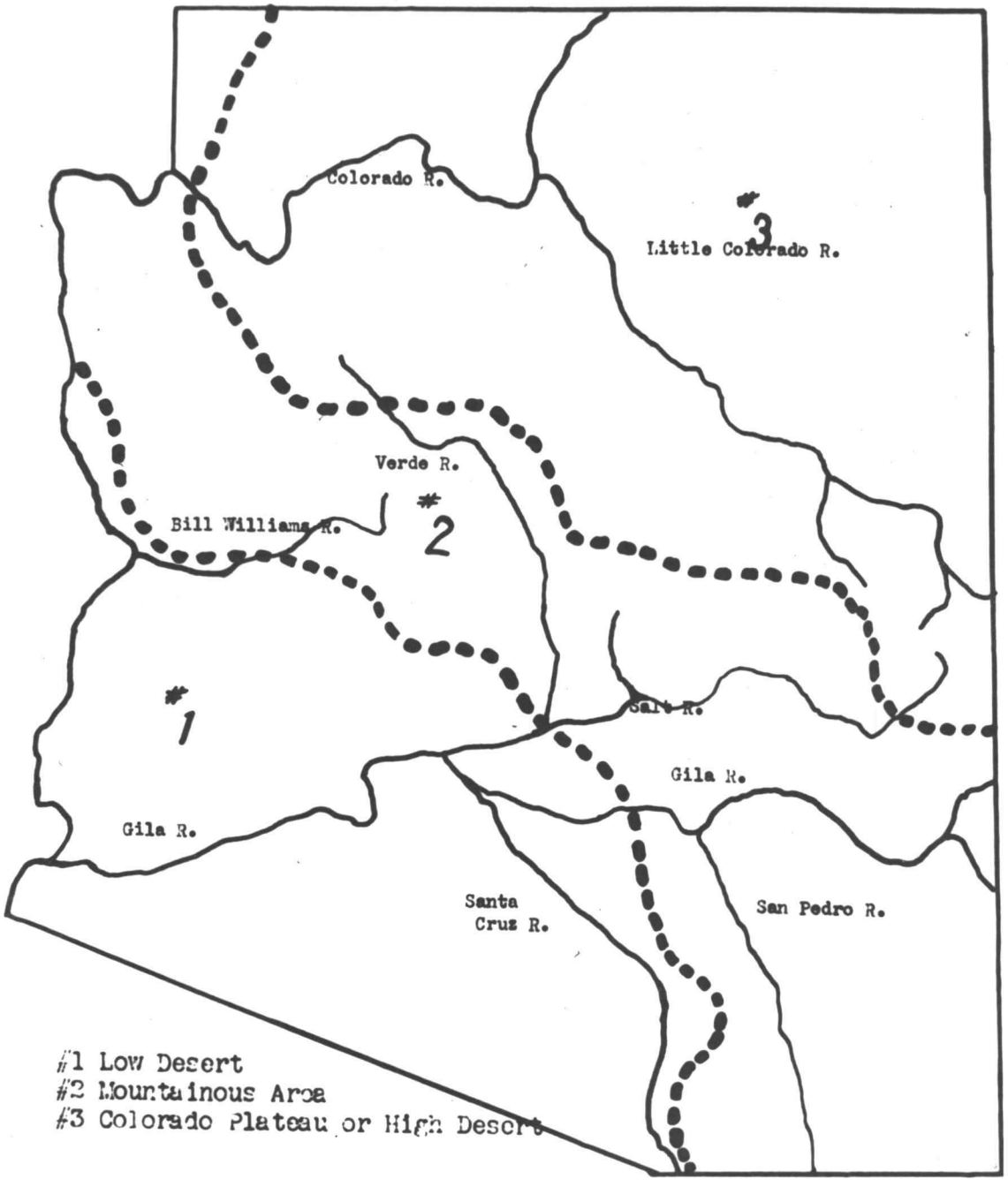
There are many limitations to a study of this nature, the principal one being that a paper of this size and the time involved in compiling it can in no way represent a complete coverage of the field of conservation. The subject is very broad and is worthy of being the life work of many individuals.

Students and teachers alike, who use this paper, will need much supplementary information. Some of this can be found at the end of this study, but new and current material will, of necessity, need to be consulted in order that the interested person may be well-informed on conservation practices in all fields.

Location of Study

The area covered in this study pertains only to the state of Arizona. Arizona is the fifth largest state in the Union. Elevations in the state range from less than 100 feet above sea level near Yuma, to the 12,611 foot crest of the San Francisco peaks. More than half the state is under 5,000 feet in elevation. All vegetative life zones are represented in the state except the humid, tropical zone.

There are three physiographic regions of the state, as noted on the map.



#1 Low Desert
#2 Mountainous Area
#3 Colorado Plateau or High Desert

1. The Low Desert, or plains area, which is under 3,000 feet in elevation and includes about 25 million acres.

2. The Mountain area, which ranges up to 12,000 feet and includes some 17 million acres.

3. The High Desert, or Colorado Plateau, which is generally over 5,000 feet elevation and includes approximately 30 million acres of the state's area. (14,p.15)

CHAPTER II

HISTORICAL BACKGROUND OF THE CONSERVATION MOVEMENT

National

In the development of the conservation movement in the United States and the steps which our nation has taken in that direction, the ownership of the land itself has had a great bearing upon the movement.

In the colonies, the land both within the boundaries of the several colonies and the land adjacent to these boundaries was first owned by groups or individuals in very large tracts. These lands were subsequently transferred into smaller holdings in some cases, and in others the lands were combined into even larger tracts. Most of the land thus owned was the result of grants from the sovereigns of Europe to men or to groups which were then in favor, or to groups that the ruler wished to be rid of for religious or for political reasons.

At the close of the Revolutionary War, the various colonies claimed the land extending from their western borders to the Mississippi River. Congress finally persuaded the colonies to cede their claims to such land to the Federal Government, in this way creating the first Public Domain. The national government, thus

having this land in its possession, began disposing of it in a variety of ways. Land was given to the states for the support of schools, for internal improvements, and deeded to railroads for the construction of transportation lines to isolated parts of the Union. It was granted to war veterans and disposed of in many other ways.

The supply of land in the hands of the Federal Government at that date appeared inexhaustable. As the nation acquired more land through the Louisiana Purchase, Spanish cessions, Oregon boundary settlement, Mexican cessions and the Texas and Gadsden purchases, the national government continued to dispose of public lands on a wholesale scale. The most notable of these dispositions were through the Homestead Act of 1862 and by the Timber and Stone Act of 1878.

Every law enacted by Congress for the disposal of public lands resulted in the transfer of property from public ownership and public control into the hands of individuals and of private corporations. This meant that the natural resources found on these lands were entirely in the hands of those individuals and groups owning them and that these resources could be disposed of or exploited as the owners saw fit.

At present, according to the Bureau of Land

Management (50; p.1), there remains about 412 million acres of Public Domain in the continental limits of the United States and about 365 million acres in Alaska. More than 95% of the present Public Domain outside of Alaska is located in the 11 western states. Arizona now has 47,948,822 acres under Federal control.

Control of land use and conservation on a Federal scale lagged behind the disposal of public lands. In the early days of our nation, natural wealth seemed inexhaustable; therefore, no control was exercised over the utilization of these natural resources.

There were, however, a few individuals who had witnessed the results of the destruction of natural resources in other countries. These men started movements in this new nation to prevent complete destruction of our natural resources. Gustafson gives the following national history (13, pp.15-27):

In 1681, William Penn decreed that for every five acres of timber cleared, one acre must be left standing for seed. The famous "Broad Arrow" proclamation of 1691, in England, stated that all trees over 24 inches in diameter must be reserved for the use of the Royal Navy. In 1828, President John Quincy Adams had a law enacted by Congress that authorized the purchase of lands on the Santa Rosa peninsula of Florida for ship-building purposes.

Oak trees were planted on this reserve, but the experiment failed because of inadequate knowledge in how to manage such an operation.

In the year 1626, the Plymouth Colony prohibited the cutting of timber on colony lands, but the conservation movement from the days of the early colonies really made little progress until about 1890. At this time, it was brought to the attention of the public largely through the efforts of one man, Gifford Pinchot.

Gifford Pinchot was the son of wealthy parents and could easily have adopted a life of ease and leisure but, instead, he became vitally interested in forestry and conservation. He studied in Europe as the American colleges of that day did not offer these courses. Pinchot later became head of that branch of the Federal Government which became the Division of Forestry in the Department of Agriculture in 1886. It later became the Bureau of Forestry in 1901 and, in July, 1905, was changed to the United States Forest Service.

In 1901, Theodore Roosevelt became President of the United States. Then the team of Roosevelt and Pinchot brought about the movement for conservation of national resources which was to have impressive results. The major emphasis in this rise of the conservation movement was on Forestry, because it was a resource that was

rapidly being depleted. The President, by act of Congress, was given authority, in 1891, to establish forest reserves. In 1907 (40, p.2), they were renamed and called National Forests from that time to the present. Land from the Public Domain was set aside as water power sites, as reserves of coal and oil lands, phosphate sites and as power and storage reservoir sites.

During the administration of President Theodore Roosevelt, and those of the succeeding presidents as stated in Gustafson (13, pp.18-27), there followed a series of Acts passed by Congress bearing upon conservation. The Acts are listed below:

The Antiquities Act of 1906 (dealing with the preservation of antiquities)

Welsh Law of 1911

Mineral Leasing Act of 1920

Federal Water Power Act of 1920

Clark-McNary Act of 1924

The Federal Wild Life Restoration Act of 1937

The Soil Conservation Act of 1935

Under the administration of Franklin D. Roosevelt, the conservation movement, under Federal control, went forward with new impetus. In his administration, the outstanding events that furthered conservation were:

1933, Civilian Conservation Corps

1933, Soil Erosion Service

1933, Tennessee Valley Authority

1934, Taylor Grazing Act

1934, National Resources Board

1935, Soil Conservation Service

1937, Wild Life Restoration Act

Many other agencies, services, and authorities have been established by the Federal Government to meet the needs and administration of national resources. However, it must be remembered that the majority of the resources now under the control of the national government are located on only approximately 12 per cent of the original Public Domain still remaining under Federal ownership. (50, p.1)

The State

The State of Arizona did not exist prior to February 14th, 1912, but the foundation of its economy was, to some extent, laid long before that time.

In singling out the most important reasons for the settlement of Arizona by the Anglo-Saxon people, with whom we so commonly associate our history, mining and stockraising would be the primary occupations which engaged the first settlers of its lands. Of course, the history of the region now called Arizona extends much farther back in history than the coming of the miner and the stockman. Strange as it may seem, the things that drew these much earlier settlers were not a great deal different from those of the Anglo-Saxon settlement period.

The occupation of the range, according to Mowry (20, p.187), began with Coronado in 1540 when, on his celebrated trek to the north from the west coast of Mexico, this Spaniard took with his party horses, pack mules, cattle, sheep and swine. These were probably the first domestic animals to enter the present state of Arizona.

Parish says (25, p.22), the early Spaniards, 1600-1700, established missions and with them a policy of

animal husbandry and of tilling of the soil. Father Kino was very active in promoting livestock raising among the missions of southern Arizona. Many of the Spanish settlements suffered at the hands of the Indians, especially along the San Pedro and the Santa Cruz rivers. The Indians of that area readily adapted themselves to the horse and many of the cattle from the destroyed and abandoned Spanish settlements were wild and were thus added to the foodstuffs of the natives.

Castetter states (8, p.47), that many of the present day Indian tribes were farmers. When Anza visited the Gila Pimas in 1774, he found fields of wheat large enough to embrace the entire width of the valley. Such farm produce as melons, beans and squash actually filtered into the area from Mexico before the Spaniards arrived. Many of the Indian irrigation systems were worthy of note, as to construction, but their lack of a cement made it impossible for their structures to withstand the annual floods.

Tonto National Forest records (26, p.2) show that in the middle 1800's, cattle and other livestock came into the territory that is now Arizona by way of trail herds from Texas, Mexico, and from California. By the late 1800's, especially after 1867 when Texas began to attempt to relieve her over-stocked ranges, there was a great influx of cattle into the Arizona country. This

lasted until 1890 when Arizona ranges were at their maximum capacity. Then came the inevitable over-grazed range with a serious depletion of stock, followed by extensive damage from erosion in the over-grazed areas.

The cattle industry suffered a severe setback at this time, and many ranchers went broke. The ranges were allowed no rest as sheep were brought in with the resultant range wars. The old-time stockmen had the pioneer idea that as soon as the grass on a given range was depleted, it was necessary only to move their stock to another range. But, by 1895, no "other range" existed. This caused reckless competition for the rapidly depleted ranges and the land suffered greatly. Stockmen with vision began to sense the necessity for some type of conservation. The first steps taken in this direction resulted in some individual cattle and sheep owners attempting to make their ranges into permanent ranges.

At this time, the United States Forest Service was in its infancy, but it had already begun some conservation work in the field of Range Management. This Service grew in strength and, at present, controls some 11,430,587 acres of Arixona range land. In fact, the Federal Government owns 65.82 per cent of all the land in Arizona, or 47,948,822 acres. These lands have been under direct supervision of the national government as to conservation

practices. The state of Arizona owns 8,353,497 acres of land which it rents or controls through the State Land Commission. This leaves some 16,542,499 acres of the state under the control of individuals or of corporate groups. (42, p.25)

Soil. Of the 16,542,499 acres of privately owned land in the state of Arizona, according to the United States Soil Conservation Service office in Phoenix (31), 959,000 acres are in croplands, the remainder being range. Of the 959,000 acres, owners of 391,000 acres of irrigated and of 18,600 acres of dry land are taking advantage of the Soil Conservation Service planned methods of conservation and production.

Such Soil Conservation experiments in areas in the San Simon Valley and on the Navajo Indian Reservation have focused a great deal of attention on Arizona as to range rehabilitation.

Of the privately owned land, about 890,000 acres are under irrigation. This brings us to another reason that people originally selected Arizona as a place for permanent homes, that of the production of crops from irrigated lands.

Water. Water has played an important part in the development of Arizona. Our first stockmen began to realize the value of water and what it would do if properly controlled, but they were not, by far, the first to use water for agricultural reasons on the lands which were later to become Arizona. There are evidences of an ancient people who built fine canals, ditches and who tilled and irrigated the soil. These ancients, known today as the Hohokam, built a vast system of canals that were, according to Turney (36, p.21), capable of irrigating nearly 100,000 acres of land. The largest centers of their population were in the Gila and the Salt River valleys; evidences of their waterways and villages, however, are also found in other sections of the state.

It is believed by most authorities on the matter that this civilization flourished about 500 to 1100 A.D. It is not known whence these people came nor where they went. Their irrigation systems were so well constructed that the white pioneers who located the present city of Mesa in 1878 first used the channel of an ancient Hohokam canal to divert the waters of the Salt River upon their chosen lands. (28, p.4) The early dams had fallen victim to floods but the canals were still visible and could be cleaned and used.

Evidence of what water meant to the prehistoric Indians of the Pueblo type can clearly be seen in the Wupatki National Monument. The sandstone dwellings there were built adjacent to water collecting points. These points usually consisted of a small canyon that shows evidence of being dammed, with a sump hole in the lowest point. The idea was to catch and to save all the available water. These sump holes, or "cisterns", in many cases have been lined with the same type of material used in the dwellings. Each cluster of dwellings making up the pueblo is perched on higher ground around the water storage areas, making them appear to be the focal point of the entire pueblo.

The early Spanish missionaries also used the waters of rivers and streams to irrigate some areas of land adjacent to their settlements. These early Spaniards raised many kinds of crops for food and left an indelible mark upon present day irrigation in Arizona in passing down to us such terms as "zanero", "acquias", "tarpons", and other terms in common use today among farmers and irrigators.

Water use in Arizona is an old occupation but water conservation is new. The earlier settlers could not conserve their water supply since it was dependent upon the normal flow of the rivers. With the building of

permanent storage dams, planned use and water shed protection have become new and vital interests to the water consumers.

Before the construction of the present dams by the Federal Government, irrigation as practiced by the early pioneers was a more-or-less hit or miss proposition. Brush and rock-filled dams were used in order to divert the natural flow of the rivers into canals. These dams were easily washed out by rises in the streams and it was necessary to build them anew before water could again be turned upon the land. As a result of this, water famines were common in early Arizona.

Major John Wesley Powell (15, p.82) in 1878 made a report on the "Lands of the Arid West" in which he brought out the fact that the lands of the Southwest could be cultivated if water were stored or diverted from the supply sources. He carried on an educational campaign which was taken up by the lawmakers, newspapers, public speakers, and technical men of his day. His position as head of the United States Geological Survey helped him a great deal in making people conscious of reclamation.

In 1902, the Reclamation Act was passed by Congress (13, p.18), thus turning the monies and efforts of the Federal Government toward reclamation on a national

scale. One of the first projects was Roosevelt Dam in Arizona and, later, in 1904, there followed authorization for the Laguna Dam on the Colorado River 10 miles north of Yuma. Roosevelt Dam was a storage type of structure while the Laguna Dam was a diversion type, sending a great deal of water into California and upon Arizona lands in the vicinity of Yuma.

According to the Central Arizona Project Map (9, map), there are now 15 major dams in Arizona as well as many small irrigation systems too numerous to mention. The building of these dams and the almost miraculously fertile lands served by them have made the people of Arizona extremely water conscious.

A water shed is the area from which a stream gets its supply of water. This supply of water in Arizona with but a few exceptions is so controlled that the water may pass through several dams before reaching its ultimate destination. It is of great importance to the water users that the water sheds be so managed that they will deliver the maximum run-off over a long period of time.

Arizona is deeply interested in the underground water as well as in the ground water. Underground water is that water which is being raised and diverted onto the land by the use of pumps. The number of large pumps has been increasing the last few years so that, at present,

we are faced with another water problem, that of the lowering of the water table under the soil.

Minerals. Arizona is fortunate in possessing rather large deposits of minerals. Mining can be traced to the early Spaniards and was the result of Coronado's trek into the territory. The Seven Cities of Cibola, the Lost Dutchman Mine, these and many other mines, lost and found, have quickened pulses and brought a constant stream of prospectors to outfit and start out on searches throughout the state.

Much evidence remains showing the Spanish attempts at mining. The most noted of these are the silver prospects near Tubac, but many authorities in mineralogy now believe that the activities of the Spanish miners were not as extensive as once believed. Tradition and romantic stories have a way of enlarging history and mining seems to lead to more fantastic tales than other occupations. In the history of mining, it is very difficult to distinguish between the flamboyant stories that came from the lips of miner and writer alike, and the actual facts as to what metals and mines actually were found and worked in early Arizona history. This is especially true of metals with high monetary values such as gold and

silver. Copper, lead and zinc, with other less valuable metals found in the state, are another story, however, and more accurate and definite information can be found about them.

Rickard (27, pp.89-141) states that a discovery made by six United States Army officers who recognized silver and lead deposits in 1858 near Patagonia, was one of the first. This deposit was developed by Lt. Sylvester Mowry.

Captain Powell, early explorer of the northern part of the state, discovered gold along the Colorado River about seven miles east of La Paz in 1862. In 1863, Henry Wickenburg opened the Vulture mine near the town which now bears his name. In 1869, W. A. Holmes did the first prospecting in the Globe area, but was driven out by the Apaches. John Pearce, in 1895, discovered silver and gold near Dragoon. The famous Ed Schiefflin, in 1877, located the claim later known as Tombstone.

In copper, the first workings by Americans were in the Ajo district, under Major B. Allen and William Blandin, in 1854. They mined the ore, transported it by ox cart to San Diego and shipped it by boat around the Horn to Swansea in South Wales, to be smelted. The record of copper discovery and development is too extensive for detailed presentation here but, as a metal, it

occupies the foremost position from the standpoint of production and income.

Arizona minerals play an important part in the economy of the state. The very existence of many of our communities is based upon the mines that are adjacent to them. The history of a mining town is determined by how long the mineral deposits near them lasted. Some towns no longer exist, others are rapidly becoming ghost towns.

Timber. Because of the geographical location of Arizona and the altitude differences of its lands, Arizona's timber supply is confined to the areas possessing the higher altitudes, 6,000 feet or better.

Generally speaking, the Mogollon Rim is the timber-producing area of the state. Much of this timber has not been touched by the lumbering industry because of its distance from market and because of the quality of the timber.

About 76 per cent (42, p.25) of all the timber in Arizona is under the jurisdiction of the National Government. Since the United States Forest Service is the oldest government bureau that has practiced conservation, this area is as well controlled as can be expected.

Information from the Forest Service (43, p.10)

indicates that the main drains upon the forests of Arizona in the past came from the need for fuel (charcoal) for operation of the mine furnaces. This was, of course, before the railroads pushed their lines into all parts of the state, and even for a short time thereafter. The coming of the railroads brought in other fuels which, in many instances, were better for smelting than charcoal, and far easier to secure. However, the railroads themselves also used much timber in the making of ties and for bridge supports. The timber supports in the mines was a major use for the timber of the areas surrounding the workings.

There are great bodies of virgin timber in the state and we should realize that these are the last, great sources of timber.

The State of Arizona owns a great deal of forest land. Some of this timber land is classed as University land, since the proceeds of the sale of the timber therefrom go to the State University.

In order to administer the state timber land, there was set up under Mulford Winsor (51), Land Commissioner, in 1914, a plan whereby the state forest lands would be cooperatively managed according to the best forest practices then known by the State Land Commission and the United States Forest Service. This plan was highly lauded

by experts in the field and was used as a model for other states dealing with the problem of State timber lands. Under the plan, the best known policies of forest conservation were to be practiced to insure continuous growth and replacement of the State's timber resources.

Wildlife. The economic history of our western United States generally follows the pattern sequence of trapper, hunter, miner, stockman and farmer. The trapper and the hunter did not find Arizona as they did some of the other western states. The climatic conditions in much of the state were not favorable for large numbers of furbearing and game animals. Many furbearing animals of the better quality are not found in this area. The hunter found better sport in the northern part of the state than in the southern.

However, the region comprising the present state of Arizona did contain a great deal of wildlife. Wild turkeys were found in abundance near old Tucson and rather generally throughout much of the state. Beavers were found in all the larger streams and rivers. The following quotation, from Bartlett (7, pp.555-556) regarding wildlife in the territory shows something of what did exist at that time:

> In the mountains and along the water-courses where there are more or less forest trees and shrubbery, both quadrupeds and birds are found in great variety. Among the former, may be mentioned the leopard, cougar, ocelot, lynx, panther, the brown, black and grizzly bear, the fox, antelope, and various kinds of deer, the large wolf (Lobo) and the coyote, raccoon, skunk, marmot, weasel; a great variety of moles, rats and mice.... hares, rabbits, squink, Rockey Mountain Sheep... The elk is not found south of the Gila. The beaver is s till met with on the Pecos, the Rio Grande, the Gila and its northern tributaries....

It is impossible to secure exact figures on the amount of wild game in this area when the white man came, but from all indications, our game population was all but exterminated by hunters and trappers.

The first Americans in this area, according to Cooke (10, pp.144-145), were impressed with the quantity of wild horses, burros and cattle that roamed the lands, especially south of the Gila River. These animals were descendents of the stock brought in by the early Spaniards and had been liberated through the raids of hostile Indians.

With the exception of a few animals such as the mountain sheep, the game population of Arizona has increased slightly during the past 10 years. The enforcement of game laws has made this possible. The establishment of such organizations as the Arizona Game Protective

Association has helped a great deal.

Conservation of wild life does not refer, of course, to game animals alone. It includes small birds, frogs and certain insects, all of which are of great value for their ability to check and control harmful pests.

CHAPTER III

CONSERVATION OF NATURAL RESOURCES FOR ARIZONA SCHOOLS

Water Conservation

If Arizona could be visualized as a small child sitting on Santa's knee and being asked what it wished most in the whole world, the answer would be "Water".

The state has fertile lands and a long growing season but it needs water to develop these to their utmost productivity.

Land in Arizona which is now worthless for cultivated crops and sells for only a few dollars an acre, would increase in value a hundred times or more if water for irrigation could be secured. Land which now takes as many as 20 to 50 acres to support a single cow for a month or two during the year would support two or three or even more cattle per acre if irrigated.

Water means a great deal to the state. It means its future as a commonwealth; a highly-productive state to help feed the nation and make it strong; it means wealth to the residents of the state. But the lack of water means loss of income, a sparse population, barren fields and small personal wealth among its people. Dearth of water means poverty and lack of life.

Gustafson (13, pp.62-63) stresses water

importance by saying that a man weighing about 150 pounds consumes something like 2,200 pounds of water annually and it has been estimated that it requires 10,000,000 pounds of water to produce the annual food requirements of one adult. Ten million pounds of water equals approximately 3.66 acre feet of water. One acre foot of water is the amount of water necessary to cover one acre one foot deep.

Water is not only necessary for plant and ainmal life but it is necessary for mining, development of power, disposal of sewage, cleanliness, and many other purposes in modern civilization. J. R. Mahoney, senior specialist in natural resources and the Public Domain for the Library of Congress, in a report to the Public Land Committee of Congress (19), declared "....Water has become, aside from the land itself, the most valuable and actively managed of our natural resources."

It is not necessary to go farther afield than our own state for examples of what controlled water can do. The state of Arizona has one of the best-known and successful reclamation projects of the nation in the Salt River Valley project. It is a model for study by other states and by foreign countries. It has proved that water, controlled and placed upon the land in the proper manner can turn waste land into fruitful, productive land with a great deal of profit in its use.

The area of land irrigated in Arizona in 1949, as estimated by the Valley National Bank (53, p.31), was about 1,000,000 acres. Of the total agricultural income of the state, well over 85 per cent is derived directly from irrigated lands.

It is very difficult to set a figure for the agricultural income of irrigated and of non-irrigated lands separately, since in the case of cattle and sheep, such stock is grazed on non-irrigated range lands part of each season and fed on, or from, irrigated lands the remaining months of the year.

In looking at the future of Arizona economy, the dearth of water is the only factor that may retard its agricultural growth. Other factors which are entirely social can eventually be changed or removed but we need the water to irrigate the land and to build a stable state. Our minerals are being depleted and cannot be renewed, but with the development of other sources of water supply, we can be assured of a longer and more prosperous existence.

From investigations of prehistoric sites in the state, it appears that Arizona has known irrigation almost as long as it has known the presence of man. The ancient peoples who occupied portions of the state prior to the advent of the European had a system of irrigation of their own. However, it has taken modern engineers and engineering methods to erect permanent storage and diversion dams

which stabilize the flow of water and make irrigation pay the dividends which it does today.

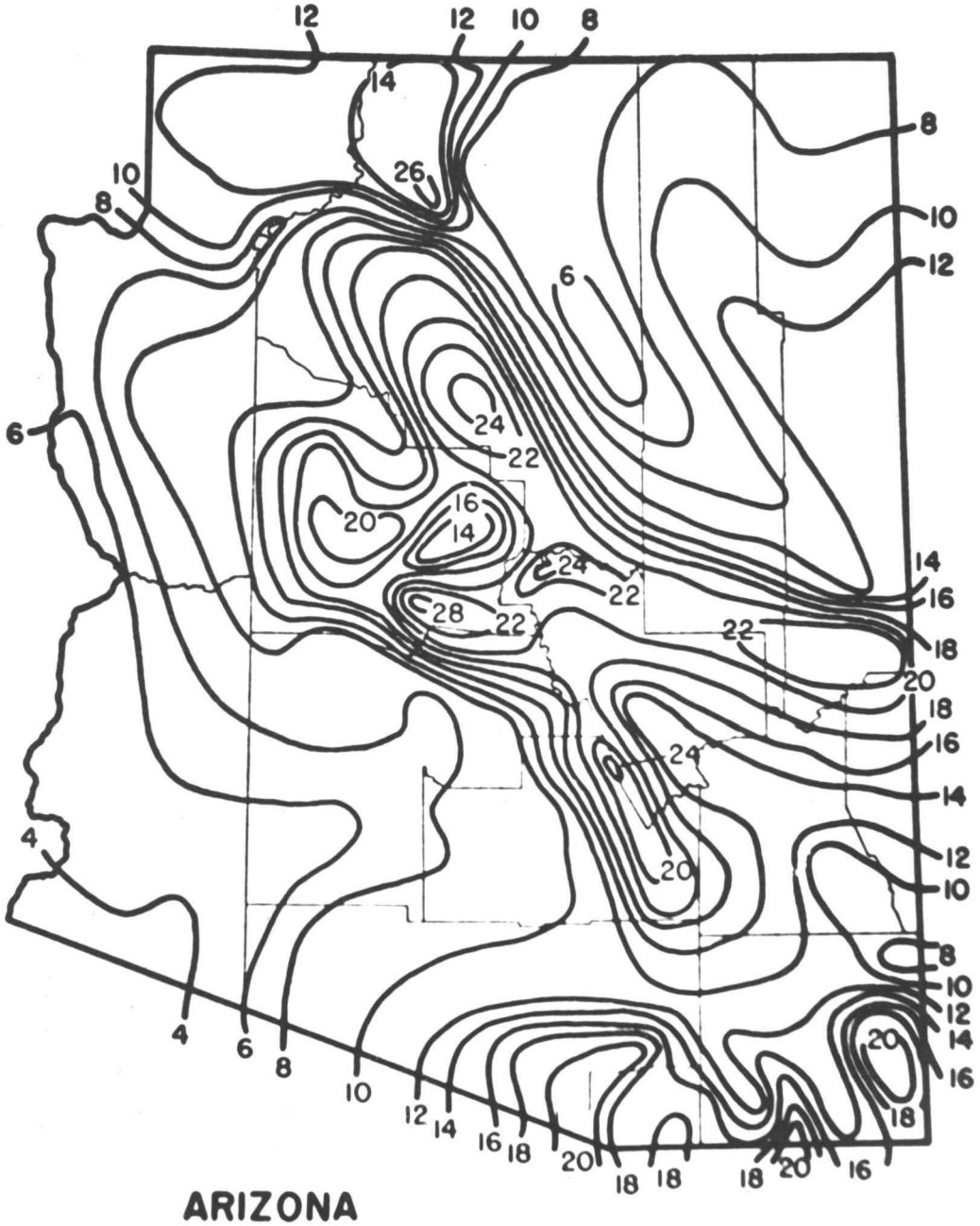
Water Resources of Arizona. All water, basically speaking, comes from the ocean. Evaporation from the ocean, transportation in gaseous form, cooling and precipitation are, according to the well-known hydrological cycle, the succession of processes by which the water moves from the ocean and is deposited upon the land.

When the water is precipitated in the form of snow or rainfall, it reaches the earth and it is (1) stored in the soil, (2) consumed and again evaporated by plants, (3) restored to the ocean eventually through a complicated system of fresh-water streams.

Our big job in Arizona is catching, controlling and securing the maximum use of the available run-off of water in the state.

The map on Page 33 shows the average annual precipitation in Arizona. It can be noted that the higher rainfall is found in the mountain regions by comparing this map with the one on Page 6.

The high areas of Arizona are the water shed areas from which comes the larger part of the irrigation water now in use. There are five such water sheds in



ARIZONA

AVERAGE ANNUAL PRECIPITATION (INCHES)

U. S. WEATHER BUREAU

Arizona of any consequence:

(1) Salt and Verde Rivers
(2) Gila River
(3) San Pedro and Santa Cruz Rivers
(4) Colorado River and its tributaries, the Little Colorado, and the San Juan River
(5) Bill Williams and Santa Maria Rivers

The Virgin River water shed could be included but it occupies a very small portion of the state.

Besides the water that is collected and used from the water sheds, the other sources of water in Arizona are from the direct fall of rain and snow upon the land and from the underground water table which is also a direct result of rainfall and of melting snow packs on the water sheds.

Water that falls directly upon the land is known as water from the original sources, that is, from precipitation; but water which is so controlled after falling on one place that it is used in another area is known as water from a secondary source. In fact, the only water on the land which we can control is water from secondary sources.

When the water falls upon the water sheds and starts its way back to the ocean, dams are placed in the streams and rivers, making artificial barriers behind which lakes for storage exist. Some of these serve only to divert the water into canals for use upon the land, and are known as diversion dams. Others are called

storage dams. All of our irrigation systems in rivers are of the storage-diversion type dam. Pumping of underground water does not fit either of these classifications and will be explained later.

There are many dams in Arizona. These are listed below under storage or diversion classification.

On the Salt River, there are four storage dams, Roosevelt, Horse Mesa, Mormon Flat and Stewart Mountain. On the Verde there are two storage dams, Horse-shoe and Bartlett. After the Verde flows into the Salt a diversion type of dam called Granite Reef Dam is found, which controls the amount of water sent to the areas on the north and the south sides of the Salt River.

On the Gila River, in the vicinity of Safford, there are several of the diversion type dams which were, until recently, constructed in the old way of rock, earth and brush. These control the flow of water onto the farm lands of the upper Gila Valley. These dams have never been a permanent type and follow the general plan of the prehistoric and historic Indiam dams, washing out often with high water. They need to be made of a more permanent construction in order to be dependable.

Below the upper Gila Valley is located Coolidge dam which is of the storage type and ranks with the largest dams in the state. Down the Gila, after its junction with the Salt, there is a small diversion dam known

as the Buckeye dam, and downstream from it, near Gila Bend, is another diversion dam, the Gillespie. Carl Pleasant dam is a small storage dam on the Agua Fria River about 35 miles northwest of Phoenix.

On the Colorado River, we share with the state of Nevada the Hoover dam, which is a storage dam. Davis dam, now being built below Hoover, is also a storage type and will be put into operation in the 1950's.

Below Davis dam, near Parker, on the Colorado, is the Parker dam, which is storage and diversion mainly for Los Angeles city water system. Downstream from Parker and near Yuma, there are two large diversion dams on the Colorado known as the Laguna and the Imperial dams which shunt water to California and divert some of the river flow to Arizona for the Yuma section.

On the Little Colorado, the Lyman dam supplies irrigation water for the land around St. Johns and the Daggs reservoir on Silver Creek supplies the irrigation needs of the land around Snowflake. Counting all the irrigation supply facilities both large and small in the state of Arizona, there appear to be some 80 storage reservoirs and 275 diversion dams. This is an approximate figure since some of the smaller facilities are not used every year.

The above listing of the dams in Arizona does not contain the names and locations of all dams in the

state, because on the upper Verde and the Little Colorado, there are several small diversion-type dams serving many acres of land. There are also a few flood control dams of which the Cave Creek dam, north of Phoenix, is a good example.

The production of electric power from the stored water in many of these dams runs into a staggering number of kilowatts, although its production is a by-product of the main purposes of the dams which are water storage and diversion.

Water is obtained for irrigation purposes not only from reservoirs and natural rainfall and snows, but also from pumps and pumping projects. It was found, several years ago, that in many sections of Arizona great amounts of water lay in underground reservoirs. This water, known as underground water was the result of precipitation that fell upon another area of land and filtered down through the soil until it reached a hard stratum of rock or other impervious earthen formation. It flowed over this into the underground lowlands where it collected under the surface of the ground, perhaps upon the floors of the ancient valleys and river beds. It can easily be tapped by huge, motor-driven pumps which produce a flow as great as 300 to 600 miner inches of water. A miner's inch of water is about nine gallons per minute.

according to Webster's Dictionary, but varies in many localities.

This underground water is measured by determining the distance from the level of water in the well to the surface of the ground. This distance is known as the water table. The water table fluctuates with wet and dry years and also by use. The lower the water table, the more expensive it is to pump the water onto the land. Much of the pump water in Arizona is highly mineralized and, in some cases, is so much so that it is of no use to plant life.

The underground water is recharged by snows and rains in the mountains, by rainfall on the area itself and by seepage and drainage from rivers and from irrigation projects. (1)

In looking at Arizona's future water supply, there appear two possibilities for adding to her available water. The first is that of securing additional water from the Colorado River and through a complicated and expensive engineering project with pumping stations, canals and tunnels to get this water upon the lands of Central Arizona. This problem is now occupying the major portion of the time of our Congressional representatives. Since the project would need the financial support of the nation in order to be feasible, Congressional action is necessary. The approximate cost of the project would be

about 526 million dollars, according to the present bill in Congress. Arizona is not the only state to have designs upon the surplus Colorado River water, however, and consequently, there is and will continue to be a legal and legislative battle for the right to the surplus water.

The second method of obtaining more water for fertile Arizona acres would not in any way equal the volume of water anticipated from the Colorado River but would rather simply augment the present supply. This method is through the use of scientific rain-making devices. These devices could range from sprinkling dry ice upon clouds forming over the water sheds by airplane to setting up machines from which salt could be projected into the atmosphere from mountains in order to start precipitation.

Mistreatment of Our Water Supply. In order for a water shed to operate to its fullest capacity, plant life should be present in abundance and the top soil of the area should contain a reasonable amount of humus (49, p.11). The water shed should function as a blotter. It should soak up the rain and melting snow. The water that falls upon the shed should be, in part, used by the plants on the water shed and the remainder should soak into the upper layers of the

ground and thus feed the surface streams by underground flow and also feed the underground streams. When very heavy rains occur, all the water of a properly managed water shed will not soak into the ground but run slowly over the surface, impeded by the vegetation and thus a certain proportion of it will reach the streams and proceed to the dams.

It appears to the ordinary observer that if the water shed were denuded of vegetation, all of the water that fell would immediately go into the streams and be impounded behind the dams. This would be true, to a certain extent, but it would not be making use of the resources to the fullest extent. Many animals can graze upon the vegetation grown on the water shed. Much valuable timber can be grown on these mountains and hills of the water shed. The land of a water shed with no vegetation to stop and ration out the water falling upon it will quickly erode and soon fill the dams with silt and debris, making them useless for storage.

The two greatest foes to good water sheds are fire and over-grazing. Both enemies are controllable by man. Fire is much the harder of the two to control but, in a large number of cases, fire is caused by man. Both fire and over-grazing destroy the vegetation in the water shed and, consequently, the area becomes eroded and the

evaporation rate is too high. Plant diseases and pestilences which also kill off vegetation are serious causes of water shed depletion.

Long periods of drouth also seriously hamper the growth of cover in a section designated as a water shed area.

It would be possible then to sum up the protection of a water shed area as the protection of the vegetative growth of that area. Many people of Arizona are of the mistaken opinion that our mountains contain very little vegetation and would probably question the statement that the protection of vegetation on the water shed is protection of the water-producing capacity of that region. Vegetation does not mean large shrubs, high grass or thick forests. The smallest plants whose roots reach into the soil serve to slow the progress of water falling upon the surface as rain or snow and contribute thus their part toward the eventual conservation of moisture.

Mountains of Arizona which do not have vegetation are of little value as water sheds. True, during a rain, their rocky slopes do direct water into certain channels so it can be stored, but these bare mountains receive rain so infrequently that no sustained flow of water results and, consequently, any planning for regular water

from them is not satisfactory. Carl Pleasant dam is not as satisfactory as other storage dams in Arizona for this very reason.

Tests made following a storm on the 17th and 18th of September, 1946, at the Sierra Ancha Experimental Station (49, p.14), proved that ground with good vegetative cover gave the highest total run-off of water.

Over-pumping of any given area eventually causes the water table to be lowered. In Deer Valley, for instance, the water table has dropped 35 feet since 1942 (16) and in other sections of the state reports of the constant lowering of water tables appear with increasing frequency whenever a great deal of pumping is taking place.

The balance for which we should strive is to pump from the ground only the same amount as the recharge rate each year. To date, there has been no adequate study on such a rate of recharge, so it would be impossible to regulate the pumping to fit the flow of incoming water.

In 1948, the legislature of the state of Arizona, in special session, passed a law providing that if a certain section of the state is designated as a "critical area" because of the lowering of the water table, the State Land Commission may prohibit further drilling of new

wells in such an area. (6, Sec. 75-1702). Eloy is the only section so far called "critical" under this law, and the pumps that have made it such an area are still operating to capacity.

About the only factor that will correct this depletion of our underground water supply stems from the economic fact that as the water table drops, pumping becomes more expensive. When such pumping cost reaches the point where it is no longer profitable to operate such wells, this over-pumping from the water stored under the ground will stop. This does not, however, in any way help the people of an area where the water level has already been lowered, since they have to go to the great expense of deepening domestic wells in order to reach the dropping water table. In 1947, the average pump lift for the state was 180 feet. (37, p.8)

How Water Can Be Conserved. With the present methods which are now in use for securing and using water, our biggest problem is to use the water we can secure to the best advantage and to so improve the supply sources so as to get the maximum amount of water on the land where it is eventually used. In other words, wise use of our available water and no waste of this basic resource must be our answer to our water problems.

An ancient proverb which has been attributed to the Chinese reads: "To rule the mountain is to rule the river." (41, p.7) This, put into modern words, means control and improvement of water sheds.

Protection of and control of a water shed means protection of the vegetation and soil of the water shed. This protection can be brought about partly through preventing over-grazing by livestock, both domestic and wild. Protection can also be furnished through control of the logging of timber on a water shed. Prevention of the cutting of too much timber from a given area at any one time is definitely a water shed protective measure. Road and trail construction, which might induce erosion and landslides, must be carefully engineered and carried out. This type of control calls for exacting methods of road and trail construction in order to minimize the dangers of resultant erosion.

Fire, which is the greatest cause of concern to those in charge of water shed protection, can be prevented or held to the minimum by: (a) Education and enforcement of fire prevention laws upon those who travel through or who live on the water shed area; (b) Well-organized, manned and equipped fire-prevention units, capable of covering the water shed in a short time. These are necessary in order to keep such fires as do start from doing

serious damage.

Control and education of those people who use water shed areas for farming can contribute greatly to the successful management of such regions. The best methods of conservation farming are valuable here to prevent erosion and to reduce soil washing to the minimum.

The planting of trees and grasses on the water shed areas aid in adding to the protective covering of the land and in control of the moisture.

Engineering works are often needed in water shed regions. Many types of special dams are needed to control floods and erosion. Such engineering devices as dikes, jetties, silt diversion works, check dams, gully plugs and terraces are useful in directing water flow and in stabilizing flood crests.

All of these methods which can protect our water sheds also protect our dams. A water shed which is functioning perfectly has little erosion and, consequently, the space behind the storage dams is in little danger of being silted. This aids these dams in maintaining their maximum storage capacity for the use of future generations.

When the water is stored in the dams or is diverted into the canals which lead into the fields, there are three factors which cause a great loss of water. These are (a) <u>evaporation</u>, (b) <u>seepage</u> and (c) <u>soaking into the</u>

banks of the canals. According to the Salt River Valley Water Users Association, about 40 per cent of the total water that leaves the dams is lost by these means before it reaches the fields. (29)

It would be impossible to stop entirely the loss of water through evaporation, the first of these three factors, but such losses can be controlled to a certain extent. Reservoirs and canals that are deep and have thus less surface exposed to the air have less evaporation than those that are shallow and wide. Tiled canals and ditches, while very expensive to construct, do help control the evaporation rate.

It is possible, however, to stop the second of the three factors in the loss of water en route from the dams. Seepage can be stopped by the use of headgates and control equipment that is well-made and of a type that will not allow water to leak out in directions not wanted. It is estimated by the Salt River Valley Water Users Association that, by the replacement of wooden headgates by a newly-designed concrete type, there is possible the saving of some 38,000 acre feet of water in 1950. (4, p.10)

The soaking of water into, and sometimes through the canal banks is the third factor in this water loss. This is being remedied to a great extent in large canals and laterals by the canal-lining program which is being

carried to completion as fast as available funds permit. Canal, lateral and ditch-lining programs are definitely the answer to seepage and soaking problems, although their expensive nature makes them slow in being realized. It should also be understood that much water loss takes place in smaller ditches, infrequently used, which have to be soaked with water each time they are used before the main volume of the head of water can reach the land. Such problems as these are being met by lining and tiling smaller ditches with concrete, by using the ditches for a longer period at a time, and by keeping the ditches clear of vegetation which hinders the flow and uses a great deal of water in its own growth.

After the water is stored by dams and directed to the fields, more ways appear by which water can be conserved so as to give the most benefit possible to crops. The first of these is to have the land level and well prepared to receive the water. Land which is comparatively level and then cultivated to a desirable depth will absorb more water and store more water than will steep, badly prepared land which allows the water to run off too quickly. It is much easier to control irrigation water on land that is level because there is no fast moving of the water and it is more easily diverted to cover the entire area under cultivation. Ditches which have little

fall, also conserve water because there is no need for so many gates and other devices for controlling the water in order to put it onto the desired area of land.

Waste water should be kept to the minimum and a farm should be so planned as to use the waste water from a field again or to so direct it that it can be used by some other farmer. Waste water is the water which runs off at the end of each field during and after the irrigation. Many crops that need deep penetration of irrigation water into the soil have a great deal of waste water. This is necessary because the water, in order to soak to the desired depth in the field, has to run on the surface of the land for a long time. This means that the water that does not soak in, runs off the field and is lost as far as the farmer is concerned unless it can be diverted onto another field. Deep initial tillage by renovators to the depth of as much as four feet help the problem by making the ground porous.

Sprinkling systems for irrigation are not used to any great extent in the state because of their high initial cost and because of the high rate of evaporation which takes place in this method of using water. Most irrigation is of the flood type, on lands about 33 feet wide, or on rows. The latter method is used on crops that have to be cultivated after growth starts.

Water conservation can be practiced by the urban dweller as well as by the farmer. The use of water for domestic purposes should be governed by the use of only the water necessary to keep the household running properly, not by the amount of the monthly water bill. The sprinkling of lawns and the watering of trees and plants should be so regulated as to have no waste, and watering of yards and gardens is best accomplished at night, or in the early morning or late evening when the evaporation rate is lowest.

Evaporative coolers in many houses are excessive users of water. Sufficient water to keep the packing moist is all that is necessary.

The plight of the farmer who sees his water supply vanishing is balanced by that of the community in any section of the United States that is confronted with almost empty city reservoirs, partly because of the same poor watershed protective measures. Water can be a rapidly-vanishing commodity in town as well as country and is, in fact, becoming almost a luxury in some parts of the United States.

Sufficient water for our use may, indeed, become like education, a privilege rather than the right we have long been accustomed to consider it.

Water Conservation, like other types of conservation, is largely a matter of common sense and can be

defined as the use of this natural resource to the best advantage of all. In summarizing this field of conservation, it can be stated that it is necessary to obtain as much water as possible from the water sheds, which water can be stored behind the dams, directed to the fields and homes with the least possible loss, here to be used to its fullest capacity.

This can be done by:

1. Better watershed management
2. Construction of reclamation projects
3. Intercepting the maximum amount of precipitation
4. Cutting evaporation loss to the minimum
5. Achieving the maximum efficiency of our present irrigation system
6. Controlling weed growth in fields (weeds consume water just as do cultivated crops)
7. Operating well-planned and leveled farms
8. Irrigating by short runs--40 acre fields
9. Cementing water-transporting facilities
10. Subsoiling land for greater water absorption
11. Using all water with minimum waste
12. Being careful of water for domestic use.

Soil Conservation

All life depends upon the soil. Even the animals and plants in the sea are dependent indirectly upon the soil for their living. The greatness of a nation can be determined by its soil resources. No nation that wastes or neglects its soil can remain great. This statement can be applied down through the sub-divisions of the nation, to the states, the counties and so to the owner or owners of the land itself.

Arizona lands under irrigation and those devoted to dry farming form such a small part of the total number of acres in the state that the main problem of soil conservation lies with our grazing lands. On the other hand, if we look at the monetary value of production from the agricultural lands of Arizona, the farming lands contribute more to the state in wealth than do the grazing lands.

The soil of Arizona is very fertile, more so than that of the majority of states in the Union. The depth of the top soil in the lowland valleys is tremendous. In many cases, the people of Arizona measure the top soil in feet, whereas in other states it is measured in inches. We have very fertile soil, easily worked, but we lack the necessary water to develop it to the fullest extent.

Arizona has a total area of 72,847,818 acres. This acreage can be broken down as follows: (42, p.25)

Federally owned lands, including Indian reservations, National Forests, Grazing Districts (Public Domain) and National Parks.	47,948,822 acres
State owned lands	8,356,497 acres
Privately owned lands	16,543,499 acres

Out of the privately owned lands, 959,000 are classed by the Soil Conservation Service (31) in 1945 as croplands. Their estimate is now, 1950, that there are approximately 995,000 acres of croplands, 942,000 of which are under irrigation.

Valley National Bank (52, p.1) figures for 1949, the cash income of Arizona farms and ranches was $235,000,000. Of this amount, $47,000,000 was from the raising of cattle and sheep. Out of the total cash income for agriculture, cotton and truck crops accounted for $130,000,000.

There are no accurate figures available for the number of persons employed in agricultural pursuits in Arizona. This is because of the large numbers of migratory laborers used. Such crops as lettuce, carrots and cotton use a great many workers for a short time during each year. This period of time varies with the season and with the size of the harvest, as well as with the market. As a result, the number of people employed in

Arizona agriculture fluctuates to such an extent that an accurate accounting would be very difficult.

Use of the Land by Regions. In general, Arizona is divided geographically into two distinct parts by the Mogollon Rim which runs diagonally across the state from northwest to southeast. The area to the south of this rim belongs to the low desert type of land with its particular sort of vegetation. The area to the north of the rim belongs to the high desert or Upper Sonoran zone. The rim itself is higher than the Upper Sonoran area and is what is usually called the Transition or Canadian zone. There are higher sectors scattered throughout the rim and culminating in the San Francisco peaks which belong to what is known as the Alpine zone.

The state receives its rainfall, or moisture, in proportion to the altitude of the land. This is because much of the moisture of storms traveling in an easterly direction has been lost on such areas as the Sierra Nevada, in California. The chart below will give a clearer picture of the regional differences of the state than is possible with statements alone.

The following information is from Nichols (22, p.1-20):

	Altitude (feet)	Zone	Annual Rainfall (inches)	Characteristic Natural Vegetation
1.	1000-3000	Lower Sonoran	3-12	Mesquite, Cacti, Creosote
2.	4000-7000	Upper Sonoran	3-20	Grassland, Prickly Pear, Pinon-Juniper area
3.	7000-8000	Transition	30	Yellow pine, Oak
4.	8200-9200	Canadian	30-35	Douglas fir, Aspen
5.	9200-10,800	Hudsonian	35	Engelmann spruce, Cork fir
6.	10,800-12,000	Alpine	30	Dwarf trees, Pine

The area belonging to the Lower Sonoran zone, lying south of the Mogollon rim's mountainous terrain, is better suited to irrigation and the rim and the area north of it are better suited to grazing. These are general statements and cannot be strictly true since there are some irrigated sections along the Little Colorado River. Much grazing is done south of the Mogollon, but the bulk of irrigated land is south of the rim and the bulk of the grazing land lies on the north of it. The greater part of the irrigated land is along the Gila River and its tributaries. The valleys south of the rim belong generally to

the broad, flood-plain type, while those in the north belong to the narrow, deep canyon sort of valley.

In Arizona, irrigation means farming areas and where irrigation is not commercially feasible grazing is the only agriculture possible.

The Soil Resources of Arizona. Soil is best defined as the loose, fine divided material that covers the surface of the earth. It is composed of mineral substances, mixed with small amounts of decayed vegetable and animal matter.

The soil of Arizona does not contain the amount of organic matter possessed by the soil of other sections of the United States having greater rainfall annually but it is very high in mineral content.

The rainfall of the state is not as heavy as that of other parts of the nation and this has prevented the leaching of soluble salts which has so impoverished the soil of other sections.

There are many different classes and types of soil. One of the best methods of classification is that which takes into consideration the size of the rock particles which make up the soil. This classification contains six types. (34, pp.50-51)

1. Sand
2. Sandy Loam
3. Loam
4. Clay Loam
5. Silt Loam
6. Clay

Of these six types, sand is the coarsest and clay the finest in texture. Sand, silt and clay, in equal proportions, form loam. If sand, clay or silt predominate in the mixture, the resulting soil is known as sand loam, clay loam or silt loam, as the case may be.

The beginning of soil is parent rock. These rocks are classed as follows:

1. Those made from molten material (lava) which is often volcanic in origin. These are called Igneous.

2. Those which are made from deposits of wind, water or glaciers. These are called Sedimentary.

3. Those which are a combination of Igneous and Sedimentary due to extreme heat or pressure and which are called Metamorphic.

These types of rock, in turn, are weathered, ground and broken by extremes of heat and cold, by ice, roots, slides, chemicals and by many other forces into the soils classified above.

Soil on, or near, the surface contains not only dead organic matter and minerals but is also teeming with

bacteria, most of which are beneficial to plant growth. These bacteria are usually native to the soil, but can be introduced in conjunction with plants, such as the legumes.

Soil, which is formed where it is found is called residual soil and that which is transported to its present site is called alluvial soil. Most of the soils in the valleys of Arizona are alluvial. These soils have been transported by the rivers and streams along their changing courses and heights during the centuries. The upper Gila valley is a very good example of this. The Gila River has changed its channel many times in the past few decades. In fact, a soil map, Plate 4 of the Atlas of American Agriculture shows practically all the area south of the Mogollon rim as an alluvial deposit, as well as that land along the Little Colorado River in the northern part of the state.

There are many types of soil in our state. Soil types vary even on parts of the same farm. Local differences are caused by the contours of the land, the vegetation and the parent materials. Vegetation, if dense, protects and holds the soil. In other sections lack of such vegetation allows the soil to be moved easily by such natural forces as water and wind. Parent materials, if soft and porous, will build soil faster since they break down more easily under the forces to which they are constantly exposed.

The soil of this earth is in layers, or strata. The upper stratum is known as top soil. Top soil varies in depth throughout Arizona being from a thin layer to many feet deep. The thin top soil is found in areas where the soil has been exposed to the wind and water for centuries and deep top soil is found in the valleys and alluvial plains of the desert areas. In many areas, along the river beds and in the valleys, the top soil is as much as 200 feet deep (29). In comparison, it might be noted that the more fertile sections of the middle west measure their top soil in inches.

In addition to the minerals, the top soils contain much porous, organic matter such as the root stocks of decayed plants and grass residue, as well as soil bacteria and air. The top soil is our fertile soil, capable of giving life and abundant living if properly cared for.

The top soil that has been accumulating in our desert valleys is rich in mineral substances, but it does not have the abundance of organic matter found in the soil of other sections of the nation, because of the scanty plant growth resulting from the small amount of rainfall. In areas of the state where the rainfall is greater, the top soil contains more organic matter, but is not so deep and does not contain the amount of minerals present in the desert soils. Some desert areas, because of poor

drainage, contain, on the other hand, too much of the mineral substances which are harmful to plant life, and the growth of plants is thereby discouraged. These areas are usually called "alkali flats".

Soils are formed very slowly. It takes between 500 and 1000 years to form one inch of top soil through the process of weathering. (18, p.17) Our desert valleys owe the extreme depth of their top soil to the fact that they have collected top soil brought from other sections by natural means and from the surrounding bare, rocky mountains.

Under the topsoil lies the subsoil which is the parent material for the residual soils. The subsoil is compact and contains little humus. The subsoil does not contain food for plants in such condition as to permit the vegetation to use it as sustenance.

The next layer is usually the bedrock or very rocky material which would need thousands of years of weathering and of root and chemical action before it would be possible for plants to survive on food secured from it.

Soil is necessary for the growth of all plant life. The material the plants need from the soil for their growth varies with the type of plant and the availability of the material. Plants require large amounts of nitrogen,

phosphorous, and potash and smaller amounts of other elements such as iron, magnesium, boron, sulphur, calcium, and aluminum (34, pp.55-57). These elements are valuable to the growth of vegetation. If a man harvests a large crop from his land, he is also harvesting a large amount of soil materials which have gone into the growing of his crop. Whenever he ships his cattle or harvests a crop, he ships away a great deal of his soil's productivity.

Jay W. Darling (11, p.3) has estimated that a cargo vessel taking a load of wheat to Europe bears a crop that is taking away with it 60,972 pounds of nitrogen, 11,618 pounds of phosphorous, 13,500 pounds of potassium, 11,824 pounds of calcium from the soils in which it was grown.

In order to keep the fertility of the top soil, the supply of plant food taken from the land should be balanced by the amount of fertile soil manufactured by weathering and soil bacteria as well as by keeping an adequate supply of organic material in the soil. Artificial fertilizers become necessary if the natural agents of soil building do not prove adequate.

In areas where the soil is not naturally fertile, vegetation does not exist. This is true of a comparatively small part of the state's terrain and is

usually found in those areas where an over-balance of a certain material in the soil exists, due to the particular geography of the area. Such an area as the Wilcox Playa is a good example of this. Here, excessive deposits of alkaline salts prohibit the growth of forage plants.

Erosion. Any wearing away or loss of soil through the action of wind or water is called erosion (13, p.13).

There are two types of erosion, natural and accelerated. Natural erosion is a very slow process of wearing away the soil since much natural protection is given the soil by its vegetative covering, where such covering exists. Natural erosion is the process by which our canyons are formed. The canyons of the Little Colorado and the Grand Canyon are good examples of this. Natural erosion accounts for the extreme depth of our top soil in the desert valleys and for the wearing away of our mountains which, in part, furnished this top soil. Natural erosion is sometimes called geologic erosion.

Accelerated erosion is usually the result of man's desire to conquer and capitalize upon the natural products of the earth with characteristic impatience. With the removal of grasses through over-grazing, of brush and trees by fire or logging, the natural vegetation has been removed from the soil and the rains and the wind are

free to carry away the productive top soil, leaving bare, unproductive gullies and fields. The water tears at the soil during the wet periods and the wind during the dry seasons until, finally, all that is left is the infertile subsoil.

Erosion is not only the loss of the top soil, but is also the loss of soil that contains the fertility necessary for plant growth.

Recognizing Erosion. According to Gustafson (13, pp.132-34), erosion can be recognized in the following ways:

1. By muddy streams, showing that there is actually soil on the move and one can be certain that it will be the best soil that is being moved, the top soil.

2. Dust storms. In Arizona, especially south of the Mogollon rim, everyone knows what dust storms are. The dry, hot winds of the summer lighten the top soil so that it loses its moisture and our strong, desert winds move considerable quantities of soil at a time.

3. Soil drifts. Soil found in deposits at the mouth of a wash or stream show that flash rains carry a great deal of soil.

4. Gullies, cuts and small washes. Land that is low in vegetative cover will show these signs of erosion as definite evidence that soil is being moved.

5. Streams, dams, rivers and ditches which begin to show signs of being clogged and filled with silt carried down from an upper area are examples of erosion effects. Roosevelt dam will need 244 years to fill completely at its present rate of silting. Coolidge dam will need 213 years to be completely filled with silt.

6. Bottom lands that have been flooded and strewn with all types of debris.

7. The drifting of sand and dust along a fence row, with posts partially or completely covered.

8. Exposed roots of trees or shrubs.

9. The exposing of bare rocks and subsoil that once had been covered with top soil.

The Grand Canyon is an excellent example of erosion from the action of water. It took many millions of years to form the Grand Canyon into the mighty spectacle that it is today. Our big problems are the miniature Grand Canyons that start on our grazing lands, our fields and our hillsides.

Erosion rate is determined by several factors.

1. Climate and vegetation. Areas which have a great deal of rainfall are more susceptible to erosion than those with light rainfall. Areas of light rainfall have little vegetation to protect the soil from the force of the rain, to check the flow of surface water, and to

bind the soil in place by roots and humus. Arizona is a state of light rainfall and mild climate. Our rains often are the hard, dashing type of rain, which has a tendency to do a great deal of washing to the soil in a short time.

Climatic cycles contribute much to erosion. During the long, dry period much of the protective covering is drought-killed and fails to protect the land.

2. Topography. The topography determining the rate and force of the run-off has much effect upon the rate of erosion. Steep slopes are subject to a great deal more erosion than are level areas.

3. Soils. Light soils erode more rapidly than heavier soils. This contributes much to the rate of erosion. Sand and silt are both classes of soil that erode easily (23, p.14).

Causes of Erosion. Erosion is caused either by man or nature. Man-caused erosion is more evident, faster and more costly than is natural erosion. Erosion that takes place under nature's plan is slow but some of the practices of which man has been guilty speed erosion to such a tempo that it has assumed the proportions of a national calamity. W. C. Loudermilk, of the Soil Conservation Service, has made a study of foreign empires of the past 7,000 years and believes that erosion is the greatest

single factor contributing to the downfall of these nations. (18, pp.1-6)

Natural erosion may be accelerated by flood, fire and winds of more than normal intensity. It can also be speeded by the natural condition of the soil itself as well as by the removal of vegetation by disease, blight or pest. But, on the whole, nature discourages the accelerated rate of erosion rather than encourages it. We can do little to combat natural erosion since we cannot entirely prevent natural fires, floods, wind and rain but we can, in some measure, minimize them.

Our greatest problem is to discourage and to correct the erosion caused by man. It has weakened and destroyed other nations and has even now affected the economy of some states of the Union.

Some of the causes of man-made erosion can be corrected. These are:

1. Overgrazing. Appendix A of this paper contains many statements by the first people who left written statements of the amount of grass and of browse in this section when they first entered it. From these statements, it can easily be gleaned that there was a great abundance of grass in various parts of the state. H. C. Hooker of the Sierra Bonita Ranch wrote in 1900 to D. W. Griffith of the Bureau of Plant Industry and made

the following statement: ".....There were fully 50,000 head of stock at the head of Sulphur Springs valley and the valley of the Arivaipa in 1890. In 1900 there were no more than half that number and they were doing poorly." (46, p.8) Overgrazing is the use of the natural vegetative cover of the land at a rate faster than it can reseed itself.

Most of the edible plants used for forage in Arizona are annual plants. These annual plants, mostly grasses, were found in great quantities and abundance by the first of the men who crossed the state as trappers, soldiers or seekers for gold. Many noted this grass and browse and decided later to bring cattle into the area.

Our range lands were, in effect, the last frontier for cattle. Large herds were brought in and when an area was "fed out", the herds were moved on. Following the cattlemen came the owners of sheep with animals fitted by their grazing habits and the shape of their mouths to get even more of the vegetation than did the cattle. (26, p.3)

The Arizona grasslands suffered greatly until, finally, it became impossible to find new grazing areas and the old areas would no longer support the large herds of cattle and sheep that they had fed during the early part of the territory's history. The land was badly

over-grazed, and the cause of this over-grazing was over-stocking of the ranges. Arizona's ranges will not carry as large a load of stock as ranges in other parts of the nation, but, because of the climate, will carry stock for a longer yearly period. In other words, Arizona has a longer grazing season. A longer grazing period gives the grasses and other plants fed upon no rest period, and the constant nibbling and trampling eventually removes even the root-stock. (21)

It is difficult to set a figure for the number of range acres needed to sustain a cow for a season in Arizona. The figure varies from 10 acres in some parts of the state to as much as 50 acres in other sections. Studies of the range in each particular area offer the only way to determine such a figure.

Climate plays a great part in over-grazing. A drought will render a range incapable of carrying stock, where before the dry season it could support many head.

Leasing of grazing land on a short term basis will also serve at times to cause a stockman to get as much out of the land as possible during the period he has it, leaving it in poor condition and over-grazed to an extent that it will take years to correct. (1)

These and many other reasons cause over-grazing but it cannot be ignored that the main reason, in most

cases, is simply over-stocking of the ranges.

In simple terms, the over-grazing removes the cover which holds the soil and the land is then liable to erosion. Over-grazing is indicated when there is a predominance of non-edible plants on the range. Stock will leave these and graze the preferred ones, leaving seedlings of the non-edible plants as the dominant plants of the locale.

2. Engineering Projects. Engineering projects sometimes furnish a strange cause of erosion and form a problem which is characteristic to the arid southwestern lands. Many times, in the building of such projects as roads, railroads, and canals, the builders, in order to facilitate their drainage, have made ditches, furrows and embankments by which they control the flood waters from our sudden, hard rains. In so doing, the builders have changed the natural course of the floods and have channeled several washes into one, so that when flood conditions do occur, more water is poured into one wash than can be controlled by its banks. Consequently, new channels are cut and new erosion takes place.

This practice would not be serious in a region where vegetation is heavy and would readily cover any exposed raw soil, but in Arizona it presents quite a problem. In many cases, old roads and drainage ditches have been

turned into gullies.

3. Burning Range Areas. Burning destroys the plant as well as the seed and, for this reason, ranges have often been burned to rid the locality of a type of growth which is considered undesirable. This is probably the cheapest way of clearing land at present but, in killing off the undesired vegetation, the desired vegetation also is often killed and the land is then subject to erosion. It may be noted here that any type of vegetation that has a root system is prevention against erosion. This vegetation may be weeds or undesirable forage plants, yet its roots give the life net to the soil. When undesirable plants are destroyed, they should be at once replaced by desirable plants.

The foregoing statements on the causes of erosion have concerned the range areas of the state. As approximately one-seventieth of the state is farmed under irrigation, it would be well to look now into some of the erosion problems peculiar to the farmer of irrigated land.

It is true that the top soil of much of the irrigated land in the state of Arizona is very deep, but with the type of tillage we now employ, farmers do not till to a depth of over three feet. The upper part of the top soil contains the bacteria and air in which we are

vitally interested. The causes of soil depletion in irrigated lands are listed below.

1. Irrigated Land Not Level. The term "level land" does not imply land that is perfectly level, but means land that has the minimum fall from the irrigation ditch to the end of the field. It also has the minimum side fall. This fall and side fall is usually .1 to .5 of a foot per 100 feet, according to the Soil Conservation Engineers (32).

In irrigating land which is steep, there is a great deal of movement of soil by water and the water does not accomplish its fullest purpose.

2. Leaching the Land with Excessive Water. By running too much water over the land, the soluble salts can be washed away. These are necessary to maintain the fertility of the land. This method, however, can also be used to remove the excess of those kinds of soluble salts that are harmful to plant growth, such as alkali.

3. Not Contouring Land. In new land where the slope is steep and the farmer does not possess the investment necessary to level the land, many fail to follow the natural contours of the land in tilling and in making the land ready for their crops. This brings the same results as the practice, in a rainy country, of running the crop

rows directly up and down the hill, each row turning into a gully of its own.

4. Poorly Constructed Ditches. Ditches which break have caused much soil washing in irrigated lands. This is not always, however, the fault of poorly constructed ditches but may be caused by rodents (gophers) and by mechanical means.

5. The Continued Use of the Same Land for the Same Crops. In many parts of Arizona, irrigated lands have been planted year after year with the same crop. This is especially true of cotton. The same crop, planted in successive years, tends to remove from the soil, the same plant food each year until that particular food is exhausted. This soil depletion in time becomes so excessive that the soil is unable to support plant life and is then easily eroded. It is "worn-out land".

6. Burning Stubble. Much soil depletion is caused by the farmer who does not return to his land the available organic matter. The main reason the farmer does not do this is that in retilling the soil for another crop or season, the old crop has a tendency to impede his cultivation operation. As a result, he often burns it and, in so doing, takes away available fertility for the soil.

Contrary to the old belief that burning stubble leaves an ash that adds to the fertility of the soil, burning destroys more plant food than is left in the ash residue. (13, p.137)

7. Not Putting the Land to Its Proper Use. Much land has been cleared for cropping that should have been used for other purposes or left in its natural state. This land was often later abandoned when cultivation proved economically unfeasible. The land was then left in such condition that there was no vegetative covering to protect the soil from erosion.

8. Economic Reasons. Economic factors often offer important reasons for soil loss but they will be touched upon only briefly here. Short term leases tend often to promote the idea to the leasee that he should get as much from the land as possible in the short time it is in his possession. (1)

Over work of the land means loss of fertility. Two or three crops a year, of such produce as vegetables, are too much for the land to produce, unless a long-range plan for keeping up its fertility accompanies this intensive use. The high price of a certain crop will often cause farmers to get as much in immediate returns from the land as possible, without giving thought to the future.

On the other hand, the low price of a farm commodity will, also, cause a farmer to adopt the "don't care" attitude and to allow his land to run down and let weeds sap the fertility of the soil.

Results of Soil Erosion. Soil erosion and loss of soil fertility have many far-reaching effects upon the lives of men. The first in the series of results from these conditions is plant starvation, the inability of soil to maintain plant life because the top soil has been depleted or removed. This, in turn, causes loss of production. The grass that grew to a horse's shoulders in the past is now only a few inches in height. The land is abandoned, and we have ghost ranches and farms which soon result in ghost towns.

The people migrate; taxes are not paid; schools close; depression engulfs the area. The land is sick, large sections are destroyed and hundreds of years will be needed for its restoration to fertility. Instead of fine homes, prosperous ranches, well-fed people and sleek stock, the country becomes a place of vacant homes, broken fences, empty fields, unsightly gullies, barren soil and dust.

The rivers run thick with moving soil. Washes deepen into canyons and rills become gullies. The soil moves downstream to silt reservoirs. Storage capacities

are impaired and, as a result, much irrigated land is no longer in use because of a dearth of water.

How to Combat Soil Erosion-----Grazing Lands. The prevention of soil erosion is not something about which to become highly enthusiastic for a year or two, expecting then to sit back and watch the labor and enthusiasm of that period bear fruit.

The prevention of soil erosion is as continuous a process as planting and harvest; as continuous as fall round-ups, as the shearing of sheep and lambing; as continuous as life itself.

To prevent over-grazing, a simple answer would be just to cut down the number of stock grazed upon the ranges. However, if conservation means to use our resources to their best advantage without destroying them, then the answer to over-grazing is not simply a reduction of stock now on the land.

The ranges of Arizona come under two classes, those which can be used the year around and those where grazing is seasonal. (21) From these two types of range, we wish to secure and to maintain the highest practicable range forage and livestock production. For the year-round grazing area, to prevent over-grazing, there is needed:

1. A rotational grazing plan whereby the same land will not be grazed continuously. Constant nibbling

will spoil and prevent the growth of vegetation which, like animals as well, needs a rest and a growing period.

2. Leave at least one-fourth of the seed stock or plants ungrazed is recommended by the Forest Service (45, p.9). This will help keep down soil evaporation and help the plant use available moisture. Rain water can more easily be absorbed instead of running off and reseeding will be insured.

3. In areas where erosion is now very bad, no grazing should be allowed and steps should be taken to reseed or replant the area to prevent further erosion.

4. Reseeding areas that will support more stock should be part of this plan.

5. Development of watering places for stock should be increased in well-distributed areas where stock will not be forced to travel the same route to and from water.

For ranges grazed on a seasonal basis, it is recommended by the Forest Service (45, pp.10-17):

1. Begin the grazing only when the new growth of grasses and vegetation is sufficient to support stock. In other words, allow the forage to get into full leaf before turning stock in upon it to feed.

2. Leave at least one-fourth of forage plants ungrazed to allow for reseeding.

3. Allow part of the range to rest entirely each year.

4. Reseed the damaged or over-grazed portions of the range.

5. Develop adequate watering places.

Ranges can be restored and improved. This has been proved by our government and state experimental stations. The Southwest Forest and Range Experiment Station near Tucson has shown conclusively what can be done to heal sick ranges in Arizona. Buckhead Mesa, near Payson, is also a good example of this.

Many a stockman has found that different breeds of stock produce better on a given range. By improving the herds, also, the actual numbers can be cut down, with no great difference in beef production. Good range management leaves a margin of productiveness of forage crops to take care of drought years. There is little we can do about the weather, but we can plan to make the best of it.

Range improvement is a big field and those people who manage the ranges should become thoroughly acquainted with all the problems and preventive measures necessary to prevent undue soil loss.

The burning of range areas should be absolutely prohibited unless the area is immediately replanted to a

forage or tree crop. Fire prevention by the United States Forest Service induces protection of its range areas as well as its forest areas. Areas containing stands of timber should never be burned under any circumstances. Many timber and grass fires are started by people who do not realize how important it is to follow strict fire prevention practices when they are using an area during fire season. Campers and smokers are the main cause of these preventable fires.

How to Combat Soil Erosion-----Irrigated Lands. There are many practices for the operator of irrigated land to follow in order to prevent erosion and soil depletion.

1. Level land is the greatest asset to the farmer using irrigation. Level land conserves water, man power, farm machinery, and most important of all, land itself. Most of the now irrigated valleys were at first comparatively level to the eye, but when water was turned upon the land, it was found that the eye was a poor leveling instrument. Many a fruitless hour has been spent on leveling land so that it looks level to the person doing the leveling. The proper method is to have the land surveyed to determine which are the high and low spots. Leveling should be carried out by machinery run by a skilled operator to grade stakes placed by the surveyor.

The United States Soil Conservation Service will do the surveying job for the farmer. Leveling often requires large and heavy equipment in order to do this job properly.

The slope to which land is leveled depends upon the soil and upon the natural contour of the land, as well as the crops to be raised upon it. Row crops such as cotton and maize, do not need the sidefall leveling which border crops require. Sidefall leveling is leveling so that the water will not run to one side of the border but will spread uniformly over the land between the borders.

Most of the land in the irrigated sections is so set up as to be irrigated in 40 acre tracts. Each tract has its own entry ditch and drainage ditch. Entry ditches should be so situated that all the acreage under the ditch can easily be reached with flowing water.

As has been stated before, a slope of .1-.5 of a foot to 100 feet is desirable for a well-irrigated farm. Maximum use of water with minimum loss of soil comes from an almost perfectly level tract of land.

If the land cannot economically or physically be leveled, the next best plan is to contour farm it. Contouring means simply to so prepare the land for crops that when water is turned upon it, the water will travel the longest distance possible before draining from the land. This is accomplished not by following the natural

slope of the land, with rows or borders, but by keeping each of the rows or borders as level as possible and yet cover the land. The contoured field looks a great deal like contour lines on a map. Very seldom will the water-control berms and rows be straight. Contouring is the best method of preventing washing of the soil on sloping land.

2. Many farmers strip crop their land, which simply means to plant a crop such as grain or alfalfa between strips of corn or some such row crop, so that if soil is washed away from the cultivated crop, it is caught and held by the grass crop. Many farmers have adapted this procedure here by having a strip of grass (Bermuda) across the section of each field where drainage occurs. This strip serves to stop and hold any washing soil. A good criterion to follow is that if the waste water from a given field is clear, not muddy, then no washing of the soil is taking place.

Gullies can be healed by leveling methods or by filling and planting to grasses, which will not allow washing of the soil.

3. Stubble tillage is the incorporation of the residue of a crop into the soil instead of destroying it by burning. Through this method, some evaporation is prevented and some fertility is turned back into the soil.

In heavy stubble, this can be best accomplished by cutting the stubble several times with stock cutters and then incorporating it into the top soil. Animal manures and green manures, that is crops not harvested but turned back under the soil, are also excellent ways to bring fertility back to the soil.

4. The proper use and placing of ditches, both entry and drainage, is of great importance to the farmer in soil conservation. Entry ditches should be tiled or lined with concrete, but this is a very expensive process. If they are not cemented, the next best thing is a "grass ditch" or one whose banks are covered with grass so as to prevent a great deal of washing in case the ditch bank does break. Gopher and rodent control is also very necessary in earthen ditches because a single two-inch rodent hole, if found by water, can soon become a six-foot ditch break. Grass-banked ditches can be fenced and serve as supplementary pastures in many cases, thus having a dual purpose.

5. The correct use of land under irrigation is also a factor in soil conservation. Land that is not level is best suited to row crops while land that is level is better suited to flood irrigation. Rough land can also often be developed into good pasture land instead of used for crops.

6. Terracing is the practice of leveling off strips of land on the contours of steep slopes in order to conserve water, to prevent quick run-off of water and consequent erosion.

7. Leaching of the soil can be prevented by not allowing excessive amounts of water to run through a field.

8. Commercial fertilizers can be used to improve the fertility of the soil so as to get better production with the least amount of soil loss. These should be used, however, only after a complete soil test by a competent chemist and with full knowledge of what crops the farmer intends growing on the land tested.

9. Crop rotation is the growing of different crops in succession on the land. Crop rotation can be done by the strip crop method or by seasonal rotation of the entire field. This helps in preventing the complete depletion of one type of plant food in the soil.

Some causes of soil erosion, of course, stem from economic factors. These can be prevented first, and best, by the owner operating his own land. If this is not possible, it is wise to give a tenant a long term lease with provisions in such leases as to the type of crops to be raised and the conservation practices to be followed. This should be coupled with constant efforts to show

tenants that such practices do pay dividends for him and, with close cooperation between tenant and owner, to meet market demands with crops.

Arizona has much work in store to meet the needs of a soil conservation program. It must also be realized that the development of new and scientific methods in range management and farming will be needed to meet such a program. New breeds of cattle, new strains of seed, new methods of water control in irrigation as well as new sources will aid also in solving our particular problems.

The people of Arizona must also realize that conservation practices in range management and soil erosion are paying methods. Many farmers can ascertain for themselves, from their own experience, that land leveling, for instance, really pays. They find the money spent in leveling their lands returned to them in extra returns on crops within a few seasons.

The rancher and farmer must also realize that there is no substitute for knowledge of the business in which they are engaged. So many people believe that farming and stock-raising are gifts of all men and that anyone, whether city or country raised, can become successful in these lines. The contrary is true. The successful farmer and stockman today are scientific men in their fields and a pair of boots and a ten-gallon hat do not

make a rancher any more than mere possession of land and equipment turns any man into a successful farmer.

Land owners can begin and carry through a program of soil saving but they need a great deal of technical advice and assistance. Much can be obtained from agencies such as the United States Soil Conservation Service. This Service has at its disposal and for the assistance of land owners, trained scientific personnel, soil surveyors, engineers, agronomists, range conservationists, foresters, and others. This organization is to help the land owner solve his particular problems and is not designed in any way to dictate to him the way he should operate his farm.

In 1941, the Legislature of the state of Arizona passed the Arizona Soil Conservation District Law, which was amended in 1945. To quote Section 75-1702 of this law on the Declaration of Policy: (6)

> It is declared to be the policy of the legislature to provide for the restoration and conservation of agricultural lands and soil resources of the state and the control and prevention of soil erosion and thereby to preserve natural resources, control floods, prevent impairment of dams and reservoirs, preserve wildlife, protect the tax base, protect public lands and in such manner to protect and promote the public health and general welfare of the people.

This law made it possible for the farmers to organize Soil Conservation districts which have at their

disposal all of the resources of the Soil Conservation Service. This Act laid the foundation for applying to the land all the information and technical advice available for soil-saving, prevention of soil erosion, and for better returns and production from the land. It is definitely a step in the right direction and deserves the full support of all people in the state, no matter what their occupation. Without a prosperous agriculture, Arizona cannot remain a prosperous state.

Mineral Conservation

Minerals, unlike other natural resources of Arizona, are not renewable. We can bring back our forests, improve our water supply, and restore our game by good management, but not so with minerals. Minerals are a great deal like a checking account in the bank. We can draw upon it until it is gone, and then there is no more. However, some minerals, unlike other resources, once mined and manufactured can be used over and over again, and do not lose their value except for that small portion which is actually worn away or lost in the reconversion process.

Minerals play an extremely important part in our lives. We have only to look around us at any time of the day or night, at home or at work, to see the many and

important uses of metals. The possession of metals makes us a strong nation and, more than that, the possession of a well-balanced supply of minerals makes us strong. For example, we have iron and the coal with which to smelt it while Brazil has a great deal of iron but no fuel to convert it into usable forms.

Arizona's economy is closely tied with her mining industry. A glance at a mineral map of the state (2, p.1) will readily show that the state abounds in mineral wealth. The income from minerals in the state over a period of years is tremendous. From 1874 to 1945, the production of copper alone was $3,214,481,000. Gold income from 1858 to 1945 was $268,993,000 and silver production income from 1858 to 1945 was $213,053,000. The total production of metallic and non-metallic metals up to 1945 was $3,847,000. This is not a complete figure since records have not always been correctly kept, and in some cases do not go back further than 1858. In 1949, according to the Valley National Bank (53, p.1), the estimated state income from metals was $177,000,000 while the agricultural income for that year was estimated at $235,000,000.

Non-metallic minerals are clay, asbestos, feldspar and the like while metallic minerals are gold, silver, copper, iron and others.

Competition with foreign markets, the supply and demand and price of metals, as well as restrictions of the Federal Government all join to determine the amount of minerals produced in a given year in the state. Arizona has many large bodies of low grade ore which are not practical to work unless the demand for, and the price of the product is high enough to make the operation of such mines profitable. Many of the state's mines are also producing more than one metal. For instance, a copper mine may also produce silver or some other metal in addition to copper.

Using the Tenth Annual Report of the Department of Mineral Resources (12, pp.1-11) as our authority, we find that the mineral and non-mineral production picture in Arizona is as follows:

Gold and Silver. The state produced 107,000 ounces of gold and 4,720,000 ounces of silver. Prices, per ounce of gold, are set at $35.00 and for silver at $0.91 by the Treasury of the United States. There are only two or three mines in Arizona that produce gold and silver, or silver alone. These mines can only operate at the above rate because their ore bodies are large enough to permit the use of cheap mining methods. The largest per cent of gold and silver produced in the state is produced as a by-product of the copper and lead mines.

Copper, Lead and Zinc. In 1948, Arizona produced 744,000,000 pounds of copper. This was the greatest production since 1943. Copper sold at 23½ cents a pound but, in the latter part of the year, dropped to 18 cents a pound. Copper is, by far, the most important metal mined in the state. Many communities owe their whole existence to the copper mines. When a copper mine is exhausted, so is the town adjacent to it. Some of our Arizona towns are definitely losing ground today while others are gaining, because of new and important ore discoveries near them, or because of new methods of working ore bodies.

Mines of Arizona produced 58,000,000 pounds of lead in 1948 and, with an increase in the price of lead to an all-time high of 21½ cents a pound, the income of the state from lead was 25 per cent higher than for the previous year. This made it possible for many small lead mines to operate at a profit. In 1947, five large lead mines had produced 86 per cent of all lead mined in the state.

The zinc production of the state in 1948 was 107,500,000 pounds but the price of zinc dropped from 17.5 cents per pound until it had reached about 10.5 the first part of 1950.

There is little activity at present in the

manganese, tungsten and mercury mines of Arizona. In fact, the low cost of foreign mercury has driven practically every mine in the state out of business.

There have been some few developments in a pegmatite area north of Morristown.

As far as non-metallic metals are concerned, there has been a great deal of recent activity in the asbestos mines. Non-metallic minerals such as mica, pumice, perlite, nata, flagstone, gypsum, feldspar, florspar, marble, rock wool, onyx, bentomic clay and silicate sand are all being produced in the state in varying amounts. Most of the non-metallic minerals are used in building materials, cleansing powders, in agriculture, and in ceramics. Flagstone has become quite a popular building stone. The most intensive development in the non-metallic line, however, has been the opening of the new Arizona Portland Cement plant at Rillito. The plant will have a capacity of 4,000 barrels per day and will add a great deal to the mineral income of Arizona.

In the past year about five new uranium mines have been opened in Arizona. These are on the Navajo Indian Reservation. At present, these mines are producing about 200 tons of ore per day which is sold to the Atomic Energy Commission of the United States. Arizona now runs second only to Colorado in the production of uranium ores.

Since mining, especially copper mining, is a large industry in the state, it is naturally an employer of many men. It furnishes the livelihood of many families in Arizona, both directly and indirectly. Just as Flagstaff and McNary are dependent upon the lumber industry, so are Ajo, Globe, Miami, Superior, Douglas, Bisbee, Ray, Morenci, and other communities dependent upon mines and mining for the healthy economy of their communities.

The mining industry also pays a large share of the state's taxes. Tax statistics of the state show that more tax income is received from mining than from any other one industry in Arizona (12, p.12).

The use and demand for minerals constantly change. During the last war, it was found that there was a need for some minerals that had been in very little demand up to that time. As an example, in 1939, there were only seven minerals listed as strategic. Yet, in 1942, this list had jumped to 53 (13, p.431). Copper itself, a few decades ago, was not used industrially in great amounts yet, with the advent of modern electrical devices, it has become greatly in demand.

It must be realized that minerals, once removed from the soil, are not replaceable like some other resources. They do not grow. There are very few mining communities that are stable for more than an indefinite

number of years. Unless these communities can develop some other form of support to supplement mining and, perhaps, to replace it when the ore is exhausted, they eventually become ghost towns. Wickenburg is a good example of a town that originated because of a mining discovery in the vicinity. Henry Wickenburg developed the Vulture mine and the community named for him sprang up on the Hassayampa River banks to accommodate the mine and others in the vicinity. After the mines were worked out, the alert citizens of the community, together with the location of the town on cross-country highways, soon brought it back, as a dude ranch center. On the other hand, there are mining communities in Arizona that are not so fortunate in converting from mining and which are losing their prosperity at a high rate.

There are many ore bodies that will last for a long time and there are others retaining only a few more productive years. The fact remains that a permanent community cannot exist, dependent upon mining, except where there are vast bodies of profitable ore. The amount of money that is spent in a mining community which, for the time being, benefits the entire state in exchange of services and goods, cannot be depended upon to last for years to come, as is the case with the income from agriculture. Our problem, then, is to make ores last as long as

possible and thus to insure the state against a severe economic set-back when mines close and communities decline.

Although it is true that minerals are not a replaceable asset to a state, so it must also be realized that they are of no value to a state or nation unless utilized. Therefore, we need stock piles of minerals, looking toward future national emergencies, whether such stock piles be underground, in the natural state, or mined and stored.

The economic value and availability of minerals vary. Our supplies of stone, clay, sand and minerals of this sort, are so abundant that there is little need for conservation. But, in the case of such metals as lead, zinc, gold and silver, we already know that in some sections, they have been completely exhausted.

Conserving Minerals. The conservation of minerals may be accomplished in several ways.

1. In all types of mining, there is a certain percentage of waste. Every car of ore that comes from the mines should be used to its maximum. That is, all the minerals in it must be extracted. In the mine itself, all the available ore-bearing rock should be worked out and not picked over in order to use only the best ore. If the

lower grade ore is left for future utilization, it should not be left in such a state as to prevent salvage. At the smelter, or concentrator, metals that are mixed with useless minerals and are discarded for that reason, cause a considerable loss in getting the available minerals from the mined materials. Many times, the known processes for separation are too costly for this separation to take place. Here new methods, discoveries and inventions are needed in order to accomplish this task in the most economical manner possible, thus conserving minerals.

2. When the minerals are made into the finished product, the most economical use of that finished product will also serve to stretch our ore supply. Minerals should be put to their correct use. If hard steel is needed on a job, it is poor economy to use pig iron. In other words, each mineral should be used to the best advantage where it will give the longest life to the product in which it is incorporated, and thus will perform its greatest service.

3. Many minerals can be used over and over again. Copper is a good example of this. In 1945, scrap copper amounted to 1,006,506 short tons, while our national production of new copper was only 772,000 short tons for that year (13, p.455).

4. State and National governments, after

complete study, have formulated a set of mineral conservation laws which will insure the best use of those mineral resources which we still possess.

5. The discovery of new deposits of ore always helps in meeting the demand and helps conserve our resources. For example, at present, we are getting all the oil possible from Arabia because we see the possibility of a shortage of oil in our own country. We are not purchasing all the copper possible from South America because our own supply of copper shows no present signs of diminishing to a level at which we need to husband it.

Constant application of scientific developments to mining will make it possible to stretch what minerals we have and to use only the part that is needed. Better mechanical devices for mining will make the development of low-grade bodies of ore possible.

6. The use of substitutes for scarce metals will help a great deal in mineral conservation. In a modern world, in fact, plastics are already replacing metals in many commodities we use.

7. Conservation in the use of strategic minerals is necessary. Many items can be constructed with substitutes and by good planning as to shape and structure of any device using scarce metals.

Forest Conservation

The state of Arizona, when considered as a home for various types of vegetation, should be divided into three parts, as stated by Nichol (22, p.184).

1. Desert Vegetation, which occupies 42 per cent of the state.

2. Grass-land, which covers 25 per cent.

3. Forest, which accounts for the remaining 33 per cent.

The forest area is sub-divided into chaparral, growing in eight per cent of Arizona, pinon-juniper in 17 per cent, and Douglas fir-yellow pine in eight per cent. The Douglas fir-yellow pine section is known as the forest proper and is recognized as such by the majority of people.

The forest proper occupies the higher elevations, usually above 6,000 feet. Ponderosa pine, or yellow pine, is found as low as 5,000 feet in the Bradshaw mountains but, in most sections of the state, it does not achieve an abundant growth in elevations less than 6,000 to 8,000 feet. The high mountain peaks, 8,000 and above, support fine stands of Engelmann spruce and cork-bark fir. In the transition zone, between the yellow pine and the spruce-cork bark fir area, is found the Douglas fir. (22, p.185)

The yellow pine forests make up the largest and most economically important forest in Arizona. (22, p.187)

The pinon-juniper area extends roughly from elevations of 4,000 to 7,000 feet, depending upon the locale and is of little commercial value for timber and timber products with the exception of fire wood, fence posts and the famous pinon nut. Many tons of these nuts are gathered by the Indians for their own use as food and for sale to whites.

The chaparral area, or brush thicket area, 4,000 feet and lower, is of no commercial value as timber but, as with the other sections, it shelters and encompasses valuable grazing lands (22, p.188).

This section will be concerned primarily with the area known as the forest proper but some information will also be given on the pinon-juniper section.

National Forest Facts says (42, pp.8-9) that in Arizona, there are 4,638,000 acres of saw timber. A considerable amount of this acreage is inaccessible and too scattered for logging purposes, or is withdrawn from cutting because it is in a National Park or Monument. The actual area of commercial saw timber in the state is 2,815,000 acres. This is broken down as follows:

National Forest ----------2,058,000 acres

Indian Reservations ---------- 686,000 acres

State of Arizona lands -------- 30,000 acres

Private lands ---------- 41,000 acres

The estimated volume of commercially valuable timber in the state is 16,270,000,000 board feet.

Out of the area occupied by this commercially-valuable saw timber, 1,969,000 acres are virgin timber and 846,000 acres are cut-over land which has been logged at least once.

Four species of tree make up 98 per cent of the sawtimber stand.

Ponderosa Pine ---------- 32 per cent.

Douglas Fir ---------- 10 per cent.

White Fir ---------- 3 per cent.

Engelmann Spruce ---------- 3 per cent.

The Douglas fir of Arizona is a smaller tree than that of the Northwest. Its size, inaccessibility and small acreage in each stand make it relatively unimportant to the timber industry of Arizona. The main commercial timber tree, therefore, in the state is the Ponderosa pine.

It should be of interest to trace the production of lumber in Arizona through a period of years. (48, pp. 136-147)

Year	Board Feet
1869	1,200,000
1879	10,715,000
1889	5,320,000
1899	36,182,000
1904	55,601,000
1912	76,287,000
1918	82,511,000
1925	145,609,000
1935	100,001,000
1940	128,776,000
1942	143,286,000
1946	240,735,000

There are eight United States National Forests in Arizona. They are as follows: (42, pp.2-5)

National Forests	General Location
Apache	White Mountains
Coconino	Area around Flagstaff and Oak Creek
Coronado	Scattered areas from Tucson to the Southeast corner of the state
Crook	Mt. Graham-Ft. Grant area
Kaibab	Surrounding Grand Canyon and near Williams
Prescott	Area around Prescott, Clarkdale and Jerome

Sitgreaves	Along Mogollon rim, McNary and Heber
Tonto	Stewart Mt. to Pine, including Roosevelt Dam.

The forests of the state of Arizona are very valuable from the income-producing standpoint. Many men derive their total income from the forests and their products. This includes the logger, mill worker, United States Forest Service employee and those employed in many allied occupations which depend wholly or in part upon the forests to exist.

The income from timber and timber-products sale in the state totaled about $835,000 in 1948 (42, p.11). At the rate of $4.32 per thousand board feet, it can readily be seen that the processing, transporting and re-sale of the finished product would increase the figure many times.

Arizona lumber retails at from $50.00 to $110.00 per thousand feet. Thus, it becomes apparent that the sale and processing of timber and timber-products in Arizona is a large scale business and very valuable as a source of income to the people of the state.

Such Arizona communities as Flagstaff, McNary and Williams owe the major portion of their income to the workings of timber and timber-products. Very interesting, beside the figure given above, is the fact that residents

of Arizona were given 4,958,000 board feet free, (42, p.11) because of the policy of the Forest Service under which residents near or in the National Forests are allowed free timber for fuel, fencing material, building and other domestic uses.

Besides the sale and use of timber and timber-products, the forests have other tangible values. One of these values is the protective influence of the forest. Forests protect the watersheds against erosion by wind and water. Forests have a tendency to regulate the flow of water from the watersheds in that they retard the swift run-offs and thus effect control on flood conditions. The protective value of forests if measured in dollars and cents, would be as high as the proceeds from the sale of timber products. Many of our watersheds are covered with a non-commercial type of forest which acts in a protective capacity quite as well as does the commercial type.

Many acres of land within the boundaries of the Arizona National Forests actually have no merchantable timber growing upon them but their value as grazing lands, watershed protective areas and recreational use is justification for their inclusion therein.

It is a well-known botanical fact that the roots of plants help a great deal in forming new soil

through chemical and mechanical action. Larger stones and rocks can be fractured by the growing tree and the fragments thus produced broken, and broken again by root and trunk action until soil is formed.

With the humus from the decaying leaves, trees and roots added, trees are therefore actually capable of forming new soil. This is a slow process, of course, but is a definite addition to the other soil-building agencies that exist.

Private forests also bring appreciable amounts of revenue into the state and local treasuries in the form of tax money which can be used in giving us some of the improvements in governmental services that are always needed. Business associated with timber production also pays large taxes and thus aids in supporting the state. These industries and establishments include sawmills, logging equipment retailers and wholesalers, and even the real and personal property represented by the towns that owe their existence to lumber and lumber-stemming industries.

The United States Forest Service, by law, returns to the counties in which the forests are located, 25 per cent of the receipts of each forest in lieu of taxes. In 1948, this amounted to the sum of $228,687.21 in Arizona which was a welcome addition to county treasuries. (54)

There exist some values of forests upon which we cannot quite place a price. These are the so-called "intangible values" of forest lands. One such value is recreational, in which the forests afford such pleasure to an ever-growing number of people. Residents of Arizona and visitors from other states make use of the National Forests for recreational purposes. It may be only a family picnic into the woods or it may be a summer camp-ground maintained by the Forest Service which hundreds of people use during each season. Each type of use offers a great deal of rest, relaxation and recreation to users of the forest lands.

Such sports as hiking, skiing, camping, hunting and fishing are recreational pursuits for many people and often owe their existence to the fact that there are still forests and forest lands. Many people from the lowlands of this state have found that summer home sites in the mountains offer a place to seek relief from the summer temperatures. Forests also provide homes for much of our wild life.

A forest value which is seldom stressed yet is certainly one not to be over-looked is, perhaps, purely esthetic. Men enjoy trees--their shapes and colors. This is a permanent and constantly renewed value as growing season and foliage and flowers change. Thousands of

songs, poems and essays have been written with trees as the subject. This brings us to another value of our forests which is closely allied with the appreciation of its beauties. This is the value of forests from the standpoint of study. The State College at Tempe has a course of nature study each year that is carried out in the Tonto National Forest. The University of Arizona and the United States Department of Agriculture carry out many technical studies in the forests of the state.

The values of the forests as ranges for stockmen to use in summering their herds and flocks can hardly be exaggerated in discussing the reasons for forest benefits in the state of Arizona.

Causes for Loss of Timber. It is customary to classify the losses of timber in a given area as natural losses or losses from natural causes and as losses caused by man.

Under the classification of natural losses, the first and foremost of them is from fire; fire that starts from natural sources, lightning and spontaneous combustion. These natural causes account for only one out of every 10 forest fires annually. (39, p.6)

Forest fires destroy not only the tree growth but burn the humus in the soil as well, causing a great loss from the timber burned and leaving the scarred land

open to erosion and consequent destruction.

There are two types of forest fires, surface fires and crown fires. Crown fires are those that are driven by winds and rise in such a manner that the flames leap from tree top to tree top in great tongues of flame that are almost impossible for man to control from the ground. Surface fires burn along the ground in the under-growth and litter and finally reach and consume the tree from below.

The crown fire is the faster of the two, but a surface fire may become a crown fire at any time through the rising of a sudden wind, or a crown fire drop to a surface fire when the wind dies. In some cases, surface fires do not gain sufficient momentum and the trees are not badly burned. Only the under-growth and litter are destroyed. In many cases, however, the trees suffer such damage that their resistance to disease and insects is lowered and even if the fire itself spares them, they soon fall prey to other enemies.

Insects and diseases of many kinds may gain a foothold in a forest without being a result of fire. Forests usually contain pests at all times which attack the trees with varying success and there is very little that man has discovered to do for these chronic conditions. However, often the diseases or insects seem to have an

upsurge of energy or numbers and attack a stand of trees in what amounts to a forest epidemic.

The total effect of tree diseases and insect losses exceeds that of fire. (44, p.2) Much money and time have been spent in attempted control and eradication of the pests and diseases, but a great deal more needs to be done in order to combat them effectively. Some of these dangers to forests only maim and cripple the trees, without killing them, but they ruin the wood for use by human beings.

Some causes for loss from disease and insects are listed here: (44, p.30)

Type or species of disease and insects	Important timber species most affected	Kind of disease
Tip moth	Ponderosa pine	Kills buds
Bark beetles	All conifers	Several species are normally present that seldom cause extensive losses but do kill a few trees in the stand each year
Stem rusts	Ponderosa pine	Attack saplings, seedling and poles. Reduce stocking or rate of growth
Dwarf mistletoes	Ponderosa pine Douglas fir Lodgepole pine	Decrease rate of growth. Predispose to beetle attack or sometimes kill directly

Cankers	Aspen	Cause stem defects and culls
Heart rots	Aspen, Ponderosa pine, Engelmann spruce, Douglas fir White fir	Result in heavy cull in many areas
Root rots	Ponderosa pine	Weaken trees, making them subject to beetle attack. In places cause understocking in reproduction

The losses to our forests which are caused by man are staggering. Ninety and seven-tenths per cent of all the fires started are started by man's carelessness. The national breakdown, according to Guise (13, p.245), of the total fire causes is:

1.	Smokers	25%
2.	Burning debris	24%
3.	Miscellaneous causes	14%
4.	Lightning	9%
5.	Campers	6%
6.	Railroads	4%
7.	Lumbering	2%
8.	Unknown	7%

In Arizona in 1948, a total of 21,027 acres was burned over. (42, p.5) People who used the forests are responsible for all except a very small proportion of these fires. They are carelessly destroying their own

heritage.

Not all losses, however, result from fire, disease and insects. Much fine timber has been needlessly destroyed through poor cutting practices.

From information given previously in this chapter, it can be seen that about 1.07 per cent of the forests in the state of Arizona are owned by the state and 1.6 per cent is owned by private individuals or companies. This means that nearly 97 per cent of the forests of the state are Federally owned and are under the jurisdiction of the United States Forest Service or of the Indian Service. This also means that the majority of timber lands (under Federal Control) are being handled according to the best known cutting practices. This has not, however, always been the case in Arizona. The United States Forest Service in Arizona was not in existence during the early history of the state. In fact, the first national forest of any type was established in Arizona on the 17th of August, 1898. (42, p.1) This new forest was in no way as completely supervised and managed as are the national forests of today.

> "Mining required large amounts of timber. Most of it was cut from trees growing on the mining claims or from the nearest body of timber and was then hewn into shape by hand. In 1865 a portable saw mill was set up just south of the present site of Prescott. Saw mills were in

> operation over most of the timber lands until about 1906. By then practically all of the mature timber had been cut." (43, p.10)

Miners, railroads, and building construction took a great toll from the forests of Arizona. There was plenty of timber in Arizona then to meet the state's needs, but the lack of any extensive transportation facilities within the state caused too much timber to be cut from areas contiguous to operations.

Arizona has been very fortunate in timber protection since very little timber has been cut to clear farms. But it has not been so fortunate from the standpoint of an over-grazed range. Over-grazing, besides destroying the grass, destroys the small trees or seedlings through trampling by the herds and by actual nibbling by domestic animals pastured. Over-grazing also helps in causing soil erosion which in turn robs the young trees of moisture and soil food. The fertile top soil is as necessary to a small tree as it is to the grasses.

Results of Timber Loss. When timber is lost either through natural or man-made causes, there are various undesirable results.

1. The loss of the product, itself. Timber burned or destroyed by pestilence is of no use to anyone.

2. The loss of soil which the timber protected causes erosion and gullied hills with resultant silting of our reservoirs. This, in turn, cuts our water supply for irrigated lands. Floods are also a by-product of this condition.

3. The loss of an industry and of taxable property which, in turn, causes the migration of people from a community and the leaving of ghost towns in the area.

4. The loss of the recreational and beauty values of a forest area.

Our forests are a part of our national wealth. Any loss to them is a loss to the people. They should be used and harvested just as any growing crop is harvested, but they should not be stripped of their productive power by mismanagement and by personal greed for immediate profits.

Preventing Forest Fire. There is very little to be done to prevent fires that start from natural causes, but these fires can be controlled. The use of modern fire-fighting equipment, which is portable and can be taken into very remote areas, is the best answer to the problem of controlling naturally-caused fires. A good network of forest roads and trails helps a great deal in fighting such fires. These roads and trails should be

kept open and passable during fire season. Some National Forests now maintain crews of trained parachutists which can be dropped immediately in the vicinity of newly started fires.

Communications such as radio and mobile telephone equipment play a large part in the fighting of present day forest fires. If a fire is too extensive for one man to handle it is possible for him to radio or telephone for additional assistance and equipment. A good system of fire spotters or lookouts also tends to minimize damage from uncontrolled fires since this arrangement gives the actual fire fighter an early report on the fire. The quicker a fire is located and reported after its inception, the more quickly it can be controlled, because all fires start from very small beginnings.

Fires caused by men are preventable. Smokers who are careless with burning tobacco and matches cause one-quarter of all the fires in our forests. Careless and thoughtless handling of matches and of burning tobacco can be prevented. There are a few simple rules to follow if you are a smoker on timber land. (39, p.8)

1. Be sure your match is completely out. Hold it in your hand until you can touch the burned end, and then break it in two before you throw it away.

2. Be sure that pipe tobacco, cigarette stubs and cigar butts are dead before you throw them from your hand. Do not throw burning tobacco out of the car. Use an ash tray. It is better not to smoke in the forests at all during the acute fire season. Smoking should be done only in camps and improved places of habitation.

3. In building a camp fire, first clear an area on the ground at least five feet in diameter. Then dig a hole and build your fire in this. Never build a fire against brush, trees or down logs. When you leave a camp site, be certain the fire is out. Pour water on the fire, mix the ashes and coals into a mud and cover with the soil dug from the hole. Remember that fires often creep underground for many yards, feeding on the accumulated pine needles and may break out far from the place you built the fire originally. So be certain your fire is <u>really out</u> before you leave.

4. When building fires to burn brush or undergrowth, first secure the permission of the local ranger or fire warden. Never burn on windy days and be certain to have adequate fire breaks around the area to be burned. Fire breaks are strips cleared of all natural material that can burn. These strips should be at least 40 feet wide.

5. In case a fire starts, no matter what the

cause, give all the assistance you possibly can, first by notifying the proper authorities and then by actually assisting in fighting the fire. Protect your investment in the nation's timber lands by helping to fight forest fires, if needed.

Equipment used in the forests for travel and in logging operations should be carefully and periodically checked for defects that could possibly start fires. Exhaust pipes and smoke stacks, if defective and without spark-arrestors, can easily start fires.

Complete vigilance at all times is necessary in order to check fires and remedy the causes of fires. Fire seasons in Arizona are in May and June, and in October and November of each year. May and June are the most dangerous months in this respect. High winds, accompanied by high temperatures and low humidity make the most dangerous fire weather. (47, p.17)

Disease and Insects. A great deal of research and experimentation as well as actual curative measures have been started in the control of diseases and insect infestations in our timber lands. These range from the cutting and destruction of the infected trees to the spraying of large areas with insecticides from planes. Another method is the destruction of growing organisms which act as hosts for the diseases that affect trees.

(Wild currant, for instance, is a pretty shrub with its orange berries, but it harbors a disease very dangerous to growing timber that does not affect the currant bush, itself.)

One of the most valuable ways in which the ordinary citizen can help in combating these pests is by refraining from carrying infested material from one area to another. This is a quarantine measure and can best be enforced by the people, themselves. The smuggling of innocent appearing plants through a state plant inspection station can result in an epidemic that may ruin the timber or fruit trees of a locale, and as a result, affect the economy of an entire area.

The use of hybrid trees and the planting of new varieties that are resistant to certain diseases also help, but the state of Arizona covers such a vast amount of land that this method is very expensive. Our best defense is to localize the infection and to avoid its spreading to other areas. Sprays such as DDT are very effective against insects and diseases but are also very expensive.

Our forests represent a growing crop and they should be harvested properly in order to obtain the best returns from them. A tree crop is exactly like any other harvestable crop. At a certain time, it reaches maturity

in growth and no matter how long it is left standing it does not improve. A tree crop does not mature all at one time like a field of wheat. Its maturation is continuous and needs to be harvested as the maturity is reached. One of the biggest problems in forest management is to harvest the trees in such a way that it does not destroy those still growing.

The answer to this problem is the selective cutting and the sustained yield program. Which simply means cutting only those trees from the forests that have matured, and leaving those which will develop into mature trees.

Instead of annual crops such as are produced by the farmer, trees develop into harvestable timber about every 60 years in the Southwest. (38, p.17) This would mean that if an area was cut over for mature trees this year, it would be 60 years before it should be cut over again. Through regulation of cutting areas around a community and by leaving 60 areas from which to cut, it is possible to set up a continuous yield project which will bring an even flow of timber into the mills and thus establish a stable economy, not only for the people employed therein, but for the other businesses dependent upon the timber. In the cutting, the diseased and undesirable trees should also be removed as well as the

younger trees thinned to allow better growth.

For sections of our state that have been badly cut so that regrowth has not started, re-seeding and re-planting are the best answer. The LeRoux Springs Nursery, in the Coconino National Forest, was established in 1936 with such replanting in mind, but it became a casualty of the second world war. (35)

According to Yochelson (54), when Arizona became a state in 1912, many acres of then Federal land was turned over to the new state. Some timber land was included in this transaction. The state at that time did not have trained men to manage and operate its forests, so it entered into an agreement with the United States Forest Service. This agency of the Federal Government administered the state forest lands and, after the expenses of administration had been paid from the receipts of the land, all remaining monies were turned back to the state. As a consequence of this wise move, the best known practices of forestry have been carried out on state-owned timber lands.

These lands include about 36,000 acres of timber, the proceeds of which, after administration, are earmarked for the University of Arizona. This acreage is under the sustained yield program of the Coconino National Forest.

The United States Forest Service also holds in trusts for the State of Arizona some 640,000 acres of land remaining out of the original state lands. From these, the state derives revenue in proportion to the number of state acres in comparison to the Forest Service lands. This plan of the United States Forest Service, by which it handles the scattered state lands, has proved very successful. In fact, it has been a model for forest management in other states. As a rule, the cost of sale, supervision and fire protection, has not exceeded 25 per cent of the total revenue from the lands and has been, in many cases, as low as three per cent.

The first line of forest protection and management, as in the protection of any resource, is a well-informed and well-educated public which is aware of the problems of forest conservation and realizes the need for conserving our forests.

Wildlife Conservation

In Appendix A of this paper are numerous comments made by early travelers and settlers, dealing with the abundance of wildlife in the area that is now Arizona. In fact, the grass which then supported much of that wildlife was the reason that so many cattlemen brought their herds into the country.

When we define conservation as "wise use", it would be foolish to advocate the idea that the large amount of wildlife existing during the pre-settler period should be maintained now. Deer, cattle and sheep eat the same type of food plants. We, as human beings, get greater returns from the cattle and sheep who fatten on the grass than we would from the large number of deer it would support.

Game management is a study in itself. Many men spend their lives in research and in experiment along this line. The findings of these men as to the type and amount of game that a region can carry without jeopardizing the agriculture, are the criteria which the public must follow in order to keep the balance between game and domestic stock.

Domestic animals do not fill the same need in the life of man that wild animals do. Wildlife is a natural product of the land and, as any other product of the land, it is to be harvested. This harvesting should be well-planned because man, in his invention of so many things, all capable of destruction, can easily overcome the natural defenses of wildlife.

In order to prevent the extinction of a species, game laws and game refuges are necessary. The story of the Merriam elk in Arizona is an example. This elk,

which was native to the state, was completely exterminated. Not a single known animal was left. The last Merriam elk was killed near Mt. Ord in 1898. (17, p.5) The elk that we now have are descendents of Montana stock imported into the state in 1913.

Values of Wildlife. The values of wildlife are many, whether they be fowl, fish, or other animals. Much of man's enjoyment and a good deal of his income come from wildlife. Some of the values which man receives from game and non-game animals are as follows:

1. Food. It would be hard to estimate the amount of food derived from wildlife in Arizona but, in 1948, there were 5,085 deer killed, 965 elk, 510 javelina and 160 wild turkeys. (42, p.23) This, added to the fish, quail, rabbits and all other edible wildlife killed would undoubtedly amount to many tons of meat.

2. Value to business. The sale of firearms, ammunition, clothing, fishing equipment, lodging, and camping equipment for fishermen and hunters amounts to a considerable sum each year. In all probability, only a small percentage of the people who were so outfitted actually took any game, yet the sale of the items mentioned above still amounts to a great deal of money. This money goes into the channels of trade and aids many people who never lift a gun or cast a fly.

3. Fur-bearing Animals. Fur taking in Arizona is not a highly profitable enterprise. At higher elevations, there is some fur trapping but the climatic conditions in the major portion of the state are not favorable to good fur growth. There were at one time many beaver in the state but they were trapped to almost complete extinction. Beaver trapping on a commercial basis is not allowed. Beavers now trapped are either taken for transportation to a more favorable site or are pelted by hunters hired by the state. The proceeds of the latter trapping go to the State Game and Fish Commission, under whose direction it takes place. (33)

4. Aid to Agriculture. There are many wild animals such as some hawks, owls, insectivorous birds, and some mammals which help agriculture by keeping down rodents and insects by eating weed seeds and by destroying various other pests which threaten agriculture.

5. Study and esthetic values. Many people care nothing about hunting but enjoy studying, photographing or just watching a herd of deer, a mallard duck and her brood, or a trout in a deep stream. This is a value to which we cannot attach a dollar sign. It is the recreational outlet of a person who can secure a great deal of pleasure out of natural wildlife and still have no desire to destroy it. These people contribute

to wildlife preservation through their taxes as fully as do those who engage in hunting or fishing except for the fact that they do not purchase a license to engage in these sports. From the study of wild animals, a great deal of information can be derived to be applied to the study of the human race.

All wildlife cannot be classified as desirable. There are animals which are predators on domestic or other animals. The mountain lion and the coyote are good examples. Both are being killed by government trappers but still manage to exist as a species, and there is reason to believe, in the case of the wily coyote, that they are even increasing in some portions of the state. The coyote is an animal that tests the ingenuity of man to the utmost in order to trap or capture him. A new poison, 1080, is very effective in the extermination of coyotes. There are those, of course, who believe that such is not desirable, basing this belief on the theory that any complete change of the balance of nature is undesirable and that the rodents killed by the coyotes should be considered in any program.

Wild animals can, of course, do a great deal of damage to range and forage crops. Many a rancher will agree to this. This is especially true with elk and deer in the northern part of the state. These seem to have

little regard for fences and possess a fine taste for fruit trees and domestic gardens. Insects, worms and birds also take a heavy toll from Arizona agriculture. Methods of control range from the use of rifles to DDT. Here again, in the case of birds, it is sometimes believed that the crops injured by certain species is balanced by their consumption of injurious insects.

The great variety of climatic conditions in the state, with the variation in altitude, make it possible for a very wide variety of wild animals to exist. Some types of animals that live in Arizona will be listed. This is not a complete list, but will be extensive enough to give the reader an idea of the different and definite types of animals found here. (33)

Big Game

Antelope. (Pronghorn) The Arizona herd has recently increased in size to the point where a hunting season has been declared for a selected number of hunters. They are found on the high deserts.

Deer. There are two main types in Arizona, the small white-tail deer and the Mule deer. The white tail generally inhabits the southern part of the state and the Mule deer is found in the mountainous regions. Two types of Mule deer exist in the mountainous regions, the Rocky

Mountain Mule deer, and the Desert Mule deer.

Wapiti. (elk) These animals are the descendents of the Montana herd imported to Arizona in 1913 to replace the extinct Merriam elk. The herd was brought to the state under the auspices of the Elks fraternal organizations. The animals are most plentiful in and around the Sitgraves National Forest.

Javelina. This is the so-called wild pig of Arizona but is really a peccary and is usually found south of the Mogollon rim. They are still hunted for their hides in Mexico.

Bear. The common bear of Arizona is the black bear. One hundred fifty-six were killed legally in 1948. They are found generally in the mountains that compose the Mogollon rim. Occasionally, a grizzly bear is found in the state. One was reported to have been killed in the fall of 1949.

Big Horn Sheep. There is evidence that these animals once roamed over the greater part of Arizona, but perhaps not in any great numbers. They are now confined to the rough heights of the desert mountains and are protected by law. Two very large desert refuges, the Kofa and the Cabeza refuges, have been set aside for these animals and cover a total of about 1,500,000 acres. It is interesting to note that the Boy Scouts were

instrumental in securing these refuges for the Big Horn sheep.

Bison, Buffalo. There is a herd of the famous American buffalo in the Houserock valley in northern Arizona. This herd is under the strict management and supervision of the State Game and Fish Commission. Buffalo are not native to the state but were brought into Arizona in 1905 and established on the Kaibab Plateau.

Small Game

Rabbits. The two main species of rabbits found in the state are the jack-rabbits and the cotton-tails. Both are distributed about equally over the entire area.

Squirrels. There are many species of squirrels in Arizona. The species most hunted, however, as game is the Abert squirrel.

Predators

Coyotes. These animals are found throughout the state and are very difficult to exterminate. Their cunning and adaptability to the conditions brought about by the coming of man into their habitat have made them almost a match for him.

Bobcats and Lynx. These large cats are numerous and well-distributed throughout Arizona. In 1949, it was

estimated that there were 11,010 in the state.

Mountain Lions. They are very destructive to young livestock and to deer and bighorn sheep. They are found in most mountainous regions of the state.

Wolf. There are still a few wolves in Arizona. In the last 10 years, there has been an average of about 11 killed within the boundaries of the state each year.

Jaguar. (El Tigre) This huge, spotted cat is still killed occasionally in southern Arizona. One was killed near the Mexican border in the fall of 1949. It is believed that they migrate into the state from Mexico.

Fox. The grey fox and the desert fox are both found in the state but do not exist in large numbers.

Fur-bearing Animals. As fur-bearing animals are not of great importance in Arizona, they will be listed below without comment.

Beaver	Badger
Coati-mundi	Muskrat
Skunk	Ring-tailed cat
Opossum	Raccoon
Otter	Mink

Game Birds

Wild Turkey. These were once plentiful but are now found only in the higher mountain regions. They are

a very fine game bird.

Quail. There are four types of quail native to Arizona:

1. Masked Bob White quail
2. Mexican Blue (Cotton-top)
3. Mearnes, or fool quail
4. Gambel's quail

The masked Bob White quail is now believed extinct. A type of quail known as the Benson quail sometimes migrates into Arizona from Mexico.

Doves. Turtle and white-wing doves are game birds, especially in southern Arizona. The white-wing seems to thrive in heat and migrates into Arizona from Mexico, living off of the grain fields. Larger than the ordinary dove, they can be identified by the large white spots on their wings.

Ducks and Geese. Most ducks and geese found within the state are migrants, coming into Arizona in the winter and leaving in the spring. As there are few large bodies of water within the state, these fowl are found mainly along the rivers, especially the Colorado River.

Rails, Coots and Gallinules. These are also listed as game birds of Arizona, but are not present in any appreciable numbers.

Band-tailed pigeons. These birds are also found within the boundaries of the state and some species of grouse live in the high altitudes.

An extensive program has been carried on to introduce pheasants and Chukar partridge into Arizona but it has not proved a success. The Chukar seems the best adapted of the two to Arizona conditions.

Non-Game Birds

A vast number of non-game birds live in or visit Arizona. These range in size from the Bald Eagle to the humming bird. Many are migratory, spending only the winter months in the state, while others spend their entire lives. Cooper's Hawk, the sharp-shinned hawk, goshawk, ospreys and road-runners are predators.

A few typical non-game birds in Arizona are the Cactus wren, which is the state bird, cardinal, meadow-lark, pyrroloxia, Gambel sparrow, finch, bluebird, flycatcher, and many others.

The golden eagle is present in the state and is predatory upon the young of the Bighorn sheep and also kills many rabbits and other small game animals.

Fish

These include:

Trout, Rainbow, Cut-throat, German Brown (Loch Leven), Native, and Montana Greyling.

Bass, large mouth and small mouth

Crappie, white and black

Bluegill

Catfish, channel, blue and bullhead

Perch

Most of the fish of the state are under a program of strict game management.

Reptiles

A visitor to Arizona is likely to think of Arizona wildlife as consisting mainly of rattlesnakes, Gila monsters and lizards. He has gained this impression from stories. The various species of rattlesnakes and the Gila monsters are the most highly publicized.

There are some 13 varieties of rattlesnakes in Arizona. The most common type is the Diamondback, and the most unique is the Sidewinder, which takes its name from its peculiar method of locomotion. The poisonous Coral snake is also found in the state, as well as several non-poisonous varieties such as gopher, garter, and king snakes.

A member of the reptile family that is native to the state, yet is little heard of, is the Desert Terrapin. This terrapin lives in the dry deserts and obtains its water from the food it eats.

Lizards abound in the state from the tiny desert

species to the Chuckawalla, a large, colorful lizard resembling an Iguana. The best known lizard of the state is the Gila Monster, a slow, colorful but poisonous reptile.

Causes for Decrease of Wildlife. There are many reasons for the decrease of wildlife within the state. The hunting and trapping of the larger animals for food and fur in the earlier days of settlement caused serious depletion and, in some cases, extinction.

Elk, deer, and antelope were hunted for the food, for their hides, and they were also killed by trophy hunters. As late as 1906, two hunters killed 600 deer on the Mogollon rim for their hides. (24, p.11)

At one time, 35,000 dozen quail were shipped from the state to market. (24, p.150) Javelina were hunted and slaughtered for their hides. Turkeys were killed for food and market until only a few were left.

Indiscriminate killing is not confined to the days of the early settler. In an area less than two square miles, just south of Williams, after the 1948 deer season, the remains of 13 does, spike-horn bucks (illegal to kill) and fawns were found by representatives of the State Game and Fish Commission. (33) Many unethical hunters kill game animals of the state with complete disregard for season, sex and number taken.

In considering the case of the native fish supply of Arizona, it appears that fish, too, have been the victims of progress. When the dams were constructed, the fish were limited as to movement and, in many cases, the streams in which they were native dried up completely. The story of the salmon trout, once living in our rivers, is a typical example. This note appears on page 168 in Appendix A.

The tailings and refuse from smelters also cuts down the fish population wherever the refuse is allowed to flow into streams or rivers.

Game decrease can be traced to many things. The introduction of domestic stock and the consequent overgrazing caused the loss of many game animals because of the lack of food. Stock, such as sheep and cattle, also have a tendency to destroy the homes of small wild animals and birds.

Stock also has a tendency to drive the game animals into smaller areas with less natural food, causing starvation and an excessive competition for food among the animals themselves.

Fencing an area often stops the natural migration of certain types of wild animals which were accustomed to traveling great distances during the various seasons of the year in search of their natural foods. In

Arizona, fencing the right of way of the transcontinental railroad stopped the normal migrations of the antelope. (24, p.163)

Fire, which burns the natural habitat of animals and birds, often destroys them either by death from flames or by resultant starvation.

The increase of predatory animals sometimes has a marked effect upon the game population of a given area. If game is confined within a certain area, it is certain to furnish a much easier target for the predator.

Poor game management and poor game laws have contributed in cutting down the game population.

The building of roads and trails into regions of the state that had formerly been accessible only by foot or horseback, has done a great deal to cut down the supply and quantity of game animals.

The perfection of firearms, with greater range and firepower, greatly contributed to the depletion of game. These weapons make the existence of game animals precarious indeed. A new type rifle, with telescopic sight, is a far cry from the old muzzle-loader using caps and black powder. The hunter using the old gun had to be certain he had favorable conditions before he shot since he seldom had a second chance. The modern hunter has a gun that throws bullet after bullet, and consequently he

is less careful to identify the age and sex of his game properly.

Dogs and domestic cats that have gone wild are particularly destructive to wildlife. No matter how useful they may be about the home during the day, dogs running wild at night have done more damage to wildlife than some of the natural predators.

As a result of game depletion, recreational hunting and fishing has become limited to small areas and to very remote regions in many cases. More people probably hunt and fish than ever before, but the take of game is smaller. This is not true of all species of wildlife. Elk and deer in Arizona are on the increase, mainly because they are protected and because so many of their natural enemies have been killed.

Hunting and fishing for the markets is a thing of the past in the state except for the seineing for fish in a lake that is drying or the netting of small fish for live bait.

Game depletion causes migrations of animals from their natural habitat. Good examples of this have occurred recently in southern Arizona. The Sinaloa deer, the coati mundi and the Benson quail migrate north across the Arizona border to escape the hunters in Mexico. (24, p.201)

When animals are forced to migrate for protection or to secure food, they may migrate into an area that is not capable of producing sufficient food for them and thus the problem of over-grazing may occur.

Settlement of the state naturally cut down the game supply, but it did not cut down man's desire to hunt and fish. Man is by nature a predator. In order to satisfy this desire to hunt and fish, steps must be taken to keep up a steadily replenished game supply. This, also, takes a great deal of money. This money should be supplied by the people who use wildlife resources.

Prevention of Game Loss. To keep our wildlife at a point where there are not too many to cause encroachment upon domestic animals and still meet the moderate demands of the sportsman, there are several things which we must do.

1. Have good game laws and enforce and respect them. The game ranger is a public servant, not a public enemy, and the attitude of the public toward him should be one of helpfulness and cooperation. The Federal Government, through the Wildlife Restoration Act, has given states a fine opportunity to help in correcting depletion of game.

2. Study of the wildlife situation is necessary. Trained individuals are needed for research and

control of our game animals in order to determine the seasons, the protection necessary for certain species, and to solve a number of other problems presented by good game management.

3. Establishment of refuges and game sanctuaries.

4. We need a program of cooperative game management with our neighbors. We should work out game management procedure with the states that border Arizona and with Mexico. In the case of Nevada and California, such bodies of water as Lake Mead, Lake Havasu and the Colorado River should be included in game laws and restrictions that are interlocking. (5, p.2)

5. We need well qualified and competent hunters. Better hunters would mean less waste. A program could be set up that required a hunter or fisherman applying for a license to take a test such as a driver now takes to qualify for a driver's license. This test should include handling of a gun and some understanding of the game he intends to hunt. Many human lives lost through accidental shooting during hunting seasons might be saved through this screening of hunters.

6. The introduction of animals from another section of the United States or from another part of the world might be of value in securing an added supply of game. Sometimes, however, foreign species prove to do more harm than good, so careful study would have to

precede such an experiment.

7. The raising and planting of wildlife from game farms has and will do a great deal to keep an ever-growing game supply.

8. Education of the public is essential. If the public was aware of the problems that exist in proper game management, the problems of control would be lessened and the supply of game for the hunter, photographer, fisherman or simple traveler would be greatly increased in the future.

Whether to have or not to have wildlife in the state is entirely up to the people. No matter how many game laws we have, if they are not observed, our game will ultimately disappear.

The question of what wildlife to destroy and what to keep is one the ordinary man cannot answer. It is a problem for scientific men who have made a complete study of the situation and, even then, their decisions will not always be correct.

CHAPTER IV

SUPPLEMENTARY MATERIAL

The use of supplementary material is necessary for the student or teacher. There is no published work which pertains to the conservation of all the resources of Arizona. The following materials contain specific reference to the problem of conservation for the state.

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3. Blessings of grass. 16 m.m. film, sound, 10 minutes. U. S. forest service. 1940.

4. Colorado river. 16 m.m. film, sound, 10 minutes. Coronet. 1947.

5. Conservation of natural resources. 16 m.m. film, sound, 11 minutes. Encyclopaedia Britannica films. 1937.

6. Conservation road. 16 m.m. film, sound, 22 minutes. 20th Century-Fox films, 1947. (History of conservation)

7. Erosion. 16 m.m. film, sound, 11 minutes. U. S. soil conservation service. 1948.

8. Everyman's empire. 16 m.m. film, sound, 20 minutes. U. S. forest service. 1948. (Forest values)

9. Grassland. 16 m.m. film, sound, 20 minutes. U. S. soil conservation service. 1938. (Grazing in the southwest)

10. Green harvest. 16 m.m. film, sound, 29 minutes. Modern talking picture service. 1948. (Wild-life and forest)

11. Fish on. 16 m.m. film, sound, 33 minutes. Standard oil co. 1948.

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14. Ground water. 16 m.m. film, sound, 11 minutes. Encyclopaedia Britannica films. 1935.

15. Heritage we guard. 16 m.m. film, sound, 30 minutes. Castle films. 1940. (Soil and Wildlife)

16. Importance of water. 16 m.m. film, sound, 11 minutes. Trans-National productions. 1948. (Water shed and flood control)

17. Life of the soil. 16 m.m. film, sound, 33 minutes. National fertilizer inc. 1943.

18. Lifeblood of the land. 16 m.m. film, sound, 20 minutes. U. S. forest service. 1947. (Water and forests)

19. Mines above the ground. 16 m.m. film, sound, 19 minutes. Western electric. 1942. (Reclaiming scrap metal)

20. Mining and smelting of copper. 16 m.m. film, sound, 15 minutes. Encyclopaedia Britannica films. 1930.

21. Muddy water. 16 m.m. film, sound, 9 minutes. U. S. soil conservation service. 1937. (Southwestern land abuse)

22. One match can do it. 16 m.m. film, sound, 10 minutes. Simmel-Meservey inc. 1945. (forest fires)

23. Paul Bunyan had a son. 16 m.m. film, sound, 13 minutes. U. S. dept. of agriculture. 1948. (Forest conservation)

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25. Realm of the wild. 16 m.m. film, sound, 30 minutes. Standard oil co. 1945. (Wildlife)

26. Return of the pronghorn. 16 m.m. film, sound, 18 minutes. Wyoming game and fish commission. 1949. (Antelope)

27. Seeds of destruction. 16 m.m. film, sound, 10 minutes. Encyclopaedia Britannica films. 1948. (Bad forestry and soil conservation)

28. Save the soil. 16 m.m. film, sound, 10 minutes. Castle, 1940.

29. Soil and life. 16 m.m. film, sound, 10 minutes. Cast tractor co. 1942.

30. Soil and water conservation. 16 m.m. film, sound, 10 minutes. U. S. soil conservation service. 1948.

31. Strength of the hills. 16 m.m. film, sound, 10 minutes. U. S. forest service. 1941. (Forest conservation)

32. Then it happened. 16 m.m. film, sound, 10 minutes. U. S. forest service. 1948. (Forest fires)

33. There's more than timber in trees. 16 m.m. film, sound, 30 minutes. U. S. forest service. 1942.

34. Topsoil. 16 m.m. film, sound, 11 minutes. Soil conservation service. 1948.

35. Trees for tomorrow. 16 m.m. film, sound, 18 minutes. U. S. forest service. 1940.

36. Tree of life. 16 m.m. film, sound, 20 minutes. U. S. forest service. 1938.

37. Under western skies. 16 m.m. film, sound, 28 minutes. International harvester co. 1946. (Western farming)

38. Watersheds and power. 16 m.m. film, sound, 18 minutes. Filmsets inc. 1947.

39. Water for a thirsty land. 16 m.m. film, sound, 20 minutes. United world films. 1949. (Southwest)

40. Water on the land. 16 m.m. film, sound, 18 minutes. Inst. of inter-american affairs. 1947. (Irrigation)

41. Wise land use pays. 16 m.m. film, sound, 19 minutes. U. S. soil conservation service. 1939.

(The Educators Guide to Free Films, published by Educators Progress Service, Randolph, Wisconsin, is very valuable as a source of available free films.)

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

The prosperity and security of our nation is in direct proportion to the amount and the variety of our natural resources. The states of the union have been very fortunate in having an abundance of natural resources. The large amount of available supplies has given us a standard of living that is the envy of the world. It is necessary for us to maintain these resources at their greatest productivity to keep this standard of living.

Much of our natural resources have been utilized in the development of the nation. Timber lands have yielded to agriculture. Minerals have contributed in countless ways to building the nation. Grass was needed to furnish meat for the growing population. But, in addition to this utilization, there has been much waste. This waste resulted from carelessness, greed, and the desire to destroy.

In order to prevent the waste of our resources, the people must be aware of these wastes and how to prevent them. This prevention calls for cooperation, understanding, participation in, and adequate financing of a conservation program. Such a program should first inform the public of the need for less waste and destruction.

It should make them aware that nature has its own set of checks and balances and when these are disturbed, much destruction takes place. The people should understand that many resources are closely related and that the destruction of one resource has a tendency to influence another. Citizens should be informed on the status of the nation's resources. The political implications on the state and national levels of conservation should also be thoroughly understood.

The schools of our state can meet the problems mentioned above by adopting a program of study that will acquaint the students with the basic principles of conservation. This program should give an understanding of today's and of tomorrow's conservation problems so that youth may be in a position to deal effectively and intelligently with them.

The material included in this thesis should serve as a basic "starter" for the student and the teacher alike. Full coverage of the efficient uses of existing natural supplies cannot be accomplished in a work as small as this. This thesis, then, should serve as a primary introduction to the conservation program. It should acquaint its reader with some causes of the losses of resources and some corrective measures that can be applied.

Recommendations

1. Teachers and students should be made aware of the problems of conservation.

2. In teaching conservation, the negative approach should not be used. Our approach should not be on how we have squandered our resources but on how we can secure the most from what we have left. The term "wise use" is imperative in teaching the subject.

3. Conservation should be made a part of the science and social science courses. This can be accomplished either as a separate unit or as part of already existing units. The political and social implications of conservation could fit quite well into the social science program. The balance of nature, ecology, geography, and so forth, could be handled in the science curriculum.

4. Additional studies could be made with special emphasis on the elementary school age groups. These studies should be applicable down to and including the kindergarten group.

5. The schools of the state should secure more conservation material that can be used by the age group of that particular school. There are many audio-visual aids on conservation but there is a lack of material presenting the conservation problems of the area. There is much existing material on the conservation of soil, timber and

wildlife. However, much of this material has been written on a national scale and does not apply directly to Arizona. More information concerning the state is needed. Water and mineral conservation need a more adequate coverage.

6. The students should be made aware that conservation actually brings financial returns to the person who practices it.

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APPENDIX A

Quotations from Narratives Regarding Range, Water, Timber and Wildlife Conditions in Early Arizona

"Sometime along in the early fall of 1882, I set forth from Ft. Apache in Arizona, seeking a suitable location for a modest bunch of cattle.....

"An old Army officer who had chased Apaches from one end of Arizona to the other advised me to look over the San Simon Valley on the east side of the Graham mountains. I had heard of the valley from stories related to me, even when it was known as the Valle de Sauz, meaning 'Willow Valley' because of the willow thickets along the upper reaches.....

"A ten day cruise over San Simon proved the old Army officer was an excellent judge of a stock range. My only disappointment was that the willows were gone. The valley was found to be practically unoccupied, a well-watered, well-grassed area about 60 miles long and 40 miles wide, including the long mountain slopes on each side. It contained, I reckoned, about 750,000 acres of grazing land.

"San Simon joined the wide valley of the Gila river near where a s tore had been established as early as 1872 and around which settlers had located their homes for safety from the Apaches. Their farms were irrigated by means of small brush and rock dams which turned the waters of the Gila onto their fields. The place eventually became Solomonville, a thriving little farming settlement.

"The stream in the San Simon valley was an intermittent affair, flowing quickly over the gravelly bottom for a mile or two before becoming lost in the sand, only to reappear again farther on. Here and there along the stream, great 'water holes' had been scoured out by the current. This guaranteed stock water when the stream flow fell away in the dry season.

"On its lower course were many beautiful grassy meadows, spangled with wild flowers of every hue. Great cottonwood trees--the pioneers' best friend---and willow thickets lined its banks.....

"Farther back and extending clear to the foot of the mountains mesquite, ironwood, palo verder and other desert trees were plentiful.

"The meadows were covered with soft, lush grasses almost untouched by animals except for the horses and mules

of an occasional traveler and the deer and antelope that came to the stream for a drink. Everywhere on the more open slopes those fine stock grasses, black, blue and hairy gramas grew luxuriantly.

"Here and there along the wash were traces of alkali land on which sacaton touched my stirrups. A little farther back large areas were covered with another useful forage plant known to the Mexicans as galleta, botanically hilaria, one of the earliest to 'green-up' in the spring.

"There were practically no banks to this stream. It simply flowed softly and quietly on top of the ground except at its lower end where it entered the Gila, a much larger and deeper stream. As I remember it, the banks of the San Simon were then not over 3 feet high and the wash itself measured not over 20 feet from bank to bank.

"Running back to the foothills on each side the grama grasses covered the whole range with their rich growth while several sages, especially one called estafietta by the Mexicans, grew in dense bodies, furnishing splendid forage in winter when the range was covered by snow or in dry season when the grass was short.

"To an embryo stockman this San Simon valley was indeed a promised land....."

(Mr. Barnes and several other stockmen decided to move to this ideal place but Apaches raided down from San Carlos and discouraged this idea before they had actually moved to the valley. This article contains a photograph showing a man knee deep in grass in 1882 and another picture titled "In 15 years Arizona was discovered by great herds of long horns from Texas and under the old 'open range' conditions the valley was devastated and the hungry Gila river swept down and carried away 20,000 acres of fine grazing lands.")

"Fifteen years later .....I returned to the San Simon valley. In the meantime southern Arizona has been discovered by west Texas ranchers crowded from their own state through the leasing of the state-owned lands to more far-sighted stockmen. The trail across southern New Mexico to Arizona was all cluttered up with herds of long horns slowly but steadily grazing their way west. Under the old 'open range' conditions these great herds of cattle were devastating the San Simon valley. It was a mad race to get the grass first. No one was there to say them nay. No one

sounded a word of warning. None could foresee the rapidity with which these glorious ranges would pass out of the picture, victims of man's carelessness and lack of understanding.

"About this time in 1895, it was estimated that fully 50,000 head of cattle were grazing on the San Simon.. .....

"A few years later, the end was in sight and nearly all the big San Simon outfits shipped their herds to eastern markets and gone out of business.

"Since then, the range has improved considerably but the matter of erosion has grown by leaps and bounds until today the San Simon valley is a shining example of what uncontrolled, unrestricted grazing can do to the best of ranges.

"My last visit to the valley was in the fall of 1934. Many of the old, valuable grasses and forage plants were gone. The green meadows were replaced by wide expanses of drifting sand. Of running water, except during the summer rains when floods appear, there was almost none. The ranges on both sides of the valley---It is now called the Solomonville Wash---were criss-crossed with deep trails, first worn by the feet of the restless herds and then dug deep into the loose soil by the storm waters. On both sides of the main wash, side washes headed into it from the mountain slopes, each doing its best to drain off every drop of water that fell from the summer rains or came from the melting snows on the mountains in the spring.

"The lowering of the bed of the stream began almost at the head of the valley and for 60 miles, ending at the Gila river, the flood waters had scoured their way.....

"Where it entered the Gila river, the San Simon wash was originally not more than ten feet wide. In 1935 it was fully 100 feet wide and 30 feet deep. In some places above the junction the San Simon today has widened out to more than 200 feet.

"Naturally, the first question to be answered is can this ruinous loss be stopped. Can forage plants and shrubs be brought back once again to cover and protect this and other like areas? Finally, can the damage already done be repaired?

"The loss can be stopped, forage plants can be brought back but only with time and proper methods of control and supervision. Nature works slowly in repairing such damage. A valley area that has been centuries in farming cannot be restored except through years of systematic control, supervision and rest.

"In conclusion, the foregoing picture is not that of an isolated or unusual area. All over the west similar areas are now going through the same destructive practices of erosion.

"Naturally the thousands of acres of valuable farm and grazing land already washed away by the rivers of Arizona and deposited in the Gulf of California cannot be brought back. But there is no doubt that further losses can be stopped by means not beyond the professional ability of irrigation and erosion engineers."

Excerpts from "Herds in the San Simon Valley, What has Happened to the Promised Land of Arizona's Oldtime Cattlemen". By Will C. Barnes. American Forests. October, 1936, page 7.

"There is much pasture, with an abundance of sustenance for horses and cattle, as well on the hills and in the dales as on the mountainless plains. In the same valley there is a great deal of cotton-wood and willow....." ....."There is sufficient water for wheat growing but scarcely enough each year for corn....."

From a petition sent by the Spanish of Tubac to Captain Don Pedro Allande y Savedra in 1777, asking for more protection from the Apaches, quoted in Appendix C of Vol. VII, Pacific Railroad Reports, Pima Villages on Gila to Rio Grande.

"But after the completion of the Southern Pacific Railroad in 1881, numerous small owners shipped in their herds from worn out districts in Texas and elsewhere, while still others, driving their cattle overland to California and detained by the terrors of the Colorado desert stopped by the way.

"During the '80's the ranges soon became stocked to the limit, even on Favorable years. It seems that when the feed was short, the cattle began to perish from starvation---then followed accelerated run-off and soil erosion."

The foregoing was from the notebook of Dr. R. H. Forbes and includes pages 216-219 from the Forester, Sept. 1901 and an article by Dr. Forbes on the Open Range and the Irrigated Farmer, Part.I. Obtained from Ben Nelson, U. S. Forest Service, Phoenix.

"On the 15th (May, 1825) we returned to the banks of the Red River, which is here a clear, beautiful stream."

From Personal Narrative, Pattie, Edited by R. G. Thwaites, The Arthur Clark Co., Cleveland, Ohio, 1905. Observations being below mouth of the Little Colorado river on the Colorado.

According to same narrative there were beavers generally on streams of the Southwest and on the entire length of the Colorado (Red) River, 1825.

"There was lots of game in the mountains (Santa Catalinas) at that time. Bear and mountain lions were numerous, a few sheep worked their way over from the Window-in-the-Rock Ridge and turkeys could be gotten at any time. They roosted so thick in the low branching pines around what was later Soldier Camp that we called it Turkey Roost and could go up there most any night and pick off a fine, large bird."

From Reminiscences of Emerson Oliver Stratton, original typed copy, Arizona Pioneer Historical Library, Tucson, taken down by his daughter, Edith Stratton Kitt, in 1925. Stratton was caretaker of the Copper Co. properties, later called Stratton Camp at lower gate of Forest Service road. Deals with game in Sabino Canyon area 1882.

"But the continuous attacks of the Apaches commencing with the year 1780 finally caused the abandonment of nearly all the mining enterprises in what is now Pima county.

"And it was not until some years after the Gadsden Purchase in 1853 when the military occupation of the country by the United States Government seemed to warrant expectations of security that mining operations to a large

extent under the auspices of the military men were resumed."

Hand-book of Arizona by Richard J. Hinton, San Francisco, 1878. Dealing with attacks on miners by Apaches in the Santa Cruz.

"He says that wild turkeys were abundant and roosted in the bottoms near town. Also wild horses were found in hundreds in the adjoining country....."

From interview with Sam Hughes who came to Tucson in 1858. Above concerns Tucson river bottoms. Interview in notebook of Dr. Robert H. Forbes, Arizona Pioneer Historical Library, Tucson, pg. 30.

"Twenty years ago, before there were so many cattle on the Southwestern range, the grama grass stood knee high everywhere all over the country and seemed to be an unlimited supply of feed for an unlimited number of cattle during an indefinite term of years."

From Arizona Sketches by Joseph A. Munk, the Grafton Press, New York, 1905. Being a quotation dealing with southwestern range conditions generally, about 1884.

"It was spring and the country was beautiful. The rolling hills were knee deep in waving grama and other grasses....."

From Reminiscences of Emerson Oliver Stratton, as told to his daughter, Edith Stratton Kitt in the summer of 1925. Obtained from Ben Nelson, U. S. Forest Service, Phoenix, Arizona, 1949. Deals with the country between Oracle and Oracle Junction 1879.

"The low mountains skirting the valley (Salt River around Phoenix) are covered with excellent grasses and would be good stock range were it not for the danger from the Indians."

From Resources of the Salt River Valley by John T. Aslep,

Original Copy Secretary of State Office, Phoenix, Typed copy, Arizona Pioneer Historical Library Tucson. Observations made 1867-68. Page 3.

"The valley of the San Simon is about 25 miles in width and contains much fine grazing land, as well as some agricultural districts. It is covered with a species of grass called Grama, which for its nutritious qualities is rivaled only by the celebrated mesquite grass of Texas. In the region where it grows, the settlers require no grass for their mules or horses as they are able to endure quite as much fatigue upon this grass as upon grain and the stock-raiser who has fed his cattle upon grama during the entire winter finds them in quite as good condition in the spring as does the Eastern farmer his stall-fed animals."

From The Marvelous Country, by Samuel Woodworth Cozzens, Boston, Lee and Shepard, 1876. Pg. 224.

"The Sonoita Valley, which opens into the Santa Cruz near Calabasas is the only one in any degree protected by the United States troops. It is about fifty miles long, in no place exceeding a mile in width and generally much narrower. When I passed up it to Ft. Buchanan (1855) the whole valley was golden with grain. In one field there were two hundred and fifty acres of corn. On several of the farms, two crops were raised last year, wheat, corn, wheat and beans and other vegetables.... This valley is almost entirely taken up by intelligent and adventurous American population....."

From Arizona and Sonora by Sylvester Mowry, Harper and Bros., New York, 1864. Pg. 26.

"Throughout the whole course of the San Pedro there are beautiful valleys susceptible of irrigation and capable of producing large crops of wheat, corn, cotton and grapes; and there are on this river, remains of large settlements which have been destroyed by the hostile Indians, the most conspicuous of which are the mining towns of San Pedro and the town of Santa Cruz Viejo. There are also to be found here, in the remains of spacious corrals and in the numerous wild cattle and horses which are still seen in this country, the evidences of its immense capacity as a grazing country."

The foregoing is from the Mexican Boundary Report of Lt. William H. Emory, Senate Document No. 108, 34th Congress, 1st Session, Washington, D. C. 1857.

"DeBar said that the Hassayampa Valley was well covered with herbaceous vegetation in 1878---in lower part especially with filaree (alfileria Erodium) and grass and shrubs. More grass as one ascended the valley. There were quite a few small bushes scattered over the country. Considerable Bermuda (mesquite grasses?).

"The Hassayampa Valley was a great place for cattle rustlers. There were lots of cattle in Hassayampa Valley in '87-88, also horses. Soon the valley became overstocked and cattlemen had to leave. Sheep men then came in. Sheep finished destruction. Now there is nothing in the valley, like a desert."

Notes taken on the condition of the Hassayampa Valley in 1878 during a conversation by Weir with William DeBar of Phoenix, in Tucson, Saturday, July 17th, 1937.

....."At the Tres Alamas (Benson) the stream (San Pedro) is about fifteen inches deep and twelve feet wide and flows with a rapid current over a light, sandy bed about fifteen feet below its banks, which are nearly vertical. The water here is turbid and not a stick of timber is seen to mark the meanderings of its bed. In the gorge below and in some of the meadows, the stream approaches more nearly the surface and often spreads itself on a wide area, producing a dense growth of cottonwood, willows and underbrush..... The flow of water, however, is not continuous. One or two localities were observed where it had entirely disappeared but to rise again a few miles distant, clear and limpid....."

From Reports of Explorations and Surveys to Ascertain the most Practicable and Economical Route for a Railroad, by Lt. John G. Parke, Published in Executive Document No. 91, 33rd Congress, 2nd Session, House of Representatives, Washington, D. C. 1857. Vol. II Pacific Railroad Surveys.

Sept. 14. "This whole valley, (Babacomeri) was covered with the most luxuriant grass we had anywhere seen.

Our mules fed upon it as they traveled for it was from three to four feet high in many places....."

Sept. 19. "A great many fish were taken in the Babacomeri today. From their appearance I would say there are several quite new species among them....."

From the report of Lt. Col. Graham, on the Subject of the Boundary between the United States and Mexico, pgs. 40-43, published in Senate Document No. 121, 32nd Congress, 1st Session, Report of the Secretary of War. 1854. Area was Babacomeri branch of the San Pedro, the distinct west slope or drainage and was seen Sept. 1851.

"Sam Hughes says that when he came here (Tucson in 1858) there were many beaver dams in the Santa Cruz as far down as Tucson. They had many dams that backed up the water and made marshy ground. Their holes could be found for a long time after they disappeared, perforating the valley soil."

From notebook of Dr. Robert H. Forbes, on the Santa Cruz from the head to Tucson, 1858. In Arizona Pioneer Historical Society Library, Tucson.

....."It (Rio San Pedro) affords plenty of good running water..... and seems to abound with plenty of fish. ..... quite a lot of salmon trout was taken, bands of wild horses were seen as well as an antelope and wild cattle and on the tenth we camped near an old Spanish village (in ruins)....."

Taken from the Diary of H. W. Bigler, typed copy in Arizona Pioneer Historical Library, Tucson. Being a description of the San Pedro, December 9th to 14th, 1848. Bigler was a member of the Mormon Battalion.

"I crossed the stream (San Pedro) near what is now the south boundary of Arizona without difficulty..... My animals get grama grass every night on the hills. It is straw-colored and looks dead but the mules have thrived on it and the thousands of wild cattle and horses are fat.

"Next day the march was fifteen miles down the

river. It seemed to be a fertile valley, the low grounds about a mile wide; salmon trout eighteen inches long were caught. The wild cattle were still more numerous....."

Taken from the Conquest of New Mexico and California, by F. St. George Cooke, G. P. Putnam's Sons, New York, 1878. Pgs. 144-145. Being Cooke's observations on the San Pedro, December 9th and 10th, 1846. On the 11th of December, they had a battle with wild bulls in grama grass on this stream.

....."Grass up to our horses' shoulders covered the valley and the hills were covered with luxuriant groves of oak."

Taken from "The Apache Country" by J. Ross Browne, Harper and Bros., New York, 1869. Pgs. 158-159. Being a description of the upper Santa Cruz in 1863.

"The bottom lands resembled meadows, being covered with luxuriant grass, and but few trees. The immediate banks of the river, which is here as diminutive as near Tucson, are lined with cottonwood trees of a gigantic size, resembling our largest elms."....

Taken from "Personal Narrative of Exploration and Incidents" by John Russell Bartlett, New York, 1854, Appleton and Co., New York, 1854. Pg. 307, Vol. II. Being impression of the upper Santa Cruz river, near Calabasas in July, 1852.

APPENDIX B

Yes No

1. Is conservation taught in your school?------
2. In what department is conservation taught?--
3. Approximately what part of the year is spent on conservation? ----------
4. Are the following types of conservation taught?

   Water----------

   Timber----------

   Wildlife----------

   Minerals----------

   Water power---------
5. What texts or materials do you use on the above?----------
6. Do you think there is a need for a text to incorporate the main phases of conservation?
7. Do you believe conservation should be taught as a complete unit or taught in conjunction with other units? ----------
8. Please include any pertinent comments.