A Survey of the Recreational Resources of the Colorado River Basin

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
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FOREWORD

Most rivers are friendly to man; they are arteries of commerce and their valleys are centers of industrial and agricultural activities, but the Colorado is a hindrance rather than an aid to travel and transportation. For about 80 percent of its course, the river is cliff-bound and most of the tributary channels are deep and narrow, ideal for the construction of dams for water
storage but not readily adaptable to gravity distribution of stored water for irrigation purposes in the immediate vicinity. In area, the Colorado River Basin comprises 8.7 percent of the United States, but contains only 0.7 percent of the population. Successful farming and fruit raising, development of the tourist industry, and the future growth of the basin depend upon the wise use of its water and other resources, including the preservation of its scenic character and appropriate development of its recreational possibilities. The snow and rain that fall in the Wind River Mountains in Wyoming and the Rocky Mountains in Colorado may help to water a melon patch near Yuma, Ariz. Wise utilization of all resources of the basin requires careful and thorough study of all their potentialities so that the best possible use may be made of them in providing a good life for the people within the basin and for the benefit of the Nation as a whole.

The Colorado River Basin includes desert and mountains, canyons and high plateaus. Among the great resources of the basin are its scenic, scientific, historic, and recreational features. With the growth and development of the Nation, interest in these features is increasing rapidly. This is particularly true with regard to recreation which is one of the fundamental necessities of human life, taking its place with health, spiritual and economic well-being, and work as basic requirements for balanced living. The economic welfare of the basin will depend largely upon its agricultural production, but the adequacy of the recreational facilities within the basin will be an important factor toward increasing and maintaining this production at a high level. In addition, adequately developed recreational facilities will attract tourists and thereby further enrich its economy. In this connection, the preservation of great natural areas like Grand Canyon and Zion National Parks for the use and enjoyment of the people for all time is of inestimable value. While Hoover Dam was constructed primarily for the benefit of the people living within the basin, a substantial benefit is carrying over to adjoining areas. For example, the power generated has made possible the establishment of large industries in southern California and the people brought in by these industries are turning to Lake Mead and other places in the Colorado River Basin for recreation.

In order that the recreational resources may receive consideration in planning and development of the basin, the National Park Service has made the survey recorded in this report.

Oscar L. Chapman
Secretary of the Interior.

NEXT >>>
INTRODUCTION

Section 2 (d) of the Boulder Canyon Project Adjustment Act of July 19, 1940, provides authority for financing conservation investigations and studies in connection with the work of the Bureau of Reclamation within the Colorado River Basin.

The Bureau of Reclamation, in November 1940, under the authority of the Adjustment Act, requested the National Park Service to identify the scenic, scientific and recreational resources of the Colorado Basin, as a part of a comprehensive plan for the utilization of the water resources of the region.

Since its establishment in 1917, the National Park Service has been concerned with these resources. At the present time it administers several areas directly affected by the developments planned by the Bureau of Reclamation.

On January 27, 1941, the Secretary of the Interior approved the inclusion of a basin-wide recreational survey as a part of the studies and investigations to be continued and extended under his direction for the formulation of a comprehensive plan of utilization of the waters of the entire Colorado River System. The Secretary also appointed Frederick Law Olmsted, distinguished landscape architect, with wide experience in regional and site planning, as consultant for the survey.

The principal purpose of the survey was to obtain the facts essential to the establishment of Departmental policies regarding classification, development and administration of possible water-control projects and areas within the basin, giving due regard to recreational possibilities and the presentation of scenery and other natural features.

The survey also embraced the study of recreational resources of large portions of the basin which are not administered by the Department. Information thus gained will be helpful to the Bureau of Reclamation in avoiding needless sacrifices of existing and potential recreational values, and in utilizing opportunities to obtain recreational benefits as an incident to the development of water resources.

Another purpose of the survey was to identify and evaluate such areas as might be of outstanding national importance, so that measures may be taken to maintain them in a high state of preservation for public enjoyment. This study was not exhaustive. An attempt to enumerate and evaluate all types of recreational resources, both existing and potential,
throughout the entire basin, would have been a huge undertaking beyond the scope of the survey.

The National Park Service first focused its attention on areas in which the most pressing problems occur, namely, Dinosaur National Monument, the Grand Canyon area, and the Canyon Lands of southeastern Utah. The work was done by the Branch of Lands (now the Land and Recreational Planning Division) of the Service, headed by Conrad L. Wirth, with Mr. Olmsted as consultant. Field headquarters of the survey were established in the National Park Service Region Three Office in Santa Fe, N. Mex. with one member of the field staff as signed to the Region Two Office in Omaha, Nebr., to cover problems falling within that region. Frequent consultation with Bureau of Reclamation officials was the rule. Valuable assistance was given by the Grazing Service (now included in the Bureau of Land Management), the Fish and Wildlife Service, the Bureau of Indian Affairs, and the Geological Survey, as well as many other Federal and State agencies and private individuals. Appreciation is expressed to Dr. Herbert E. Gregory and Edwin D. McKee for their collaboration in the preparation of the chapter on the geology of the basin, and to Dr. Emil W. Haury, Dr. Gordon C. Baldwin, and Dr. Jesse L. Nusbaum for their collaboration in the preparation of the chapter, Prehistory of Man. Appreciation is also expressed to the many individuals listed on page 223, who generously contributed their time and special knowledge in checking various portions of the life zone map and the biological information presented in the text.

Although the report is dated June 1946, a few minor revisions in the original draft have been made subsequently in order to include later information, such as revised height of proposed dams and the redesignation of Boulder Dam as Hoover Dam and Boulder Dam Recreational Area as Lake Mead Recreational Area.

NEWTON B. DRURY, Director, National Park Service.
SUMMARY

The Colorado River Basin is one of the outstanding recreational regions in the United States because of its great variety of natural scenery, climatic conditions, areas and objects of scientific interest, abundant evidence of prehistoric occupation, and present Indian, Spanish, and Anglo cultures. Here one may enjoy a large amount of sunshine and find perfect climates and settings for various types of outdoor recreation the year around. The basin embraces latitudes from Mexico almost to Yellowstone National Park and altitudes ranging from 248 feet below sea level to 14,431 feet above sea level. All of the life zones of the United States are present except the Tropical Life Zone of southern Florida.

Geologic features.—An unusual feature of the basin is the peculiar alinement and local setting of the drainage channels, glaringly out of accord with the topography, exemplified by the mile-deep Grand Canyon through the Kaibab Plateau and Split Mountain Canyon. The central part of the Colorado Basin is unique in geologic history, topographic form, and scenic grandeur. Within it are displayed the oldest and youngest rocks exposed on the North American Continent. Major subdivisions of the geologic time scale are represented in orderly succession.

The Uinta Mountains and Uinta Basin are unique in the United States in that they trend east-west in contrast with the general north-south alinement of similar features elsewhere. The Uinta Basin is a famous source of fossils, and derives additional interest from its scattered outcrops of solid hydrocarbons, including rare forms, some of them unique and little understood. The outstanding features of the Colorado Plateau are the widespread Triassic, Jurassic, and Cretaceous strata in approximately horizontal position; the gigantic cliffs of different geological ages and marked by distinctive colors; and the multitude of canyons that carry the perennial, intermittent, and ephemeral run-off. In places, the surface has been roughened by folding, faulting, the building of volcanoes, and the intrusion of igneous rocks.

Bordering the Colorado Plateau on the east is a belt of tangled topography developed on rocks complex in structure, composition and relationships. The landscape is characteristic of the Rocky Mountains rather than the plateau country.

The Prescott, Ariz., area is significant in that great ore bodies have been
brought up by faulting. Many mines have been developed in this region. The asbestos deposits that appear as conspicuous white lines from a distance are an outstanding geologic feature of the Sierra Ancha Mountains in central Arizona. Similar asbestos deposits are found in the Salt River Canyon.

The Verde Hot Springs, Soda Springs, fossil trackways of prehistoric mammals, salt deposits, prehistoric salt mines, and lake deposits with mollusks are important features of the Verde Valley.

The San Francisco Mountains, the White Mountains, and, to a lesser extent, the Mount Trumbull region are areas of geologically recent volcanic activity which have so modified both the appearance and character of the country as to merit special attention.

The lower portion of the basin, below the great plateau region, is totally different from that to the north. Rugged mountain ranges rise out of broad, flat valleys like islands in the sea. The mountains contain rocks of many geologic ages and their structural histories are complex.

The delta of the Colorado River is formed in, and is controlled by, one of the most remarkable and unique structural troughs in the earth's surface. It is a depression comparable to the trough of the Dead Sea and Jordan Valley in Palestine.

Events representing the history of the earth undoubtedly are more closely and simply illustrated by the record of the rocks in the Colorado Plateau than anywhere else in the world. In order that this history may be skillfully presented to visitors, emphasis must be placed on original materials. Facts must be dealt with and presented in a way that will guide people's thoughts toward a realization of the principles. The task is to lead people to the best possible illustrations through the skillful development of roads and trails and to make available data necessary to a correct interpretation and correlation of facts.

Plants and animals. — Plants and animals are dependent upon one another in a manner so complex and far reaching that they cannot be fully enjoyed or protected separately. Without plants there can be no cool, clear trout streams; no shady camping spots; no fertile, humus-bearing soil; no food for other forms of life. Recreational enjoyment of plants ranges from subconscious appreciation of their beauty and shade to active interest and wonderment at the marvelous diversity of plant forms which results from their adaptation to extremes of climate and environment. The recreational value of animals is indicated by the fact that by 1945, in spite of wartime restrictions, 20 million anglers and hunters spent 2 billion dollars per year in pursuit of their sport. But fishing and hunting are only two of the many recreational values of wildlife.

Originally the basin had a much greater wealth of vegetation and wildlife than at present. Many desert watercourses that present generations are accustomed to think of as dry washes or as intermittent streams once flowed the year around. The more luxuriant vegetation of those days checked the run off from the storms more efficiently than it is
checked at present. After 1870, cattle increased greatly in the desert regions and the forage thinned and disappeared. Trampling hoofs stripped the thin protecting layer of decaying plant materials from the surface of the soil and as a result plant growth changed or disappeared and animal life was starved out. Animal life in the mountains has undergone a corresponding decrease as a result of direct persecution, as well as from forage and habitat depletion.

Another cause of depletion of wildlife has been the occupancy of most of the choice, fertile regions by cities and farms. Elk, deer, beaver, turkeys, and many wild creatures, today considered to be almost exclusively mountain dwellers, originally had their centers of abundance, particularly during the winters, in the lower hills and adjacent valleys.

The decline of wildlife reached a low in the late 1920's. Since then, vigorous conservation efforts have partially restored some species. The viewpoint that wildlife is a direct product of the land, to be increased by restoring the appropriate environment and growing conditions, and, where desired, to be harvested according to a definite plan, with a definite financial return like any other crop, was first emphasized during the early 1930's. This concept had wide appeal and has enlisted support for conservation efforts. Restoration has commenced but lags behind knowledge. Today millions of tons of soil continue to wash away needlessly. In the Southwest proper, grazing capacity has long since been exceeded and vegetation is far from adequate to protect the surface against erosive forces.

Grazing is a major basin industry that needs stabilization.

The problem of determining the proper uses of the Colorado River Basin is largely one of conserving its basic soil and water. In general, the present economic use pattern seems well adapted to the land. The principal need is to replace destructive methods by up-to-date ones with respect to existing land uses. The public is uninformed regarding basic conservation issues largely because conservation education has lacked focus. More support is needed for conservation education.

*Archeologic features.*—The Colorado River Basin contains abundant evidence of prehistoric occupation and use by man. Exploring the ruins and learning the dramatic story of these early peoples is one of the important recreational activities in the basin. The evidence of prehistoric settlement and use of the lands and waters constitute a resource of recreational and historical significance of unique and irreplaceable value to the Nation.

A considerable part of the archeological wealth of the Southwest is concentrated in valleys adjacent to adequate water supply and tillable fields. The construction of dams and flooding of river valleys will destroy thousands of these prehistoric and historic ruins. To offset this potential loss, there is a definite and immediate need for a well-planned and coordinated archeological program that will include specific recovery measures. The program should include (1) a careful archeological survey of each dam and reservoir site; (2) excavation of
important archeological sites; and (3) thorough laboratory study and adequate publication of the scientific data.

Factors determining the recreational values of reservoirs.—In the arid portions of the basin, the creation of large artificial lakes on reservoirs is of great recreational importance. The higher portions of the basin are fairly well supplied with clear streams and small lakes. The recreational value of a reservoir is dependent to a large extent upon its location, accessibility, the population of the area served, the nature of the reservoir site, and the plan of operation of the dam. The amount of fluctuation of water-surface area and elevation are major factors determining the recreational value of reservoirs, although water temperatures and the fertility of the reservoir sites have an important bearing on aquatic life within them.

Potential reservoir sites.—The survey covered about 135 potential reservoir sites. The recreational potentialities of these sites will be considerably increased in a number of cases particularly the smaller reservoirs if a dead storage or conservation pool can be assured. A number of reservoirs are proposed in locations where the existing natural features are of greater recreational value than can be expected of the proposed reservoirs. The majority of the proposed reservoirs, however, will create new recreational resources benefiting the basin.

Grand Canyon region.—The proposed Bridge Canyon Dam in the Grand Canyon will create a lake 93 miles long at a maximum surface elevation of 1,876 feet. Construction of the dam at the proposed elevation would amount to virtual disestablishment of Grand Canyon National Monument and, in addition, would back up water into Grand Canyon National Park for a distance of about 18 miles. The National Park Service deplores this proposal because for an exclusively economic gain it would substantially alter natural conditions and injuriously affect the natural scenery along the Colorado River as far as the backed-up water would extend. At the same time it is recognized that, even under the present plans for Bridge Canyon Dam, the major portion of Grand Canyon National Park would remain in its natural state. It is realized also that some persons will regard the damage to the natural features partially mitigated by the water recreational opportunities that will accrue. The National Park Service does not believe that these recreational benefits are sufficient to compensate for the loss of natural values and has urged that any dam constructed be at a lower level.

A dam at the Marble Gorge site might not be objectionable from the scenic and recreational view point. In fact, a high dam at that site, which would eliminate a dam at the Glen Canyon site, might create a reservoir more adaptable for recreational development and use than a low dam at the Marble Gorge site and a high dam at the Glen Canyon site. On the other hand, the proposed diversion of Colorado River water around Grand Canyon National Park, by a tunnel through the Kaibab Plateau, in order to obtain the benefit of the fall of the Colorado River through the park would be extremely objectionable because it would eliminate the flow of the Colorado River through the most spectacular portion of the Grand Canyon which it formed.
All sections of the Grand Canyon are parts of one great physiographic unit. Man-made boundaries mean little as to the relative value of different portions. From the standpoint of the American people as a whole, it is important that the entire Grand Canyon and the bordering portions of plateaus be protected and that appropriate sites be developed for recreation, primarily of the inspirational type. The extension of opportunities to use Grand Canyon, especially the little-known western part, would greatly help in solving the future problem of adequate space for meeting the recreational needs of an increasingly large group. If water-control facilities are constructed in the Bridge Canyon area, the Peach Spring-Diamond Creek area, Granite Park, and the Toroweap-Whitmore Wash area, it appears that they will be suitable places for future major recreational centers in the Grand Canyon.

Canyon Lands of southeastern Utah.—The area comprising the Canyon Lands of southeastern Utah, part of the largest section in the United States without improved roads and one of the least known, is a region of the unusual in color and form: of great natural bridges, monuments, spires, deep twisting canyons, mammoth terraces with sheer walls a thousand or more feet high, and rock forms that resemble huge castles and cathedrals. It is a vast unoccupied area of great potential recreational value.

Two dams are proposed, one at the Dark Canyon site, the other possibly at the Glen Canyon site 4 miles above Lees Ferry in Arizona, or at an alternate site 15 miles above Lees Ferry. The combined length of both impoundments along the Colorado River would be 279 miles through the Canyon Lands. Although the reservoirs would eliminate for the few the thrills of boating down the untamed river and reduce the apparent depths of the river canyons, they would be confined in the canyon of the Colorado and Green Rivers and have little, if any, effect on the great recreational resources of the region. Instead, the reservoirs would provide a means of access for many to see the wonders of the canyons.

The area is large enough and varied enough to permit the continued use and development of its resources: water power, minerals, forage, and recreation. Except in certain limited sections where a single use is essential to obtain the greatest benefits, these resources can be developed and used simultaneously.

The most important recreational sections of the Canyon Lands of southeastern Utah are the Grays Pasture—Junction Butte area, the Elk Ridge—Needles area, the Lands End area, the Hole in Rock area, the Hite area, the Wahweap area, the Goosenecks of the San Juan River, the Arch Canyon area, and Fisher Towers. Certain parts of these areas which contain known features of national importance should be withdrawn to afford them proper protection.

Dinosaur National Monument.—This monument was established in 1915 to preserve a rich deposit of fossilized dinosaur bones. In 1938, it was extended to include other resources of scientific interest found in the adjoining canyons of the Green and Yampa Rivers. Functionally, the monument now consists of the Quarry Unit, comprising three or four thousand acres, and the Canyon Unit, consisting of about 206,000 acres.
Two dam sites for utilizing the water resources of the Green and Yampa Rivers the Echo Park and Split Mountain are located in the monument. Construction of dams at these sites would adversely alter the dominant geological and wilderness qualities and the relatively minor archeological and wildlife values of the Canyon Unit so that it would no longer possess national monument qualifications. The Echo Park project would not affect the Quarry Unit. At the time this report was prepared, data were not available to determine whether the proposed pressure tunnel from Split Mountain Dam to a power plant on the Green River would affect the Quarry Unit.

The policy of the National Park Service, as the administrative agency now responsible for Dinosaur National Monument, is to make the protection of the natural and archeological values of the area the controlling factor in administering it. Before authorization is given to develop the water resources of the monument and to recognize water use as the principal consideration in the administration of the Canyon Unit, it should be clearly shown (1) that the economic and social values of such development will exceed the costs of producing them; (2) that it would be more economical to develop the water resources of the monument rather than some other resources available for the same purpose within practicable reach; and (3) that it would be of greater benefit to the whole Nation to develop the area for water storage and power than to retain the monument in a natural state for the enjoyment of all the people.

Conservation of recreational resources.—The Colorado River Basin lies directly across all lines of travel between the rapidly increasing population of California and the densely populated eastern half of the United States. In the past the basin was to a large extent considered just a vast space that had to be crossed on the way to California. Now, with the Pacific Coast more fully developed, people seeking undeveloped, uncrowded areas are beginning to discover the basin. It is time for immediate action which will assure the preservation of its many and varied recreational features. It is also time to develop facilities which will enable people to see and enjoy the region. There are natural limitations on the amount of land that can be placed under cultivation. There is a limit, already reached in most sections, on the number of domestic animals that can be grazed. But the possibilities for the development of the recreational use of the basin are almost unlimited.

Some of the more important areas that should be preserved and made available for recreation are the western slope of the Wind River Range in Wyoming; the San Juan—San Miguel—Uncompahgre Mountain area, White River Plateau, the Elk Mountain area, and the Park Range in Colorado; the Uinta Mountains, the Aquarius Plateau—Boulder Mountain area, Monument Valley, and the Canyon Lands of southeastern Utah; the Gila primitive area and Manuelito area in New Mexico; Meteor Crater, Fort Bowie, the Blue Range area, Mount Baldy—White Mountains area, the San Franciscan volcanic field, the Mogollon Rim area, Travertine Bridge, and the Kofa Mountains in Arizona; and Palm Canyon in California. Nationally significant archeological sites that should be permanently preserved are Poncho House in Utah; and Kinishba Ruins, Clear Creek Ruins, Chaves Pass
Ruins, and Awatovi in Arizona.

To preserve the great areas of open country free of scattered reminders of city life and to maintain and stimulate the economic life of existing communities, it is recommended that facilities for the accommodation of travelers and vacationists be concentrated near existing towns and villages. Many towns are now focal points for recreational use of the surrounding country. This condition should be encouraged and developed.

While it will be necessary, in developing the resources of the basin, to construct new roads and improve existing ones and to construct other facilities, it must not be forgotten that among the basin's greatest recreational assets are the large areas in which there are no roads or other developments. Some roadless areas have been established, others are needed.
Chapter I: THE COLORADO RIVER BASIN

GENERAL DESCRIPTION

From Gannet Peak in the Wind River Mountains of Wyoming and the 14,000-foot mountain peaks in Colorado to the Salton Sea in southern California, 248 feet below sea level, stretches the vast region of forests, deserts, plains, mountains, canyons, and plateaus drained by the Colorado River.

The outline of the Colorado River Basin as it follows the crests of adjacent mountain masses is irregular, but its general shape may be compared with the ear of a horse. The lower end of the basin in southern California, Arizona, and New Mexico, corresponding to the base of the ear, is broad, being some 500 miles wide at one point, and is bounded for the most part by low, desert ranges. Northward, in Utah and Colorado, the basin becomes progressively narrower, edged by loftier mountain ranges, until at the extreme northern tip of the ear, 830 miles from the Mexican border, it is reduced to a width of 25 miles as it culminates in the magnificent Wind River Range of western Wyoming.

The Colorado River Basin not only is ringed with mountains but contains
within its boundaries many extensive ranges and lofty plateaus. In the north, these interior ranges run in an east-west, or else a northwest-southeast direction, forming a series of more or less parallel mountain barriers and high plateaus across the basin. Between these barriers lie great valley systems, also running more or less east and west. Only the mighty Green and Colorado Rivers have cut deep gorges in a southerly direction through the barriers to unite all the streams into one drainage. Toward the south, the interior ranges pivot gradually from the northwest-southeast direction, until in southern Arizona, Nevada, and New Mexico they run nearly north and south. The physiography of the basin can be most readily described in terms of these various mountain barriers and their intervening valleys.

Farthest to the north lies the spacious but bleak valley of the southward-flowing Upper Green River in Wyoming, with the elevated and still more barren Red Desert to the east. These areas have long, cold winters and short, dry summers. They extend south into northern Utah and Colorado where they encounter the first of the mountain barriers. This barrier is formed by the Uinta Mountains and Yampa Plateau as they extend eastward toward, but do not quite meet, the Danforth Hills and White River Plateau—which in turn are westward extensions from the main Rocky Mountain Divide. Winters are still longer and colder than in the valleys, with a heavy snowfall. Summers are cool, with frequent afternoon thunderstorms.

Beyond this first barrier to the south lies the broad, east-west valley of the Duchesne River, elevated and bleak, but farmed, and its counterpart on the opposite side of the Green River, the wilder but similar valley of the White River. These valleys have long cold winters and short dry summers like the Upper Green River Valley. They are bounded on the south by the second mountain barrier, comprising the Tavaputs Plateaus which, with the Roan Plateau, form an 8,000- to 9,000-foot wall all the way across the basin from the Wasatch Mountains on the west to the White River Plateau of the Rockies on the east. Only the Green River has been able to cut a cleft through this wall to join with the stream systems still farther south. The climate of this mountain barrier resembles that of the first, being characterized by deep, long-lasting winter snows and cool summers with afternoon thunderstorms.

About 50 miles south of the Tavaputs—Roan Plateau barrier, the southward-flowing Green River joins the Colorado River which, with its great tributary, the Gunnison, flows southwest from the heart of the Rockies through broad sagebrush valleys to this junction point. The Colorado River beyond this junction plunges into a wild and fantastically eroded land of winding gorges and sandstone mesas whose vast expanses are punctuated at irregular intervals by the isolated, steeply upthrust masses of the Henry, Abajo, and Navajo Mountains. With the exception of the mountain summits, which are cool and moist, the greater portion of the area receives but little snowfall in winter and is characterized by a long, warm summer season. Average temperatures are higher than those of valleys to the north, in conformity with the decrease in latitude, but lower than those of deserts to the south. The annual precipitation ranges from about 6 to 14 inches, with the greatest amount coming from thunderstorms during July and August.
This desolate but spectacularly scenic sandstone area is referred to in this report as the Canyon Lands of southeastern Utah. Into it from the east, through a deep meandering gorge, flows the turbid San Juan River which, with its tributaries, drains a far-reaching area, including the La Plata Mountains, the San Juan Mountains and other lesser ranges on the Continental Divide, the Chuska Mountains, and enormous areas of mesa land in the interior of the basin. From the Wasatch and Aquarius Plateaus on the west come other, but lesser, silt-laden streams, all carving the deep, winding canyons which have given this country its name.
The Canyon Lands terminate, approximately, at a third, intermittent barrier formed by the Paria Plateau, Black Mesa, and the Chuska Mountain mass. Southwest of this third barrier lies the great valley of the Little Colorado River and the adjacent House Rock Valley a semidesert grassland, piñon pine, and juniper country which, in spite of its enormous area, contributes but a meager stream flow because of the sparse annual rainfall and snowfall. Winters are mild and summer temperatures about the same as in the Canyon Lands.

South and west of the Little Colorado River, the last great highland barrier extends in a vast curve across the Colorado River Basin from the southern boundary of Utah through Arizona to western New Mexico. This barrier is formed by the Grand Wash Cliffs, the Coconino and Kaibab Plateaus, the San Francisco group of volcanic peaks which rise above 12,000 feet, the long but narrow Mogollon Plateau averaging above 7,000 feet, and the 11,000-foot crests of the White Mountains. Heavy snowfall, long winters, and cool summers with afternoon thunderstorms characterize the climate of most of these highlands.

West and south of this last barrier lies the great southern desert of Nevada, Arizona, California, and Mexico. Rainfall is scanty and the summer season long and intensely hot. Winters are mild. Many low mountains rise from this desert. The most important of these ranges are the Hualpai, Harquahala, Santa Maria, Bradshaw, Pinal, Santa Catalina, Rincon, Galiuro, Pinaleno, Santa Rita, and Chiricahua Mountains. They comprise a series of cool islands rising out of the surrounding desert heat rather than a climatic or physiographic barrier.

The life zone map (Pl. 12, in pocket) summarizes graphically the natural features of the Colorado River Basin. It indicates the climates of the basin and their characteristic plants and animals. In view of the close relation between temperatures and altitudes, to be described later, the map also
shows enough of the topography to furnish a rough three-dimensional presentation of the basin, the extent of the many great plateaus, the island-like distribution of many of the southern mountain ranges, and the deep penetration of the Rocky Mountains by numerous long, winding valleys.

The life zone map indicates the nature and distribution of the basin's various recreational regions. The Lower Sonoran Zone is principally a winter recreation region, where the desert scenery and sunshine are ideal for photography, swimming, camping, hiking, horseback riding, and motoring, and where some hunting and fishing may be enjoyed. The Upper Sonoran Zone, in valley and plains lands, provides recreational opportunities similar to those of the Lower Sonoran Zone, but is usable in summer when the latter region is too hot for comfort. The northern limit of the Upper Sonoran Zone is generally open sagebrush country not suitable for winter recreation.

The Transition Zone of the foothills and lower mountains probably attracts more vacationists than any other because it is the principal retreat of those seeking to escape from the summer heat of the lowlands. The location of this zone at the lower mountain levels usually renders it easily accessible at all seasons, while the coolness which accompanies its ample precipitation makes it the principal zone of winter sports. In the Colorado River Basin, water is most plentiful in the Transition Zone, so that it includes most of the best natural fishing areas, and for similar reasons the finest forests. With this abundance of vegetation are associated most of the big game animals, affording maximum opportunities for hunting and wildlife photography. In fact, nearly every form of outdoor recreation may be found in the Transition Zone and many kinds reach their highest development there.

The Boreal Zone is the high mountain recreational region. In the northern half of the basin it is visited nearly as frequently as the Transition Zone because it extends to fairly low levels. However, in the southern half of the basin it is, as a rule, sufficiently difficult to reach that only those who can
appreciate its wilderness character are likely to penetrate it very deeply or permanently. High mountain recreational developments usually are restricted to the general vicinity of the relatively few roads that penetrate Boreal regions, and such developments are further restricted in their operations by the extreme shortness of the summer season. Camping, hiking, fishing, horseback riding, winter sports, photography, and the enjoyment of wildlife and rare flowers reach their culmination for many persons in this remote, and, to many, most beautiful and inspiring of all recreation regions.

LIFE ZONES

Because the basin embraces latitudes from Mexico almost to Yellowstone National Park, and altitudes ranging from 248 feet below sea level to 14,431 feet above sea level, all of the life zones of the United States are present except the Tropical Life Zone of southern Florida. These life zones are as follows:

Boreal Zone.—In detailed studies of small areas this often is subdivided into three zones Alpine, Hudsonian, Canadian but these finer distinctions are needless here. This zone is characterized by the cool, moist climate of Canada and the northern coniferous forest belt of the United States. Winter snows are heavy and long-lasting. Total annual precipitation is from 23 to 60 inches or more. On the other hand, at the lower levels of the Boreal Zone in the arid Upper Green River Valley of Wyoming, annual precipitation may be as low as 15 inches in some localities. The annual mean temperatures are in the neighborhood of 45° to 27°F. or less. Narrow tongues of the Boreal Zone extend far south of the main area along various high mountain crests such as the Rockies. With the increase in average temperature toward the Mexican border, the tongues give way to a series of scattered islands as the zone becomes restricted to the tops of the loftiest peaks.

In the Colorado River Basin, the most reliable and conspicuous plant indicators of the Boreal Zone are the lodgepole pine, limber pine, whitebark pine, white pine, foxtail pine, white fir, alpine fir, Engelmann spruce, blue spruce, dwarf juniper, aspen, red elderberry, dogwood, and the blueberries. Extensive timberline grasslands and scattered high mountain meadows also occur in this zone.

Some of the more interesting or conspicuous animals and birds that characterize the Boreal Zone are the pine squirrel, marmot, cony, snowshoe rabbit, lynx, red fox, marten, wolverine, goshawk, three-toed woodpecker, Rocky Mountain jay or camp robber, clark crow, and crossbill.

Transition Zone.—The zone was given this name because it was considered to be essentially an area where the ranges of many northern (Boreal) and southern (Sonoran) plants and animals overlapped. Although this is to some extent true, the Transition Zone possesses a quite distinctive climate and a number of prominent and characteristic species of its own.

In Wyoming, Colorado, and northern Utah, where the Boreal Zone covers all the major mountain masses, the Transition Zone occupies the foothills
and higher valleys. Farther south, however, where the Boreal Zone is restricted to projecting tongues and isolated high peaks, the Transition Zone occupies most of the mountain masses, and is replaced in the valleys by a warmer climate. Winter snows are moderate. Total annual precipitation is from 17 to 26 inches, occasionally as much as 32 inches, and sometimes more. [2] Annual mean temperatures usually are between 40° and 50°F., except in a few Transition areas of extreme cold and aridity such as the Upper Green River Valley at Pinedale and Kendall, Wyo. [3]

Throughout a large part of the Colorado River Basin, this zone coincides very closely with the open, parklike ponderosa pine forests of the mountains and foothills, but north of the San Juan Mountains, Uncompahgre Plateau, and the Aquarius Plateau, the Transition Zone becomes a partially open region, characterized by sagebrush valleys and grassy slopes, often covered with Gambel oak and other chaparral shrubs. This reduction of forest growth may be due to the fact that precipitation in that region is relatively light even at the higher altitudes, while soil moisture and average relative humidity are further reduced by frequent high winds. [4] In this northern part of the basin the ponderosa pine gradually is replaced by Douglas-fir, but distribution of the latter within the zone often is restricted to steep slopes, shady areas, or the crests of plateaus above 7,000 feet, leaving the major part of the zone to the sagebrush and chaparral.

Other plant indicators are the narrow-leaved cottonwood, Utah oak, bur oak, bearberry, Rocky Mountain birch, Oregon or holly grape, elderberry, maple, locust, and alder. The sagebrush previously mentioned cannot be used as an exclusive indicator of the Transition Zone because it occurs even more extensively in the next warmer zone and sometimes enters the lower limits of the Boreal Zone. Since hardly any two kinds of plants, or animals, have precisely the same climatic requirements, the location of
zone boundaries is based upon the presence of not one but a large number of the appropriate indicators. Obviously, therefore, the establishment of sharp lines of division between zones represents merely a compromise among various arbitrary decisions that it is necessary to make in order to draw up an intelligible small-scale map.

![Figure 7.—Upper Sonoran Zone—Canyon lands of southeastern Utah.](image)

Animal indicators confined to, or particularly characteristic of, the Transition Zone include the tuft-eared squirrels, certain local races of wood rats and pocket gophers, and other small rodents, wild turkey, and band-tailed pigeon.

*Upper Sonoran Zone.*—This and the next zone take their names from the Province of Sonora in Mexico, from which they derive some of their plants and animals. Climatically, the Upper Sonoran Zone is considerably cooler than much of Sonora. It comprises most of the broad lower valley lands of the basin except in southern and western Arizona, southern Nevada, and adjacent California, where it gives way to a still warmer climate and becomes the principal life zone of the foothills, extending even to the summits of the lower desert mountains. Snow is light or absent, and the summers are warm. Total annual rainfall usually is from 10 or 12 to 18 inches, occasionally more, and annual mean temperatures are between 50° and 65° F.
Figure 8.—Transition Zone—Shivwits Plateau.

The Upper Sonoran Zone is typified by the seemingly endless foothill and mesa regions, sparsely covered with junipers (3 species) and piñon pines, that comprise vast areas in the Colorado River Basin. The zone is practically coextensive with these trees wherever they occur but is by no means restricted to such areas. It includes also extensive regions formerly covered with nutritious grasses where soil and moisture are too meager for piñons and junipers; also the alkali plains, sagebrush flats, and parched wastelands of the Upper Green River Valley and Red Desert in Wyoming, the sandstone barrens in the Canyon Lands of Utah, and the shortgrass and alkali plains of the Little Colorado River.

Some parts of the Upper Sonoran Zone that have a slightly greater rainfall and higher mean temperature than the piñon-juniper region support an extensive belt of scrub oaks. [5] Growing conditions seldom are favorable enough to permit these scrub oaks, which comprise several species, to become full-sized trees. Usually they are low, spreading shrubs that form dense thickets covering thousands of acres of foothill country. The Upper Sonoran oak brush is prevalent in the disconnected chain of foothills and low mountains south of and paralleling the Mogollon Plateau in Arizona, and is well exemplified in Kirkland Valley and the hills south of the town of Prescott. It also occurs, though apparently less extensively, in some comparable foothill areas of southeastern Utah and southwestern Colorado, such as the Abajo Mountains. [6]
Additional plant indicators are the sycamore, boxelder, greasewood, hackberry, cliffrose, silk tassel, rabbitbrush, winterfat, and antelope brush. Mammal indicators include several species of small rodents, shrews, and bats which are not listed here because of the difficulty encountered by the average person in distinguishing these species from quite closely related animals inhabiting adjacent life zones. Such a list would be of practical use only to the technical worker, who can readily obtain such information elsewhere.

Bird indicators also are numerous, but, as in all of the life zones, only those are given this status that are known to nest in the zone in question. After nesting season, most of these birds spread into adjacent life zones, so that here again, a list of breeding birds would be of little help to any but the technical worker. The few birds that are listed as indicators elsewhere in this outline are believed to be year-round residents of the zone concerned. The piñon jay probably comes the closest of any bird to being a year-round resident of the Upper Sonoran Zone, but even this species wanders briefly into other regions.

**Lower Sonoran Zone.**—This, the last and lowest of the Colorado River Basin life zones, is the hot southern desert zone. It extends from Mexico northward into Arizona as far as the highland barrier formed by the Grand Wash Cliffs and the previously described chain of foothills and low mountains that parallel the Mogollon Plateau and White Mountains. It completely surrounds many of the southern desert mountains as an ocean surrounds an island, particularly in the southeastern part of the State, while other mountains of lesser height, including the many low ranges of southwestern Arizona, are completely submerged by it. This zone occupies the Salton Sea region (among other places) of California and extends long fingers into the lower valleys of southern New Mexico. It occupies the desert plains and valleys of southern Nevada and extends a dilute arm for a short distance into the adjacent Virgin River Valley of southwestern Utah. Another dilute extension of the zone threads its way up the Colorado River, deep beneath the surrounding land surface, between the shear, heat-reflecting walls of the Grand Canyon. It extends briefly at the lower end of the Little Colorado River Valley in the vicinity of Cameron, and in the lower Paria and Wahweap Valleys above Lees Ferry.

Snow is practically absent, and annual precipitation averages from 1-1/2—2 to 12 or 15 inches. In some parts of the zone there may be no rain at all for 2 or 3 years, but irregularly occurring cloudbursts help to raise the average figure. The summers are long and in many areas intensely hot, and annual mean temperatures are between 51° and 74°F.

The Lower Sonoran Zone is the zone of mesquites, many kinds of cacti, and the creosotebush. The mesquites are too dependent upon subsoil moisture to occur throughout this zone, while some kinds, though not all, of the cacti are sufficiently tolerant of cold to occur well beyond its limits. The creosotebush is the most conspicuous, widespread, and characteristic single plant of the Lower Sonoran Zone, and is almost coextensive with it except that it does not occur in the poorly drained alkaline soils of the desert sinks.
Other Lower Sonoran Zone plant indicators are the screwbean, catsclaw and other acacias, ocotillo, desertthorn, althorn, paloverde, smoketree, tesota, bluethorn, varnish bush, arrowwood, century plants, and sotol.

Mammals used as indicators by ecologists include the round-tailed ground squirrels and cotton rats, as well as various other rodents whose close relatives occur in adjacent zones. Among birds, the white winged dove, Arizona cardinal, and Arizona pyrrhuloxia are good indicators where they occur, but their range within the zone is not as wide as that of the mammals.

LIFE ZONES IN RELATION TO ALTITUDE

In general, the higher the altitude the cooler the air; roughly, the temperature decreases 3-1/2° F. for each increase of 1,000 feet in elevation above sea level. Stated in another way, an increase of 1,000 feet in altitude is equivalent to a northward shift in latitude of approximately 200 miles. An easily remembered illustration is experienced by anyone who travels over the desert in summer by airplane. On taking off at approximately sea level from a desert airport that is sweltering under a temperature of, say, 110° F. in the shade, a few minutes' climb to 5,000 feet brings a reduction of temperature to 92° F., followed by a further drop to 74° F. if one continues through the upper layers of air to the 10,000-foot level. One can even fly over Death Valley during midsummer in complete comfort in a plane at 11,000 feet, and no doubt this new form of recreational travel will become increasingly important in desert regions and elsewhere.

The lowering of temperature with increasing altitude helps to explain the permanent coolness of mountaintops, and why they constitute islands with a northern climate rising above the surrounding ocean of warmer air. On these island summits cling assemblages of cold-climate plants and animals that have been stranded there since the last Ice Age, when more than one-half of the continent was buried under a vast, unmelting crust of ice and...
snow. In southern regions these mountaintops usually are choice recreation areas.
Provinces and subprovinces of the Colorado River drainage area, as recognized in this report, are based on physiographic character, on rock structure, and on the age of surface rocks. The value derived from using such subdivisions is chiefly that of ease in making descriptions of geologic features. Thus, elements of similar nature are considered together and contrasts are made apparent.

This portion of the report is prepared with a twofold objective: first, to present a general description of geology in the Colorado River drainage system and, second, to indicate specific features of unusual interest or unique character which should be permanently preserved and or made accessible because of their educational or inspirational values. The general description of the area is essential to an understanding of the individual features which are discussed in more detail later. An appreciation of these features is essential in evaluating the recreational possibilities of the region or in planning its development.

**GENERAL FEATURES AND RELATIONS OF DRAINAGE BASIN**

In its continental relations, the area comprising the drainage basin of the Colorado is a feature of the great intermountain region outlined by the Rocky Mountains and the Sierra Nevada—an enormous expanse of relatively low land that might have been drained by a single river system. During Tertiary times this vast area was separated into two parts by the building of crinkled mountains in western Wyoming and uplifting masses of sedimentary rock to form the high plateaus of Utah. West of this common boundary is the Great Interior Basin, characterized by elaborately faulted and uptilted strata arranged as ridges between broad flats—a region of dwindling streams which never reach the sea. East of the division zone and extending to the crest of the Rocky Mountains lies the well-drained Colorado Basin, developed in dominantly flat-lying sedimentary rocks whose continuity has been interrupted by lava flows and igneous intrusions, and which in places have been bent upward into monoclinal folds or sliced into long earth blocks by faults. During a large part of Tertiary time the basin was the dumping ground for rock debris worn from its border lands. As a regional structural unit the Colorado drainage basin is a geosyncline—a downwarp formed at the time when its counterpart, the Rocky Mountains,
An outstanding feature of the Colorado River Basin is the alinement and the peculiar local setting of the drainage channels. The original streams chose courses in accord with regional and local slopes and the relative hardness of the surface rocks. Some doubtless were through-flowing and others formed lakes, but nearly all of them eventually became parts of an integrated drainage system whose master stream, the Colorado, reached the sea. In the soft, uniformly textured Tertiary rocks that once covered most of the plateau country, the streams developed in the usual fashion, but as their channels were deepened, more resistant rocks in various attitudes were encountered. To escape these obstacles, some streams developed new round about courses, but many were so firmly established in deep trenches that readjustment was impossible, and as erosion of the adjacent lands proceeded their position became glaringly out of accord with the topography. Thus, with seeming disregard of regional features, the Green River crosses the Uinta Mountains, the Uinta Basin, and the Tavaputs Plateaus, and its tributaries pass through, instead of around, rock domes; the San Juan River meanders through Hogback Mountain and the Monument upwarp; the Paria River crosses the East Kaibab monocline; the Virgin River plunges through the Hurricane Cliffs, and farther on through the Beaverdam and Virgin Mountains; and the Colorado itself flows squarely across the Grand Hogback and the Waterpocket Fold and has cut a mile-deep trench across the Kaibab Plateau. Obviously, these streams, so strangely out of place in the present landscape, are superposed; they have inherited courses established on higher, less complex surfaces. They illustrate the superposed stream pattern characteristic of the entire Colorado drainage basin.

In developing their runways by down cutting, headward cutting, and the sluicing-out of rock waste, the Colorado and its scores of tributaries have removed from their drainage basin rocks with an average thickness of about 5,000 feet, and during this process have exposed all the major geologic formations. Along the Grand Canyon, where vigorous erosion has continued longest, rocks of Pre-Cambrian and Paleozoic age lie at the surface; northward across Utah, Mesozoic rocks predominate; and in southwestern Wyoming the floor of Tertiary limestones and shales is almost continuous.

In southern and western Arizona, below the great plateau region, the Colorado River and its tributaries drain an area totally different from that to the north. Rugged mountain ranges rise above broad, flat valleys like islands in the sea. The mountains contain rocks of many geologic ages and their structural histories are complex. Surrounding plains are in reality deep valleys that have been filled to thousands of feet with debris worn off the mountains within relatively recent geologic time. The present drainage follows the gentle surfaces of these valley floors between the ranges, flowing over sediments at low elevations.

The Colorado River drainage basin comprises areas of unlike physiographic and geologic history. For convenience of description they are listed as provinces, each of which is discussed as a separate unit. They are the Green River Basin, the Uinta Mountain Region, the Colorado Plateau (north and south portions), the eastern and western border lands, the
Arizona mountain region, the Arizona volcanic areas, and the basin and range province. (Plate 3, in pocket.)

GREEN RIVER BASIN PROVINCE

In its broad relations, southwestern Wyoming and an adjacent narrow strip in northeastern Utah, together with an area of considerable size in northwestern Colorado, comprise a topographic depression of about 30,000 square miles, shown on modern maps as the Green River Basin or the western part of the Wyoming Basin. The basin is completely enclosed except for a deep trench in its south rim, through which the waters carried by the Green River and its large tributaries—Sandy Creek, Little Snake River, Yampa River, Vermillion Creek, La Barge Creek, and Blacks Fork—pass southward and finally reach the master stream the Colorado. (Plate 3, in pocket.)

The general floor of this regional basin consists of flat stretches and broad slopes of gentle gradient trenched by relatively broad valleys and shallow canyons, but is roughened by ridges and elongated domes sufficiently high and resistant to erosion to outline somewhat poorly defined subordinate units. The Rock Springs Dome and the White Mountains separate the Great Divide Basin—4,200 square miles in extent—from the Bridger Basin, the latter extending along both sides of the Green River, from the foothills of the Wind River and Gros Ventre Mountains southward for 150 miles to the base of the Uinta Mountains. The lofty cuesta-like Lany Rim and Cathedral Bluffs mark the boundary between the Bridger and Great Divide Basins and the Washakie Basin, and farther south the anticlinal Cherokee Ridge separates this structural depression from the much larger Yampa Basin.

Though its average altitude exceeds 6,500 feet, the Green River Basin is surrounded by mountains 10,000 to 12,000 feet high. At its northeastern border stands the massive Wind River Range. On its southwest side, the broadly exposed granite core of the range rises abruptly from the flat lands of Bridger Basin along a fault, and northeastward is flanked by the truncated edges of steeply inclined strata. The Wind River Range originated as an uplift in late Cretaceous time, during which thick, horizontal Paleozoic and Mesozoic strata were bent upward in elongated anticline. Then during a long period of erosion the up-arched strata were worn down to Pre-Cambrian rocks and the mass uplifted again and reexposed to erosion by the present-day powerful streams.

The southeastern border of the Green River Basin is defined by the Park Range, which essentially is a mass of ancient granite; the basal rock of an anticlinal uplift that in Pre-Tertiary time was deeply mantled with sedimentary rocks. In consequence of erosion, a second uplift, and recent dissection by streams, the originally arched surface of the range has been worn down to a plateau of moderate relief, above which in places rise craggy, glaciated alpine ridges to heights exceeding 12,000 feet. The eastern border of the Green River Basin between the Park Range and the Wind River Mountains is poorly defined. For a distance of 125 miles the rocks characteristic of the crests of the high ranges along the Continental Divide occupy a huge structural sag, where they are covered by sediments of younger age. In the place of the usual topographic drainage divide, the
margin of the basin is a sinuous line across featureless plains where the intermittent and ephemeral streams tributary to the Green River seem to be interlaced with those flowing eastward to join the Platte.

The western border of the Green River Basin is a belt of parallel mountain chains—the prominent Wyoming Range, Salt River Range, and Oyster Range—that rise 8,000 to 11,000 feet above the Intermontane valleys, and southward decrease in height to less than 1,000 feet. Their component strata, chiefly sedimentary, are closely folded—much like those of the Appalachian Mountains—and are broken by faults of enormous dimensions. In the Bannock fault, 150 miles long, the rocks have been overthrust toward the east, possibly as much as 35 miles. At Aspen Ridge (Aspen Station, Union Pacific Railroad), an anticline is crossed by three long faults, in one of which (the Absaroka) the strata were raised more than 15,000 feet, bringing Jurassic rocks to the level of the Tertiary. These border ranges are famous as illustrations of geologic structure, and if made more accessible, doubtless would be visited each year by many students. (Plate 13, Sections 1 and 2, in pocket.)

The drainage pattern of the Green River Basin is peculiar; to an extent not duplicated elsewhere in the United States, the alinement of rivers and creeks is out of accord with the topography. Bitter Creek goes through, instead of around, the Rock Springs Dome, crosses a valley, and then plunges directly into the face of White Mountain. In the present topography an unobstructed course lies 1,000 feet below. Equally remarkable is the drainage of the Great Divide Basin, particularly the Red Desert, where the streams have no outlet. On a surface of flat land, ridges, and remnant mountains they terminate in alkaline lakes or die out on mud flats in the midst of brightly colored sand dunes—the all-year home of antelope and a winter grazing ground for sheep.

The interpretation of the anomalous stream pattern its wholesale disregard of present day mountains—involves the assumption that the Pre-Tertiary rough floor of the Green River Basin—its highlands and lowlands alike was completely buried by younger sediments and that the courses of streams established on the new-made surface have been maintained regardless of the structure and composition of the exhumed mountains encountered in down cutting. In geologic terms, the entire drainage system is superposed.

Within the Green River Basin most of the exposed rocks are sedimentary in origin and geologically very young. Lavas cap a few mesas and, at Leucite Hills, lavas, volcanic tuffs, and ash occupy about 750 square miles; in a few places Upper (?) Jurassic rocks are in sight; and Upper Cretaceous beds crop out in some valleys and inter-stream areas and are uptilted along folds and faults. But the basin is almost completely filled with Tertiary strata in nearly horizontal position. (Pl. 13, Secs. 1 and 2, in pocket.) The hard Cretaceous rocks form hogback ridges, while the poorly consolidated Tertiary strata erode into banded cliffs and picturesque castles, towers, "pulpits," and "witch rocks," in places into extensive badlands. From them have been obtained the fossil mammals, fish, birds, and plants exhibited in American and foreign museums.

Yampa River Valley.—The salient Yampa River Valley topographic and
The geologic features of the Green River Basin in Wyoming extend southward into northwestern Colorado where an area of about 2,000 square miles drained by the Yampa River, particularly its chief tributary, the Little Snake River, is surfaced with rocks of Tertiary age. This plainlike expanse, most of it north of the Yampa, is trenched by shallow streams, and its easily eroded soft rocks have been carved into attractive small-scale badland forms. Locally, the Tertiary beds are overlain by lavas or so far stripped away as to expose Cretaceous sandstones, igneous dikes, and volcanic necks. At the Elkhead Mountains, a lone mass of metamorphic and igneous rock that culminates in Hahns Peak (altitude 10,824 feet) interrupts the continuity of the flat-lying Tertiary beds. Near its mouth the Yampa has cut deeply into the steeply tilted rocks of the eastern Uinta Mountains, exposing the edges of Paleozoic and Mesozoic strata. The Yampa also transects Cross Mountain and, farther east, Juniper Mountain, which are short domelike masses that rise abruptly from the regionally flat surface. Like Douglas Mountain and Spring Mountain north of the river, these conspicuous landmarks are anticlines once arched over by Cretaceous rock but now so deeply eroded that the Cambrian and Pre-Cambrian core rock is exposed, and against it the Paleozoic and Mesozoic formations lie in orderly sequence. In shape and structure these isolated masses are so like the Uinta Mountains that they have been dubbed "Little Uintas."

Also suggestive of the Uinta structures is the remarkable Axial Basin a valley formed by stripping away the crest of an anticline which crosses the Yampa River and farther southeast merges with folds of the White River Plateau. The sequence of strata shows that the anticline is post-Eocene in age; the date of the second up-arching of the Uintas. South of Juniper Mountain, beyond the Axial Basin, the land rises to the anticlinal Danforth Hills, which stand 2,000 feet above the bordering lowland and outline the drainage divide between the Yampa and White Rivers. Here in the Cretaceous rocks, Goodsprings, Wilson, and Morgan Creeks, and Maudlin and Temple Gulches have cut deep channels across hogback, ridges, and the Collom syncline. From Juniper Mountain to Steamboat Springs, Colo., except near the mouth of Elkhead Creek, where Tertiary rocks are exposed, the Yampa and its southern tributary flow on Cretaceous rocks, developing broad valleys and rounded hills in soft shales, and rugged landscapes of ridges, mesas, and "pagodas" in the most resistant sandstone. The many-branched Williams Creek, Trout Creek, and the Upper Yampa start abruptly at the Flat Tops extensive sheets of basalt and andesite.

East of the latitude of Steamboat Springs, characteristic landscapes of the Yampa Basin entirely disappear. In the topography the plainlike surfaces developed on approximately horizontal beds are replaced by rugged mountains trenched by steeply inclined streamways and, as stratigraphic units, the dominant Tertiary formations are replaced by schists, gneisses, and granites. In other words, the southeastern edge of the Green River Basin—the northeastern edge of the Colorado River drainage basin lies on the west slope of the Park Range and its features are those of the Rocky Mountains rather than of the plateau lands farther southwest.

If approach roads were available, the deep meandering canyon of the lower Yampa and a large part of the ruggedly carved landscape along its upper tributaries, now accessible only on foot or horseback, would add much to the recreational resources of northwestern Colorado (Plate 13, Section 5, in
White River Valley.—In transporting White River Valley surface water and rock waste from northwestern Colorado to the Green River, the streams that drain the Yampa River Basin are assisted by those within the similar, but much smaller, White River Basin. Like the Yampa, the meandering White and its major tributaries have developed most of their channels in nearly horizontal Tertiary strata and have cut into Cretaceous and older rocks only where anticlines lie athwart their long-established route. In the soft Tertiary rocks, the streams have cut innumerable runways and thus have carved the surface into flat-topped ridges, mesas, and towers which are well displayed at Cathedral Bluffs, Gray Hills, Powell Park, and Douglas Peaks features of the "Goblin City" mentioned by diarists of the second Powell Expedition. (Plate 13, Section 6, in pocket.)

Figure 19.—The Green River passed through Split Mountain, part of the Uinta upwarp.

UINTA MOUNTAIN PROVINCE

Uinta Range.—As a highland belt 25 to 40 miles wide with an average elevation exceeding 11,000 feet—2,000 to 6,000 feet above the peripheral lowlands—the Uinta Mountains are the dominating topographic feature of northeastern Utah between the Wasatch Mountains and the Green River. In some respects the Uinta Mountain region—the lofty Uinta Range and the Uinta Basin along its southern base—is unique. In contrast with the general north-south alignment of similar topographic features elsewhere in the Colorado drainage basin, in fact, within the United States, the mountain mass, its bordering structural valleys and its principal fault lines trend east-west and, unlike that which characterizes the mountainous masses along the eastern edge of the Colorado Basin, the topography is in close accord with the structure. As a major feature of the regional landscape, the present Uinta Mountains differ little except in height from their ancestral forms; the
crestline seems always to have been approximately the drainage divide and the bordering slopes to have retained their original position. The widely exposed core rock of the Uinta Mountains is the brick red, thickly bedded quartzite and sandstone of the Pre-Cambrian Uinta formation. On the flanks of this central mass, Paleozoic and Mesozoic formations in normal sequence are everywhere steeply tilted and, on the north and east sides of the mountain, broken by faults, some of great magnitude. (Plate 13, Sections 3 and 4, in pocket.)

The rocks of the Uintas contain a rich fossil fauna. The bones of dinosaurs are particularly abundant in the Jurassic Morrison formation at Dinosaur National Monument.

The major events in the geologic history of the Uintas include two periods of crustal movements, two of widespread denudation, and an epoch of glaciation. Soon after the close of the Cretaceous period the rocks of the region were pushed upward in the form of an elongated fold, thus bringing strata previously below sea level to altitudes exceeding 20,000 feet (Powell's estimate is 30,000 feet). This great up-arching was associated with down-warps paralleling its borders—on the north the Bridger Basin, on the south the Uinta Basin, and on the east the Yampa Basin. Then followed a period of erosion, an estimated 45,000,000 years, during which the range was greatly reduced in height. The bordering strata were truncated, and rock thousands of feet in thickness eroded from the highlands, the sediments being deposited in the adjacent basins, forming thick extensive deposits of sands and muds, now represented by the formations of early and middle Tertiary age. Before denudation ceased, the original lofty mountains had been worn down to a low-lying surface, probably of inconsiderable relief. In late Tertiary time, crustal upthrust was renewed, the remnant of the original arch was raised, and the edges of the flat-lying surrounding sediments were bent upward. There was thus introduced a second major cycle of erosion which has not yet come to an end. The new conditions have been favorable for roughening the surface of the mountain mass by cutting deep canyons and outlining peaks and ridges, especially along the borders. Twice during the glacial period the summit mountain surfaces were covered by ice. Thirty distinct glaciers, the smallest 1-1/2 miles long and the largest 27-1/2 miles long, extended down the highland valleys. Over an area exceeding 1,000 square miles only a few peaks and narrow divides escaped burial. The peculiar work done by these stationary ice caps and slowly moving ice streams is plainly recorded by striated rocks, cirques, U-shaped valleys, moraines, and glacial lakes—about 400 of them large enough to be shown on maps.

Most of the streams in the Uinta region are in accord with the topography, and also generally with the structure. They occupy synclinal troughs or DESCEND THE FLANKS OF ANTICLINES, and locally follow courses determined by the relative hardness and attitude of the rocks encountered. In other words, they are consequent or subsequent streams. A conspicuous exception to the normal arrangement is the Green which, after flowing southward for 150 miles over soft flat-lying rocks, abruptly turns east, crosses a great fault, meanders through the hard, steeply upturned rocks along the flanks of the Uintas, and passes entirely through the range in spectacular canyons. To account for this abnormal course involves the supposition, based on a study of the regional geology, that the ancestral Green River was established on a
surface that lay far above its present canyon walls at a time when the eastern end of the Uintas was buried beneath strata of late Tertiary age. In consequence of readjusted alinement caused by the growth of its tributaries and by local tilting and faulting, the stream became so well established that it maintained its course, cutting through the soft rocks and on into the complex hard rocks its present floor. Like many rivers in surrounding regions, the Green through the Uintas is superposed; its course has been inherited.

**Uinta Basin.**—Among the physiographic features of outstanding interest in northeastern Utah and northwestern Colorado, the Uinta Mountains are matched by the Uinta Basin which covers an area of about 8,000 square miles in Utah and 7,000 square miles in Colorado drained by the Green River and its large tributaries, the Duchesne, Uinta, Yampa, and White Rivers. From the Wasatch Mountains the basin extends eastward for about 170 miles to the White River Plateau, as a border belt for the Uinta Range and the Axial Basin anticline. Southward from the base of Uinta uplift it extends to the crest of the Book and Roan Cliffs 40 to 120 miles distant. Within this large area a few remnants of an ancient erosion surface are exposed, but generally the older rocks lie beneath thick deposits of Tertiary age exposed to view only in the deep canyons. These Tertiary rocks, 500 to 12,000 feet thick, floor not only the Uinta Basin but also the lands east and north of the Uinta Mountains. (Plate 13, Section 3, in pocket.)

The Uinta Basin is both a topographic and structural depression. In generalized north-south profile across its central part, the surface descends from 7,000 feet at the base of the Uintas to about 5,000 feet (along Green River, 4,000 feet), then ascends to altitudes of 8,000 to 9,000 feet. This topographic expression is largely in accord with the attitude of the underlying sedimentary rocks. In structure the basin is a long syncline; from its axis northward, the strata bend upward to the base of the Uintas and southward up the back slopes of the Tavaputs Plateaus.

The Uinta Basin is a profitable agricultural section, a potential oil field, and the site of the largest and oldest Indian reservation in Utah. It is a famous source of fossils, and derives additional geologic interest from its scattered outcrop of solid hydrocarbons, which include rare types, some of them unique and little understood—uintaite, native asphalt, ozocerite (mineral wax), wurtzililze, tabbyite, and bituminous sandstone. Especially peculiar are the deposits of commercially valuable gilsonite, which on both sides of the Green River fill deep vertical cracks 1 to 8 feet wide and 3 to 8 miles long, and appear at the surfaces as conspicuous black streaks.
Chapter III:
PLANT AND ANIMAL LIFE

RECREATIONAL VALUE OF PLANTS AND ANIMALS

Plants.—Regions devoid of plant life are among the most uninhabitable wastelands in the world. The rains or melting snows, unchecked by an absorbent mantle of forest or grassland, sweep over the bare slopes in torrents, carving out gullies that grow with the years until they become great barren valleys. Then, with the passing of each unchecked flood, the watercourses shrink to a trickle or vanish entirely.

Without plants there can be no cool, clear trout streams; no shady camping spots; no fertile, humus-bearing soil; no food for other forms of life. Even in desert lands there is usually a thin mantle of plant cover which, though sparse, helps hold the soil in place and permits a foothold for higher forms of life.

Recreational enjoyment of plants ranges from subconscious appreciation of their beauty and shade to active interest and wonderment at the marvelous diversity of plant forms which results from their adaptation to the earth's extremes of climate and environment.

Unity of plants and animals.—Plants and animals are dependent upon one another in a manner so complex and far reaching that they cannot be fully enjoyed, or protected, separately.

As an example of this interdependence, in mountain regions acorns roll downhill when they fall from the trees. Therefore, in the course of centuries the forests would travel downward from the high country and eventually would disappear if their reproduction were not assisted by other members of the plant-animal community. However, jays, woodpeckers, squirrels and other small animals that eat acorns assist the forest through their habit of carrying off and storing the surplus crop.

Abert squirrel
Often these creatures fly or run up hill with the seeds, and not infrequently they fail to find them or are caught by some natural enemy before the storehouse can be used. Seeds which sprout from these abandoned supplies become the trees which maintain the forest in the high places. [1]

In a like manner, many species of desert yucca are wholly dependent for their pollination upon a single kind of moth. This insect thrusts its eggs into the plant tissues surrounding the future seed, where the larvae will be safe from most enemies, and at the same time collects and applies the yucca pollen by means of mouth parts that are specially shaped for this work. [2]

A commonplace, though very important and often forgotten, example of plant-animal dependence is the plowing and cultivation of the soil by billions of insects, earthworms, field mice, pocket gophers, moles, and other small burrowing animals. The vegetable matter that they drag underground to line their nests, or to eat, is transformed into humus that is essential to plant growth. In addition, the loosening and turning over of the earth through burrow excavations permits air to enter, which is required by the humus-forming bacteria. It also allows water to penetrate the soil, which otherwise would settle and pack year by year until it became as impervious as sandstone. When water penetrates the earth instead of quickly running off the surface, there is far greater plant growth; the soil washes away but little or not at all; floods are fewer; the soil is more fertile; and the land is a better place for living—and for recreation.

Animals.—If plants are essential not only to other forms of life, but to most recreation, animals are hardly less so.

During the decade ending in 1930, hunters and fishermen increased 400 percent and totaled 13 million. It was estimated that the recreational attraction of wildlife accounted for 254 million dollars of tourist expenditures annually, and that 158 million dollars was spent by hunters. [3]

By 1945, in spite of wartime restrictions, 20 million anglers and hunters spent 2 billion dollars per year in pursuit of their sport. [4]
The postwar trend toward shorter working hours and increased leisure no doubt will result in still more hunting and fishing. Some estimates place the future annual expenditures for this purpose at 3 billion dollars. [5]

At the beginning of the war only about 2 percent of the millions who went into the armed forces had previous experience with firearms. Their new skill and acquired habits of wide travel surely will further stimulate hunting, and no doubt fishing as well.

The trend may be still further accelerated if there should be a revolutionary increase in civilian aviation, permitting the average sportman to reach even the remote and choicest fishing and big game areas in a few hours.

Fishing and hunting are only two of many recreational values of wildlife. Rivaling the sportsmen in enthusiasm is a rapidly increasing group of amateur and semiprofessional wildlife photographers. Though the hunter may have a lifetime of unforgettable experiences, the wildlife photographer can claim an even richer field of opportunity and golden memories. For him there is no closed season, and no animal, however rare, is on his forbidden list. With luck and patience he may "catch and hold," to enjoy forever, yet unharmed, many beautiful and vanishing creatures denied to the hunter, such as the trumpeter swan of the northern lakes or the stately bighorn of the crags and canyon walls.

Probably even more important, though less vocal than these special groups of enthusiasts, are the millions of persons who derive lasting enjoyment from just watching and being near wildlife. For them the splash and spreading ripple of a beaver on a twilit pond or the fairy-like chimes of a thrush in the cathedral stillness of a forest, are a source of inspiration complete in itself. Their enjoyment is not to be measured in dollars, any more than sunshine or freedom can be so measured.
Chapter IV:
PREHISTORY OF MAN

Wherever one travels in the Colorado River Basin he is certain to be impressed, sooner or later, with the abundant and basin-wide evidence of prehistoric occupation and use by man—extensive ruins of ancient buildings; early camp sites strewn with broken pieces of pottery; shaped stones; ancient ears of corn; and strange symbols and drawings on rocks and cliffs. Curiosity and interest are immediately aroused. Exploring the ruins and learning the dramatic story of these early peoples is one of the recreational activities of the basin. These evidences of prehistoric settlement and use of the lands and waters of the Colorado River Basin constitute a resource of important recreational and historical significance—of unique and irreplaceable value to the Nation.

Nowhere in America is the story of man's struggle with environment so vividly told. Here, to survive, man had to develop an uncommonly keen sense of things about him. He had to know what plants were natural providers of food and where they grew; the habits of game animals; how to go from place to place over long waterless wastes; the location of fertile lands for planting and how best to coax his crops from these lands, whether by taking advantage of natural subsurface moisture or by directing water to them by means of canals; and above all the source of water, the elemental necessity for human existence, affecting directly, along with the food supply, the stability and population density of a sedentary people. Since geography plays such an important part in determining the pattern of culture of a people, the following review of man's history in the Colorado River Basin must consider the physical environment as the back drop against which the cultural achievements can be projected.

The archeological story of this region is laid essentially in the valleys, for here the prerequisites of land and water were at their best. And our modern twentieth century civilization follows precisely the same pattern, since water is still the most precious asset of this entire region. Consequently, the priceless and irreplaceable ruins and relics of the prehistoric peoples of the region are found concentrated primarily along the streams including the major waterways which modern civilization is essaying to control and harness. As the reservoirs rise behind the new dams, and as lands below are modified, archeological remains not excavated in advance will be forever lost.

It was the permanence of abode—dictated by the tremendous investment
in the construction of the canal systems by the people along the Gila and Salt Rivers, or the labor expended in the founding of great communal settlements, the Pueblo apartment houses of the Colorado Plateau, wherever land and water permitted that led to the notable achievements for which the native folk here have become renowned.

As pointed out in Chapter I, the full range of environmental types, from the hot, barren, inhospitable desert to the cool, forested altitudes of the mountains, is found within the basin. Accordingly, the archeological picture is exceedingly complex and the following review is not more than a brief inspection of the general historical and cultural elements.
Chapter V:
FACTORS DETERMINING THE RECREATIONAL BENEFITS OF RESERVOIRS

LOCATION

In the Colorado River Basin, where few lakes occur naturally, the creation of large water bodies is of great recreational importance. This is especially true in the large, arid, lower portions of the basin. The higher portions of the basin are fairly well supplied with clear, year-round streams and attractive small lakes. Here reservoirs play a much less important role in the general recreation picture.

On the whole, a reservoir on a mountain stream will be of less benefit for fishing than one on a lowland stream, at least in the Colorado River Basin, and may be seriously detrimental to fishing. One reason for this is that the mountain streams usually are silt-free, and provide a fair-to-excellent habitat for fish even before construction of the reservoir. Another reason is that in the Colorado River Basin the majority of the potential mountain reservoirs as now planned will have a large drawdown. Thus, fluctuating shore lines, with their drastic curtailment of aquatic food production, are substituted for the relative stability of the original mountain stream condition.

As will be shown, the potential productivity of a reservoir is rather closely limited to the area of shallow bottom that is kept at a favorable depth for plants, rather than by mere volume of water. The productive area of a proposed deep reservoir usually will occur only along the shallow margins, whereas the productive area of the mountain stream that it is to replace usually comprises the entire stream bed from bank to bank. Extreme examples occur, particularly in Colorado, wherein existing fish production and extremely important attendant recreational values on various beautiful mountain streams would be jeopardized by the substitution of relatively barren reservoirs with bleak, fluctuating shore lines. One of the best of such examples is afforded by the Gunnison River, which is one of the finest natural trout fishing streams in the United States. Reservoirs on the upper reaches of this river and its major tributaries would, in most cases, destroy more recreational values than they could supply. On the other hand, reservoirs near the headwaters of these tributaries sometimes bring an increase in production and furnish good fishing, as in the case of the Taylor Park
Reservoir near the upper end of the Taylor River. In this case, improvement may have resulted from the substitution of a large body of water with extensive, shallow shore lines for a previously existing small streamway. It illustrates again the need of estimating the effects of each proposed reservoir separately.

Reservoirs in national forest primitive areas and other high mountain country usually add little if anything to the general recreational value of the area and frequently destroy more than they create. They alter natural conditions just as do roads and other facilities. Construction of the dam requires roads for the transportation of men, materials, and machinery. Aggregate or fill for the dam is usually obtained as near as possible to the dam site, eliminating a piece of wilderness. Stockpiles and construction camps take more. Tunnels and canals for transporting the water from the reservoir to the area of use further spreads the effects of the project. The cuts and fills required for highline canals on mountainsides are frequently visible for long distances. This is not all. The mere fact that these works exist eliminates the important intangible value of an area undisturbed by works of man.

There are a number of instances in the Colorado Basin where the economy of the nearby communities is dependent to a large degree on the income from fishermen and vacationists attracted to the region from considerable distances. If the rarer trout stream fishing is replaced by the more common and widespread reservoir fishing, it is likely that the attraction of these regions will be considerably less.

Converting natural lakes into reservoirs.—In the Colorado River Basin, the enlargement and conversion of a natural lake into a reservoir rarely, if ever, will increase biological productivity and benefit fishing or related recreation. Raising the level of the lake obviously is for the purpose of using the additional water, which means that a considerable fluctuation will take the place of the former stability. The additional volume of water will not bring a corresponding increase in productivity. Only the addition of permanent, nonfluctuating, shallow water can do this. The prospect of such a loss of original productivity and recreational value, without any corresponding recreational gain, is illustrated by a plan, subsequently abandoned, to dam beautiful San Cristobal Lake on the upper reaches of Lake Fork of the Gunnison River.

Reservoirs in arid regions.—More often in the Colorado River Basin the creation of a lake will introduce recreational activities and be of distinct value to the district. Many of the reservoir sites are in arid regions where water is a welcome sight and, though some of the reservoirs may not be ideal for recreational use, they will still have some recreational value. Frequently the water area will provide an opportunity for a number of new enterprises such as cabin camps, boat equipment, supply and storage, fishing supplies, and refreshment establishments.

The construction of a large reservoir on a desert stream profoundly alters the immediate environment, and often improves it greatly for fish and some other kinds of wildlife. This is particularly true if the stream above the lake is heavily silt-laden. Water entering the lake loses its velocity sufficiently to deposit this silt. Productivity of the resulting clear water
in a warm environment of high light intensity may be increased a thousand fold, depending upon the degree of water-level fluctuation.

The improvement in the environment resulting from reservoir construction on a desert stream is not limited to the lake itself, and may be even greater in a section of the stream below the lake. The Colorado River, for a 50-mile stretch below Lake Mead, affords an excellent example of this kind of improvement. Water discharged from the lower levels of this deep reservoir ranges approximately between 54° and 61°F., [1] whereas temperatures for the undammed Colorado River at Yuma range between 40° and 90°F., with the normal variations perhaps 10°F. less extensive than this. [2] Violent churning of the water as it passes into the open air from the turbine outlet of the dam renews the high oxygen content. The silt-free water flows for 50 miles or more over clean gravel shoals that are covered by an almost continuous blanket of green algae. [3]

Growth of such bottom plants in the intense light is rapid, and is uninterrupted because the absence of a severe winter climate permits water temperatures to remain fairly constant throughout the year. The result is that fish-food organisms also multiply enormously and continually. Trout, which normally could not exist within scores or hundreds of miles of this stretch of river, have been introduced with great success. They grow rapidly and so uniformly that the age determinations on the basis of growth rings on scales have been futile. [4]

Reservoir construction on desert streams can be of great benefit to recreation when, as in the case of Lake Mead, it substitutes a large, clear lake suitable for warm-water game fish, together with a section of Transition Zone trout stream, for the previous turbulent, silt-laden, and unproductive river waters.

By contrast, Lake Havasu, a municipal water supply reservoir 112 miles below Lake Mead, is far less productive of fish and other aquatic life because of the difference in its construction and functions. Although the reservoir is 42 miles long, the dam raises the water level only 75 feet at maximum, and the discharge occurs at only 50 feet below this extreme high-water line. For this reason, the stream below the dam, though silt free, is but little cooler in summer than the undammed river and therefore is unsuitable for trout, though favorable for warm-water fish. [5]

Still more in contrast to the deep, relatively stable power reservoirs, are most irrigation reservoirs, wherein the maximum drawdown usually occurs in the middle of the growing season for aquatic plants. The amount of drawdown may depend on year-to-year variations in rainfall and in the resulting storage capacity, and therefore may be less excessive during the wetter years. Nevertheless, the general operational cycle of irrigation reservoirs usually is characterized by far greater extremes of fluctuation than is the case with power reservoirs. Production of plant and animal life, therefore, is far from stable, while in extreme cases, which unfortunately are numerous, water levels drop so far that the reservoirs are biological deserts.
Convenience of access is an important factor in determining the value of an area for recreational use. Reservoirs on or near high-standard roads are likely to receive a much larger use than those reached by mountainous, narrow, rough, sandy, or otherwise difficult approach roads. In the case of the smaller reservoirs where the bulk of the use comes from the neighboring communities and farms, travel distance is a prime consideration. If the area is within an hour's drive, the day use may be expected to be of importance; if more than 2 hours' driving distance away, the area probably will not be used extensively unless overnight accommodations are available.

Population of region.—In general, the recreational use of a reservoir is in proportion to the population density of the region in which the reservoir is located, but a number of limiting factors enter into the picture, such as the character of the population, climate, nature of site, operation of the reservoir, type and quality of the facilities provided, administration, and maintenance.

It has been found that a larger percentage of the urban than the rural population may be expected to use the reservoirs for recreation; also that reservoirs located in the recognized vacation regions as, for example, the winter vacation region of southern Arizona and the summer vacation region of Colorado, will have a greater use due to the number of people in the region primarily seeking recreation.

NATURE OF SITE

The topography of the reservoir area determines to a considerable degree the amount of recreational use that can be made of the area. Reservoirs situated in open valleys usually offer more and better opportunities than those located in steep-sided canyons, where access to the water is difficult and sites for recreational facilities are limited. On the other hand, a very flat slope is also objectionable because of the wide shift of the water line between high and low water levels, frequently leaving unsightly mud flats exposed between the usable land above high water and the lake. The ideal situation is where the top of the dam is determined by a flattening of the topography so that there are gentle slopes adaptable to recreational development near both the high and low water lines.

Sandy soil along the shore line and the presence of trees and shrubs for shade and stabilization of the soil are other assets. Freedom from mosquitoes and other annoying insects is an important consideration in selecting sites for camping, swimming, and other activities.

Outstanding land forms, colored rock, interesting plant growth, or historic and scientific features in the vicinity of a reservoir tend to increase the attendance at the area. Especially are visitors from a distance attracted to the area by the publicity given these special features.

Although the recreational use of a reservoir will depend to a large extent upon the quality of fishing that can be maintained, the adaptability of the
reservoir area to a diversity of recreational activities will increase its use and value. As with fishing, however, the quality and adequacy of the recreational facilities will have much to do with the amount of use a reservoir area will receive.

Among the requisites for a successful swimming area are: A comfortable surface underfoot, sandy and free from mud, rocks, and weeds, both above and below the shore line; water temperature about 70°F. or above; protected shallow areas for small children and nonswimmers; and deep-water diving areas. Camping areas are more popular when some privacy is offered between camp sites, which means the presence of adequate plant growth for screening. Parking spaces convenient to the boat docks, beach, and picnic areas contribute to the success of the development.
Chapter VI:
POTENTIAL RESERVOIRS

The survey of the recreational resources of the Colorado River Basin involved the consideration and investigation of about 135 potential reservoir sites. (Plate 15 in pocket.) The object of the investigation was to ascertain, at least in a preliminary way, the character of the area which would be flooded or affected by the reservoir; the recreational and scientific importance of the scenic, historic, geologic, archeologic, or biologic features of the reservoir area; the effect the potential project would have on important existing features; and the potential recreational values of the reservoir area.

In most instances, project plans had not been completed for the dams and reservoirs, and in many cases the only information available at the time was the approximate location and purpose of the dam and the size of the reservoir. Hence, it was not possible to make a final appraisal of the potential recreational values of the reservoir. Generally, however, it was possible to determine whether important recreational features existed in the reservoir area and whether the potential reservoir would or could have recreational values.

In a number of cases, particularly in regard to smaller reservoirs, the recreational potentialities of the site will be increased considerably if, as the project investigations progress, it is found possible to provide a dead storage or conservation pool.

For convenience in planning the development of the water resources of the Colorado River Basin, the Bureau of Reclamation has divided the basin into seven main divisions suggested by physical characteristics. The same divisions are used in the following discussion.

GREEN RIVER DIVISION

*Upper Green River Basin.*—In the Upper Green River Basin, the Flaming Gorge, Red Canyon, Fontenelle, and Kendall Reservoir sites appear to be of most importance for recreation. The mile-long Flaming Gorge of the Green River is unusually colorful but it is not unique or outstanding in comparison with the colorful scenery found farther down the Green River. However, the combined scenic and geologic interest of Flaming Gorge, the nearby Horseshoe Canyon, and the canyons of Sheep Creek, plus the proposed reservoir would make this section of considerable recreational value. There is certain to be a demand for recreational facilities in the
vicinity of the dam and at one or two points up the reservoir to serve people traveling through the region and those living in the vicinity of Green River, Wyo.

The Red Canyon Dam site, 31 miles below Flaming Gorge, is also in the scenic country on the north side of the Uinta Mountains. With the Flaming Gorge Dam the Red Canyon Reservoir should be fairly free of silt and should offer good fishing possibilities. The sheer walls of the canyon, however, greatly limit the possible use of the reservoir for recreational purposes.

The Fontenelle and Kendall Reservoirs on the Green River in Wyoming would be primarily of local recreational interest, but would receive some tourist use because of the proximity of United States Highways 189 and 187.

Most of the other potential reservoirs lie in the open sagebrush plains and hills and would offer little in the way of recreational attractiveness because of summer drawdown and lack of cover. Burnt Lake, lying within the Bridger National Forest, is notable for its natural scenery and its nearly complete freedom from artificial development. Alteration of the water level, as has been proposed, would ruin the scenic and recreational values of the lake.

Figure 51.—Flaming Gorge—looking down Green River to dam site. This is where the Green River starts cutting through the Uinta upwarp.
Figure 52.—Fontanelle Reservoir site—looking upstream from dam site.

Figure 53.—Burnt Lake on the west slope of the Wind River Range.
**Yampa and White River Basins.**—The Juniper and Upper Bear Reservoir sites are conveniently located to serve the more populated sections of the basin. With some development of recreational facilities and fishing, they should be popular with the local people and those traveling through the region. The other reservoir sites are situated in sparsely populated areas and would have little effect on the recreational resources of the basin.

**Uinta Basin.**—The two potential dam and reservoir projects, Echo Park and Split Mountain, will effect Dinosaur National Monument. These projects are discussed in Chapter IX.

The many good lakes and streams in the Uinta Mountains lessen the need for water recreational areas in the adjoining Duchesne and Ashley Valleys. However, the proposed Pelican Lake, Starvation, Stanaker and Red Creek Reservoirs should have some local recreational value. Crow Creek, in a remote location, would probably receive little use. The Hades site is on one of the main approach roads to the High Uintas Primitive Area. The proposed reservoir development would not compensate for the loss of the present recreational assets. The enlargement of Strawberry Reservoir is not likely to increase its present recreational values unless the percentage of drawdown on the enlarged reservoir is less than that of the present one.

**Price and San Rafael River Basins.**—This section lacks natural water areas suitable for recreational use. Hence, all of the sites, except perhaps the Buckhorn which is in desert country and would be subject to complete drawdown, should be planned for recreational use by the residents of the nearby irrigated districts. The Mammoth and Joes Valley sites in the Manti National Forest at fairly high elevations appear to offer the best possibilities.

The two large potentialities in this subdivision are the Desolation and Rattlesnake Dams located in the remote and almost inaccessible canyons of the Green River. The reservoirs formed by the two dams would extend...
from a few miles north of Green River, Utah, almost to Ouray, Utah. The main access of the reservoirs would be from these two towns. Although the reservoir areas have only been investigated from the air, it is doubtful that the scenic or recreational values, either existing or potential, will be found important. Present information indicates that scenically this section does not compare with sections along the Green above Jensen, Utah, and below Green River, Utah. Some archeological sites of importance have been found in side canyons, indicating that an archeological survey of the reservoir areas should be made well in advance of the completion of these projects.
Chapter VII:
THE GRAND CANYON

From the mouth of the Nankoweap Canyon on the east to the Grand Wash Cliffs on the west—more than 200 miles by river the Grand Canyon maintains approximately the same 5,000-foot depth and a width between rims measured in terms of miles. All sections of the Grand Canyon are parts of one natural physiographic unit. Although the general character and form of the canyon change greatly from place to place, there is an imperceptible transition from one section to the next, and all are inseparable parts of the one great canyon.

Man-made boundaries in the Grand Canyon mean nothing as to the relative value of different portions. It is not possible to say that one part is either inferior or superior to another; each is different but each is great and part of the whole.

BRIDGE CANYON RESERVOIR SECTION

The inner part of the Grand Canyon which would be affected by the proposed Bridge Canyon Reservoir may be divided both scenically and
Bibliography

geologically into four main divisions. The eastern division of the inner canyon, starting some miles above the mouth of Havasu Creek and extending almost to Toroweap Valley, is characterized by extreme narrowness of the gorge and by very high sheer walls of sedimentary rocks. Near the mouth of Havasu Creek, for instance, resistant beds of Muav limestone wall in the river and the soft shales that normally form the flat Tonto Platform below are not exposed, with the result that the inner canyon to a height of nearly 2,000 feet is extremely narrow, probably the narrowest within the entire canyon.

From Toroweap Valley to Whitmore Wash and beyond, the scenery has been changed by the introduction of vast quantities of volcanic materials and the cutting of the river progressively deeper into the sedimentary rocks, with consequent widening of the gorge. The Toroweap section is one of the most spectacular and remarkable parts of the Grand Canyon. At the foot of Toroweap Valley the nearly vertical walls of the inner gorge rise almost 3,000 feet above the river. Great lava flows have cascaded down into the gorge and cinder cones perch on slopes within the canyon. On the rim of the gorge at the foot of Toroweap Valley stands a large cinder cone known as Vulcans Throne.

Below Whitmore Wash the river turns south following the trend of several major fault lines—especially the Hurricane Fault to the north and the Peach Springs Fault to the south. The entire aspect of the canyon changes. It is considerably wider and cut into older rocks than those exposed in the Toroweap area. The most impressive part of this section is known as Granite Park.

From the great bend of the Colorado River at the mouth of Diamond Creek westward to and beyond the Bridge Canyon Dam site, the Colorado flows through the lower Granite Gorge, and the scenery near the river resembles that in the inner gorge of the Bright Angel section. Above the inner gorge the Tonto Platform also shows a resemblance to the corresponding feature in the eastern section of Grand Canyon.

On the south side of the canyon the great Cataract Plain extends west from the Williams-Grand Canyon Road to the Aubrey Cliffs—unbroken except for Cataract Canyon. West of the Aubrey Cliffs to the Grand Wash Cliffs are vast colorful canyons, plateaus, and mountains.

Prospect Canyon, which parallels the Aubrey Cliffs, provides a means of access to the high east rim of the canyon overlooking Granite Park. In this section, from Granite Park to Diamond Creek, the Grand Canyon reaches its greatest depth. The rim attains an elevation of 6,890 feet while the river at the mouth of Diamond Creek is an an elevation of 1,335 feet. From the piñon- and juniper-covered rim there are magnificent views of the brilliant canyon and the surrounding country. Hualpai Peak 72 miles to the southwest, the Music Mountains, and Peach Spring Wash are visible. To the northwest is the Shivwits Plateau. Below is Granite Park. Across the river to the north are the Pine Mountains, Parashont Canyon, and Whitmore Wash, and rising out of the red Tonto Platform like a huge ant hill is a volcanic cinder cone. The lava flow down from Mount Emma ending abruptly in Whitmore Wash and the gigantic row of red Supai windows projecting through the lava are also plainly visible. The scene is entirely
different from that of the Bright Angel section but equally grand. There are fewer dramatic formations in the canyon but a greater variety of landforms and an endless horizon.

Figure 67.—Burnt Springs Canyon from Twin Point—Grand Wash Cliffs form the skyline.

Peach Spring Draw, which joins Diamond Creek just before it enters the Colorado, provides the only natural grade suitable for a road to the bottom of Grand Canyon. Before the railroad was built to Grand Canyon Village, the old Diamond Creek Hotel near the mouth of the creek was the most popular place in the Grand Canyon. It may become popular again as an access point to the reservoir if Bridge Canyon Dam is constructed. Diamond Peak, near the junction of Peach Spring Draw and Diamond Creek, is one of the well-known geologic features of the canyon.
Figure 68.—Looking toward Whitmore Wash and Pine Mountains from Shivwits Plateau.

Figure 69.—Bridge Canyon and Gneiss Canyon (right). The inner gorge of the Colorado River is about 800 feet deep. (Air photo)
Spencer and Meriwitica Canyons, west of the Bridge Canyon Dam site, are fine examples of side canyons. Meriwitica Canyon is of special interest for, according to tradition, it is the original home of the Hualpai Indians. Between Spencer Canyon and the Grand Wash Cliffs the high points on the rim of the canyons offer views of canyon scenery as rugged, colorful, and interesting as any part of the Grand Canyon.

North of the river the region is divided into a series of canyons and plateaus. East of Kanab Canyon is the high, pine-covered Kaibab Plateau. Between Kanab Canyon and Toroweap Valley on the west is the comparatively uninteresting Kanab Plateau. However, from the rim of this plateau as at Boysag Point, Kanab Point, and Toroweap Point, there are marvelous views of the Grand Canyon. West of the gently sloping 3-mile-wide Toroweap Valley are the Pine Mountains, a series of forest-covered volcanic cones striped by large lava flows. West of the Pine Mountains are the spectacular Whitmore Wash and Parashont Canyons. Beyond them is the Shivwits Plateau, a green peninsula in the sky flanked by brilliantly colored deserts and canyons. The Toroweap-Whitmore Wash area, including the Pine Mountains and Parashont Canyon, is the most outstanding section west of Kanab Canyon. Here are the great faults, evidences of volcanic activity, pine forests and desert vegetation, springs, deep narrow canyons, and color.

The recreational value of the Shivwits Plateau is primarily in the fine views of the Grand Canyon from the rim and its remote wilderness character. However, the views are not unlike those obtained from the east rim of the Grand Canyon above Diamond Creek, and the high points along the latter rim are about 300 feet higher than Mount Dellenbaugh, the highest point on the Shivwits Plateau.

**LANDS AND AGENCIES INVOLVED**

All of the Grand Canyon is within areas now administered by the Federal Government through the Bureau of Indian Affairs, the National Park Service, the Fish and Wildlife Service, the Bureau of Reclamation, and the Bureau of Land Management, all of which are in the Department of the Interior, and the Forest Service of the Department of Agriculture.

The eastern side of the canyon between Lees Ferry and the Little Colorado River is part of the Western Navajo Indian Reservation. From Lees Ferry to Nankoweap Canyon, the west side of the canyon is partially in the Kaibab National Forest and partially public domain. Grand Canyon National Park includes all of the canyon from Nankoweap Canyon and the Little Colorado River to Tapeats Creek. From the west side of Tapeats Creek Canyon to the west rim of Kanab Canyon, the area north of the river is part of the Kaibab National Forest. On the south side, Grand Canyon National Park extends west to include Havasu Canyon. Grand Canyon National Monument lies between Grand Canyon National Park and Lake Mead Recreational Area, the greater portion being north of the river. Lake Mead Recreational Area extends west to include Havasu Canyon. Grand Canyon National Monument lies between Grand Canyon National Park and Lake Mead Recreational Area, the greater portion being north of the river. Lake Mead Recreational Area adjoins the southern portion of the monument on the west. South of the river, the Hualpai Indian Reservation extends from National Canyon almost to the Grand Wash Cliffs. Lake Mead Recreational
Area overlaps the Hualpai Indian Reservation to include most of the Grand Canyon south of the river which is within the reservation.

**BUREAU OF RECLAMATION PROPOSALS**

*Bridge Canyon Dam and Reservoir.*—Nineteen miles northwest of Peach Springs, Ariz., in the seldom-visited western half of the Grand Canyon, the Bridge Canyon Dam may some day rise to the towering height of 740 feet above bedrock if the present plans of the Bureau of Reclamation are carried through. Exceeding Hoover Dam in height, this dam would in turn be dwarfed by the canyon. Though the dam would raise the water 672 feet to a maximum elevation of 1,876 feet above sea level, the multicolored canyon walls would tower more than 4,000 feet above the fiord-like lake. The quiet water of the lake thus created would extend upstream 93 miles to within a tenth of a mile of the mouth of Kanab Creek. At normal water surface elevation 1,866 feet, it would extend to within four-tenths of a mile of Kanab Creek. The minimum surface elevation of the reservoir would be 1,645 feet.

Bridge Canyon Dam is proposed primarily for the generation of power. Coincidental with the construction of the Bridge Canyon Dam would be the construction of the Coconino Dam on the Little Colorado River 49 miles upstream from the Colorado River and the Bluff Dam on the San Juan River 132 miles upstream from its mouth. Both of these dams would serve as flood control and silt detention structures. The Bluff Reservoir also would regulate the flow of the San Juan as required by downstream power plants. These two dams are essential to the life of the Bridge Canyon Reservoir.

*Marble Gorge Dam and Kanab Tunnel.*—Following the Bridge Canyon, Coconino, and Bluff Projects in the Bureau's schedule of development would be the Glen Canyon Dam located 4.5 miles upstream from Lees Ferry. This dam would be for power development and river regulation. This project is discussed in Chapter VIII—Canyon Lands of Southeastern Utah. In the 150 miles between the Glen Canyon Dam site and the estimated headwaters of the potential Bridge Canyon Reservoir at normal water surface elevation, the Colorado River falls approximately 1,260 feet. About 100 miles and 950 feet of the drop are within the boundaries of Grand Canyon National Park. To take advantage of this drop and yet avoid the construction of dams or other works in the park, the Bureau of Reclamation suggests a plan for diverting the Colorado River waters "not needed to maintain a steady stream for scenic purposes in the park" through a 44.8 mile tunnel from just above the east end of the park to a power plant on the Colorado River near the mouth of Kanab Creek. The capacity of the Kanab Tunnel would be 13,000 second feet. A 298-foot dam at the Marble Gorge site 15.5 miles upstream from Nankoweap Canyon would divert water to the tunnel. Water released from the dam for scenic purposes in the park would pass through a power plant.

The maximum and normal water surface elevation of the Marble Gorge Reservoir would be 3,125 feet, the elevation of the Colorado River at the Glen Canyon Dam site, and the minimum water surface would be 3,115 feet above sea level.
Proposed operation of reservoirs.—According to present studies of the Bureau of Reclamation for reservoir operation in connection with the Parker diversion route of the proposed Central Arizona Project, Bluff and Coconino Reservoirs would be for the purpose of silt control. Glen Canyon and Marble Gorge would be future developments for river regulation, silt control, and power. Generally, the Marble Gorge Reservoir would be maintained at maximum content. However, during a critical year of operation the active content of Marble Gorge Reservoir would be withdrawn prior to utilizing the active content of Bridge Canyon Reservoir. Such withdrawal would be made only after the active storage contents of Bluff and Glen Canyon Reservoirs had been exhausted. Release through the Marble Gorge Power Plant would be at a uniform rate of approximately 1,000 second feet. Operation of the Kanab Power Plant would be closely coordinated with the operation of the Glen Canyon Power Plant.

Normally, after full river regulation is provided by upstream storage, Bridge Canyon Reservoir would be operated at maximum content with release of water for power corresponding to releases from Glen Canyon.

With this method of operation, the water surface elevation of Bridge Canyon Reservoir would normally be between 1,866 and 1,876 feet. Only in an extremely dry period would it be drawn down to a minimum elevation of 1,645 feet. The Marble Gorge Reservoir would have a maximum fluctuation of 10 feet between elevations 3,125 and 3,115.
Chapter VIII: CANYON LANDS OF SOUTHEASTERN UTAH

LOCATION

Broadly speaking, the region considered is the portion of the Colorado River Basin between Lees Ferry, Ariz., the Dewey Dam site on the Colorado, and the town of Green River, Utah, on the Green River, excluding the San Juan River Basin above Bluff, Utah, and the high plateaus along the west side of the basin.

The region is roughly bounded on the east by State Highway 47 and United States Highway 160; on the north by United States Highway 50; on the west by State Highways 10, 72, 24, the road through the Dixie National Forest from Torrey to Boulder, the county road from Boulder to Escalante, Utah, State Highways 23, 22, and 12, and United States Highway 89; and on the south by United States Highway 89, and the road through the Indian reservations from Tuba City, Ariz., to the Utah State line where it connects with Utah State Highway 47.

This report is especially concerned with the vast, colorful land of deserts, mountains, canyons, plateaus, and buttes that lie within the fringe of settlements and the connecting roads more than 20,000 square miles, in which probably less than 200 people have their permanent residence, exclusive of the Indians on the Navajo Reservation. Men running cattle and sheep in the area live in the bordering settlements and go out to their stock occasionally by truck and horseback. The shepherders camp here during the winter and move to higher mountain pastures for the summer. (Plate 9 in pocket.)

PRESENT ROADS AND TRAILS

This region is part of the largest section in the United States in which there are no improved roads. Within the belt there are no improved roads except the short spur to Henrieville, the road in Bryce Canyon National Park, and in the settled section around Price. Two hundred and ninety miles of the 800 miles of roads forming the belt are unimproved.

State Highway 24 crossing the northwest portion of the area from Green
River to Fruita in Capitol Reef National Monument is only a fair-weather trail, as is State Highway 95 from Blanding to Natural Bridges National Monument. The remaining roads in the area are truck trails constructed by the Grazing Service (now the Bureau of Land Management) or the local people to give access to cattle and sheep camps, mines, and oil prospects. Between Lees Ferry and Moab on the Colorado and the mouth of the San Rafael River on the Green River there is only one place where it is possible to drive to the rivers without extreme difficulty. The old trail down North Wash Canyon and up White Canyon to Blanding has been improved. The lower end of the trail from Escalante to Hole in Rock, a distance of about 6 miles, has not been used since the Hole in Rock pilgrimage in 1939, except by men on horseback. There has been a trail from Notom on State Highway 24, down Halls Creek to within a few miles of the river, but this was not passable in 1943 beyond a point 18 miles from the river. In the spring of 1943, trucks were driven from Kanab to the site of the old town of Paria, thence southeast to Lone Rock on Wahweap Creek, about 8 miles west of the point where the Colorado River crosses the Utah-Arizona State line.

On the east side of the Colorado it is reported that an automobile has been driven to a point west of the Clay Hills on the old Mormon Trail which runs from near Natural Bridges National Monument southwest toward Hole in Rock.

Fourteen miles north of Monticello there is an unimproved road leaving United States Highway 160 which gives access to the north side of the Abajo Mountains and Indian Creek Valley. Following this road down Indian Creek and around the north side of North Six-Shooter Peak, it is possible to drive, under favorable conditions, to the northeast edge of the spectacular Needles area, about 7 miles air line southeast of the junction of the Colorado and Green Rivers.

Half way between Moab and United States Highway 50 there is a truck trail leading to the west which gives access to the high plateau between the Green and Colorado Rivers. It is possible to drive to within 1 mile of the southern tip of the plateau. This point is about 3 miles from both rivers, approximately 2,400 feet above them, and 8 miles almost due north of their junction. Branch trails lead to Upheaval Dome on the west side of the plateau overlooking the Green River Canyon, and Dead Horse Point on the east side. Dead Horse Point is within a mile horizontally of the Colorado River and approximately 2,000 feet above it. Unquestionably the most spectacular and far-reaching views of the Colorado and Green River Canyons obtainable by automobile at the present time are from these trails on the plateau between the rivers. The only other point, now accessible by automobile, which rivals these, is Lands End at the southeast edge of the plateau between the Green and Dirty Devil Rivers. Excellent views of the canyon country are obtained along the last few miles of the trail from Hanksville to Lands End and it is about a mile walk from the end of the trail to Lands End, a high point on the rim of the plateau, only 5 miles from the Colorado River and more than 3,000 feet above it.

RECREATIONAL AND RELATED VALUES OF THE REGION
Monument Valley has been referred to as "The land of room enough and time enough." To this could be added beauty and thrills, and mystery enough, all of which are applicable to the Colorado River country of southeastern Utah. It is stark realism and mystical surrealism. Trying to make a living raising cattle on the Green River Desert or driving an automobile across its deep sandy wastes on a hot afternoon, one suffers the torments of hell, and curses the country and the reasons that brought him there. However, as the purple shadows begin to lengthen across the gold and red sands, as the towering buttes take on a rosy hue, and distant purple mountains are silhouetted against a royal blue sky, it becomes a dream world of marvelous beauty. Searching across barren rocks for a water hole in summer, or climbing a steep, rocky, snow-covered trail up a canyon wall in winter, you realize why no humans and few animals make their homes there; and yet, standing on Horse Mountain, or Dead Horse Point, or Lands End, or camping near a spring on the Kaiparowits Bench with the canyon of the Colorado below, and Navajo Mountain rising from its fluffy sandstone base across the way, you wonder why so few people have made their way to these places. You are exalted spiritually, but dwarfed by the scale of the scene. Your eye is attracted quickly from the nearby rocks to the mountaintops 40 to 70 miles away; across miles of bare, pink, red, buff, and white sandstone; down canyons 2,000 feet deep; and up buttes 1,000 feet high. All is yours—20,000 square miles or more and yet, to approach on foot or horseback even one of the nearby canyons is a giant's task.

It is a land of the unusual in color and form, of great natural bridges, monuments, spires, intricately twisting canyons, mammoth terraces with sheer walls a thousand or more feet high, and rock forms that resemble castles and cathedrals. But the most impressive feature is that of space. Not the monotonous space of the Great Plains, but dramatic, colorful space accentuated by these varied land forms and the high mountains to the east and west and the broad sweeps of unfenced range.

From high points the region appears as a great, deeply eroded plain from which rise three beautiful mountain masses. The LaSals to the northeast rise to 13,089 feet above sea level; the Abajos in the east central part rise to 11,445 feet; and the Henrys in the west central part rise to 11,485 feet. To the southwest, the Kaiparowits Plateau stretches southeast from the high plateaus for 50 miles, at the 7,000-foot level, as far as Navajo Mountain (elevation 10,416 feet) which stands alone on the south side of the Colorado River. East of Navajo Mountain, the monuments of Monument Valley standing against the sky may be seen from great distances. To the north the Book Cliffs, with the Roan Cliffs above, form the skyline. To the
northwest the San Rafael Swell, and beyond and above it the Wasatch and Fish Lake Plateaus, end the view. West of the Henrys, Boulder Mountain and the Aquarius Plateau, elevations 10,000 to 12,250 feet, respectively, blend into the western end of the Kaiparowits Plateau to form the distant skyline. To the south and southeast is a horizon less definite and broken by great mesas and mountain peaks. From the south end of Elk Ridge, which lies to the west of the Abajo Mountains, may be seen the Carrizo Mountains, Pastora and Zilbetod Peaks just south of the four corners, and Ute Peak southwest of Cortez, Colo. East of the Abajo Mountains, the great sage plain stretches on and on to the snow-covered peaks of the La Plata and San Miguel Mountains in Colorado. East of the La Sal Mountains is a jumble of canyons and mesas terminated by the Uncompahgre Plateau.

Down through the center of all this, majestically flows the Colorado River in its great canyon that starts just below the mouth of the Dolores River and continues almost unbroken to the Grand Wash Cliffs, a distance of 590 miles, the first 285 miles of which are in Utah. From Moab to the junction with Green River, the Colorado flows along a fairly smooth bed, easily navigable by small boats. From the junction to Mille Crag Bend are 40 miles of some of the roughest water of the entire canyon section of the river, hence, Powell's name for this section Cataract Canyon. From Mille Crag Bend to Lees Ferry the river flows quietly between monumental walls. The beauty of the scenery and quiet waters suggested to Powell the name Glen Canyon. Because of the depth of the canyon, little is seen from the river, except the immediate canyon walls. Powell and other river adventurers had to be continually scaling the canyon walls in order to get an idea of the country they were passing through. From the tops of the river canyon walls the scene is quite different from that obtained from the higher observation points on the plateau. For example, standing on the rim of the river canyon 1,200 feet directly above the junction of the Green and the Colorado, the great mountain masses and the plains are not visible; instead, there are the thousands of little mountains, buttes, spires, domes, and walls formed by the erosion of the great plain that forms the skyline. You are down in another world surrounded by a complicated jumble of pink, buff, and red sandstone formations, fantastic and beautiful. To the west, north, and east above the general level of this land of standing rocks, two great irregularly shaped terraces rise about 2,000 feet. Here and there, rising from the dark red lower terrace, are huge buttes and smaller walls and spires of the same color. The face of the upper terrace is sheer and of an orange-brown tone, which has given it the name, Orange Cliffs. To the south, on the east side of the river, an intricate system of parallel faults and erosion have created the unique Needles area which blends into formations similar to the Standing Rocks. These in turn build up gradually to Elk Ridge which runs generally north and south at an average elevation of 8,600 feet. Horse Mountain, the high point at the north end of Elk Ridge, rises 5,587 feet above the Colorado River to an elevation of 9,202 feet above sea level.
Below Cataract Canyon the scene changes; great side canyons run back into the mountains on the east and west. The terracing is more broken and disappears entirely in some sections. From the river at Hite can be seen Mount Holmes, 6.5 miles away rising 4,500 feet above the river to an elevation of 8,000 feet above sea level, and Mount Ellsworth, 9 miles away, rising 5,800 feet above the river to an elevation of 8,250 feet above sea level. From the Escalante River to below Hole in Rock the Navajo sandstone forms a ridge along the west side of the river canyon. Climbing up from the river to this ridge one finds remarkable views in all directions. The Red Rock Plateau of apparently limitless barren sandstone obscures the view of the Abajo Mountains and the country to the east. But to the north, over the deeply carved back of the Waterpocket Fold, loom the peaks of the Henry Mountains and the rim of the plateau between the Colorado and Dirty Devil Rivers almost 70 miles away. To the northwest for 50 miles stretches the Escalante Valley, walled on the southwest side by the Straight Cliffs of the Kaiparowits Plateau. From the base of the Straight Cliffs the desert rises gradually to the northeast to the Waterpocket Fold and the Circle Cliffs. In the long twisting gash in the bare sandstone along the southwest side of the Waterpocket Fold is the Escalante River. Beyond the upper end of the desert can be seen the highland of the Aquarius Plateau, 70 miles away. To the south the lone peak, Navajo Mountain, dominates the view.

After the river winds down between the Kaiparowits Plateau and Navajo Mountain it comes out into more open country. The immediate canyon walls are lower and the land steps up gradually in great wide benches. This continues until the river reaches the Paria Plateau and swings around the east end of the plateau in a deep narrow canyon. It is in this more open stretch of the river that Escalante [1] found the Old Indian Crossing. If the Glen Canyon Dam raised the water to the elevation suggested by the Bureau of Reclamation, the widest expanses of water would be in the
vicinity of the Crossing of the Fathers. Barry Goldwater of Phoenix, Ariz., stated in an article which appeared in Desert Magazine describing a trip down the river from Green River, Utah, to Hoover Dam: "Glen Canyon has always been synonymous in my mind with the unusual, the beautiful and the historic."
Chapter IX:

DINOSAUR NATIONAL MONUMENT

Dinosaur National Monument was originally established as an 80-acre area by proclamation of President Wilson on October 4, 1915, under authority of the Antiquities Act, for the purpose of preserving a rich deposit of fossilized dinosaur bones found here in an excellent state of preservation. By proclamation of July 14, 1938, signed by President Franklin D. Roosevelt, the area was extended to include other resources of great scientific interest, such as the canyon of the Yampa River and the Canyon of Lodore, Whirlpool Canyon, and Split Mountain Canyon on the Green River. The total area, including State and private lands within the exterior boundaries, as of October 1945, is approximately 209,744 acres.

LOCATION

The monument lies in semiarid northwestern Colorado and northeastern Utah; about 70 percent falls within Colorado and 30 percent in Utah. It is essentially a canyon-plateau area. Earth processes of a past geological age with contemporaneous biological developments of a spectacular nature have produced its outstanding features. It lies on the southern flanks of the eastern end of the great east-west Uinta Mountain uplift. While there are other notable geological, wilderness, and scenic values in the vicinity, the monument is, from the standpoint of such values, the spectacular core of a considerable region on the Upper Colorado River Basin. Between the northern end of the monument and the Utah-Wyoming State line are noteworthy canyons on the Green River, such as Red Canyon and Flaming Gorge. Fine as they are, they do not possess such exceptional qualities as are present in the monument.

SCIENTIFIC, SCENIC, AND RELATED VALUES OF THE MONUMENT

Functionally, the monument consists of two contiguous units which will be referred to as the Quarry Unit and the Canyon Unit. The comparatively small Quarry Unit, comprising three or four thousand acres, includes not only the 80 acres of the original national monument, but also surrounding land west and north of the Green River and south of Split Mountain. The Canyon Unit, consisting of about 206,000 acres, comprises the rest of the monument. Operationally, the monument is split into three distinct units of...
roughly equal size by the virtually impassable canyons of the Green and Yampa Rivers.

**Quarry Unit.**—The most remarkable single feature of the monument is the world-famous dinosaur fossil deposit in the Quarry Unit. The fossils are found in the Morrison formation (upper Jurassic) on the south limb of the Split Mountain anticline. This formation underlies the shales and sandstones of the Cretaceous, and is underlain by other strata of the Jurassic. Below the Jurassic lie the "red beds" of the Triassic group. In the vicinity of the "Quarry," the strata of the Cretaceous, Jurassic, and Triassic dip sharply to the south. Extensive excavations have been carried out, and considerable removals of important fossils have been made. It is to be expected that the unexcavated parts of the formation at the "Quarry" are just as rich in quality and variety of fossil specimens as was the excavated part.

![Figure 110.—Dinosaur Quarry—Dinosaur National Monument.](image_url)
Near the "Quarry" the upturned sedimentary rock formations tell a geological story of events preceding and following the era when dinosaurs roamed over a landscape much different from that of the present. The tilted rocks exposed in the Quarry Unit are part of the thousands of feet of strata that have been raised in an anticlinal fold parallel to and south of the main east-west trending Uinta Mountain uplift. The view from the hills above the fossil bed is worthy of recognition. There, in the presence of the evidence of the most spectacular biological development of the past, one may contemplate the future.

Because of its paleontological values, the Quarry Unit justifies its inclusion in the National Park System.

*Canyon Unit.*—Geological and scenic values are of predominant importance in the Canyon Unit. Here the folded and faulted sedimentary rock formations have been cut by the deeply intrenched meanders of the Green and Yampa Rivers. The dynamic process of river erosion has produced a colorful, rugged wilderness of deep canyons, dissected erosional benches, and bold promontories.
The precipitous Canyon of Lodore on the Green River, which is upwards of 2,700 feet deep near Triplet Falls, has been cut in quartzites, sandstones, limestones, and shales, some of them characterized by deep reds and purples. It possesses an exceptional degree of grandeur. The Yampa River Canyon, whose course is marked by deeply intrenched meanders, here and there separated by narrow promontories, has been cut in sandstones and limestones. Its walls are often sheer and, in the vicinity of Warm Springs Draw, rise about 2,000 feet above the Yampa. One of the more notable parts of Whirlpool Canyon is the section downstream from Sage Creek, where the river has cut through the side of an abrupt mountain fold, leaving a relatively thin outer shell or crust of fold standing as the north wall of the canyon. The Split Mountain Canyon is of interest for the way in which the river has cut along the middle of the fold, about on its axis. All of the canyons possess notable scenic qualities.

Jones Hole, Echo Park, and Castle Park are three of the more noteworthy, relatively small areas of the monument. Jones Hole and Echo Park contain perennial clear streams. The three areas are walled by high cliffs. In Echo Park at the junction of the Green and Yampa Rivers, and in Castle Park at the junction of Hell Creek and the Yampa, the cliffs are of Weber sandstone. In Jones Hole, they are of limestones and sandstones along Ely and Jones Hole Creeks. In each case, a feature unusual in this region is the relative abundance of deciduous cover.

In addition to the predominant geological, scenic, and wilderness values of the Canyon Unit, there are distinct though relatively minor biological interests. Deer are numerous in most sections; mountain sheep are present, though rarely seen. The vegetative cover embraces a variety of plant habitats, in life zones ranging from Upper Sonoran (mixed desert shrub and juniper-piñon) through Transition into Boreal (aspen, lodgepole, and fir). There are many plant associations correlated with geological structure, and many interesting biotic units whose origins are related to the development of the canyons and the local mountain structures on the flank of the Uinta Mountains.

Varied and frequent evidences of primitive Indian occupation constitute the archeological exhibit. Evidences of prehistoric Indian life are found in many sectors—in highlands, on benches between highlands and canyons, in canyons, and in valley bottom "parks" such as Castle Park, Hardings Hole, Pool Canyon, Echo Park and Island Park. They include petroglyphs, camp sites, rock shelters, middens, and caves that were inhabited or used for storage.

Variety in the characteristics of the Canyon Unit is a quality of exceptional importance. Geological exhibits of sedimentation, and stratigraphic, structural, and physiographic features are of prime significance. Second only to them are the conspicuous aspect of wildness and the scenic values which so often form an inseparable combination with those of geology. The Canyon Unit is of national importance for its geological and wilderness values. It is notable and distinctive, and in its present, unaltered state, warrants its existence in the National Park System.
RECREATIONAL VALUES OF THE MONUMENT

To date, the monument has received a minimum of planned development. Access to the Quarry Unit is provided, but no provision for public access into the Canyon Unit has been supplied. Such access to the latter as exists is by way of low-standard roads which are used by ranchers in the locality. Recreational utilization of the monument, save for the part centering around the quarry, is negligible at present.

Recreational values exist, though they are undeveloped. The area offers excellent possibilities for the layman to see and learn interesting stories of the land forms and the plant and animal life of past geological periods, the early occupation by man, and the present plant and animal life. Over most of the monument the geological features—the thick sequence of rock formations of Paleozoic and Mesozoic ages, the structural folds and faults, and the rugged relief blend with the scenic features and the wilderness characteristics to form a setting which offers many opportunities for education, spiritual uplift, and physical recreation, including camping, boating, horseback riding, hiking, and fishing.

PROPOSALS BY THE BUREAU OF RECLAMATION

Potentialities for using the water resources of the Green and Yampa Rivers within and near the national monument are being studied by the Bureau of Reclamation. Under consideration are proposals for the Echo Park and Split Mountain Dams, reservoirs, and appurtenant facilities.

Echo Park Dam and Reservoir.—The proposed site of the Echo Park Dam is in the narrow inner gorge of the Green River at a point near the base of the tip of Harpers Corner. Normal stream elevation at this point is about 5,048 feet. At high water, currently being considered for elevation 5,550 feet, the reservoir would run throughout the length of the Green River Canyon within the national monument upstream from the dam, and would extend northwestward from the north boundary, through Browns Park, for a distance of 30 miles or more by river. Another arm of the reservoir would lie in the Yampa River Canyon, and would extend to a point in Lily Park east of the eastern boundary of the monument.

Maximum drawdown might amount to 150 feet during periods of extreme drought. High-water levels could be expected to take place normally during July and August, with relatively high levels in September. Low water ordinarily would occur during the late winter months before spring run off. Seasonal variation would be from 20 to 50 feet.

The Bureau of Reclamation has not made a decision on the height of the dam, location of construction roads, construction camps, or power lines. It is planned to open a gravel pit in Island Park.

Split Mountain Dam and Reservoir.—The proposed site of the Split Mountain Dam lies near the head of Split Mountain Canyon. A dam 118 feet high to raise the water surface to an elevation of 5,048 feet is being considered. A reservoir at that elevation would inundate Little, Rainbow, and Island Parks, and the bench land at the mouth of Jones Hole. Present
studies indicate practically no fluctuation either seasonally or annually. Only in years of extreme drought would there be any radical lowering of water level.

The Bureau's report of March 1946, on the Colorado River Basin states: "A power head of 200 feet could be utilized by means of a pressure tunnel in three sections, extending from the dam 8.3 miles downstream to a power plant 5 miles up the river from Jensen, Utah."

Figure 112.—Steamboat Rock, Echo Park, and the Green River.

Figure 113.—Whirlpool Canyon—spurs of Wild Mountain at left; Zenobia Peak is the high point on skyline (right); and Echo Park Dam site is in the narrow inner gorge.
Chapter X:
CONSERVATION OF RECREATIONAL RESOURCES

The Colorado River Basin lies directly across all lines of travel between the rapidly increasing population of California and the densely populated eastern half of the United States. To a large extent in the past, it was considered just a vast space one had to cross on the way to California. Now, with the Pacific Coast more fully developed, people seeking undeveloped, uncrowded areas are beginning to discover the Colorado River Basin. The increased consciousness of color, brought about by colored photography, is causing people to become aware of the beauties of the region. Moving picture companies have discovered that the clear air, the high percentage of sunshine, and the great variety of colorful unspoiled scenery makes southern Utah and Arizona ideal for taking colored photographs of outdoor scenes. The same features are attracting more and more vacationists.

It is time for immediate action which will assure preservation of the many and varied recreational resources of the Colorado River Basin. It is also time to develop facilities which will enable people to see and enjoy the region. There are natural limitations on the amount of land that can be placed under cultivation. There is a limit, which has been reached in most sections, on the number of domestic animals that can be grazed. But the possibilities for the development of the recreational use of the basin are almost unlimited.

Much has been done. Vast areas, chiefly the higher plateaus and mountains, were designated as national forests in the early 1900's primarily for protection of the watersheds and for forage, timber, and wildlife production. Since their establishment, it has been found that many of them contain scientific and recreational features of national importance. A number of areas originally included in the forests have been set apart and dedicated as national monuments, while three other areas have been rededicated as national parks. These areas are now administered by the National Park Service. A number of other areas of major recreational value remain in the national forests. Some of these, in high remote sections of the forests, have been declared wilderness or primitive areas. Recreation is now recognized by the Forest Service as one of the important uses of the forests. In addition to the national parks and monuments originally included in the national forests, a number of other areas have been set aside as national parks and monuments to preserve their intrinsic qualities for the
enjoyment, education, and inspiration of all people for all time.

The establishment of these national forests, national parks, and national monuments has been the most important factor in insuring the preservation of the recreational resources of the basin. So far, only California, Nevada, and Arizona have established State parks in the basin. Utah, however, has recently indicated interest in this direction. This is fortunate, as there are many areas which, while not qualified for establishment as areas within the National Park System, nevertheless merit preservation as State parks or monuments.

IMPORTANT RECREATIONAL AREAS AND SITES WHICH SHOULD BE PRESERVED AND DEVELOPED

In addition to the areas of high recreational value described in preceding chapters, there are certain areas within the Colorado River Basin which contain outstanding existing and potential recreational resources. Some are believed to be of national importance. Others are primarily important to the State or region in which they are located. It is not recommended that all of the areas be set aside exclusively for recreation but that the preservation and development of the recreational resources be at least one of the major elements in any future plans affecting them. Local, State, and Federal agencies should cooperate in planning for the use and development of these areas so that the people living in the basin and in other parts of the United States may enjoy the fullest benefits from them.

WYOMING

1. Wind River Range. The western slope of the Wind River Range is a mountain area of such exceptional scenic quality and recreational value as to be of national importance. A number of peaks in the range reach elevations of more than 13,000 feet. Gannett Peak, the highest in Wyoming, reaches 13,785 feet, topping the Grand Teton by 20 feet. The Forest Service has set aside a large portion of this region of picturesque peaks, ridges, more than 900 lakes, and the largest glaciers in the United States as a wilderness area accessible only by trails.

The main approach to the area is from the south over United States Highways 187 or 189. Highway 187 continues northwest to the Jackson Hole country. Low-standard roads lead from Highway 187 to the foot of the range, where several lakes are located at the mouths of ravines. With the improvement of access to the area it can become one of the major attractions of the Rocky Mountains for visitors from all parts of the United States. The recreational resources can become of major economic value to the nearby communities.

2. Fossil Quarries. Fossil Mountain west of Kemmerer, Wyo., and one of the quarries southwest of Granger, Wyo., should be preserved and developed as examples of the sites from which were obtained the famous fossil mammals, fish, birds, and plants exhibited in American and foreign museums.
3. Fort Bridger is the historic site of the famous trading post built by Jim Bridger in 1841 and served as a base of operations in the western fur trade, the Oregon Trail immigration, the Pony Express, and the Union Pacific Railroad. It was leased by the Federal Government as a military reservation in 1859 and abandoned in 1890.

COLORADO

1. The San Juan-San Miguel-Uncompahgre Mountain area in southwestern Colorado is one of the most extensive spectacular mountain regions of the United States. This area, at the headwaters of the Dolores, San Miguel, Animas, Los Pinos, Rio Grande, Lake Fork, and Uncompahgre Rivers, is one of jagged, steep mountain peaks; deep precipitous canyons; dashing streams; beautiful waterfalls; lakes set in austere backgrounds; extensive timberline areas and forests unmarred except by fire. For natural beauty of the grand and rugged mountain type, the area cannot be excelled. Numerous streams and lakes abound in trout. Deer, elk, mountain sheep, bear, beaver, grouse, and ptarmigan are all found in considerable numbers.

The area is bisected by United States Highway 550, a scenic mountain road connecting Durango, Silverton, Ouray, and Montrose, Colo. At Red Mountain Pass the highway reaches an elevation of 11,018 feet above sea level.

The Needle Mountains and the Grenadier Range, spectacular groups of mountain peaks, at least 18 of them more than 13,500 feet high, and three more than 14,000 feet high, are east of the highway between Durango and Silverton. The San Miguel Mountain section west of the highway varies in altitude from 9,500 feet to 14,250 feet at the top of Mount Wilson. The Uncompahgre section straddles the highway in the vicinity of Ouray. Uncompahgre Peak, 14,306 feet, Wetterhorn Peak, 14,020 feet, and Mount Sneffels, 14,143 feet above sea level, are the highest peaks, but several others in this section are more than 13,000 feet high.

The area is a mecca for geologists. Here the whole story of glaciation is easy to read and such features as the great rock streams and mud flows, not duplicated elsewhere in the United States, are fully displayed.

Extensive mining operations have been carried on in the region during the past 50 years and gold, silver, lead, and zinc are still found in limited quantities. Although the mining has taken its toll from the landscape in places, it has added a special interest. The visitor is amazed to see mine buildings perched high on almost sheer mountainsides, thrilled by finding pieces of rock containing silver or some other mineral in old mine dumps, and awed by the strip mining on top of Red Mountain, elevation 12,865.

Lake San Cristobal at the head of Lake Fork of the Gunnison River is a popular recreation area, and Lake City, a former mining town, has been converted into a resort center. Ouray, a county seat which prospered during the heyday of mining, is beginning to realize that its future economic life will depend to a large extent on the wise use of the recreational resources. The town is ideally suited to serve as a center for vacationists, being situated in a beautiful little basin surrounded by colorful high mountains.
The town of Silverton retains much of its original flavor. Most of its construction took place 40 to 50 years ago and little modernization has taken place. It is an interesting representation of an era in the development of the Rocky Mountain region. The setting of the town, 9,300 feet above sea level, is dramatic. Bleak, high, rugged mountains enclose the narrow valley floor on which the town rests.

There are few roads in the San Juan-San Miguel Uncompahgre area, but trails lead to the high country from the roads that approach the area from the north and south and from United States Highway 550. Fishing, hunting, hiking, mountain climbing, horseback riding, and camping are the main recreational activities. A branch of the Denver & Rio Grande Railroad follows the Animas River from Durango to Silverton, another follows the Uncompahgre River from Montrose to Ouray, and a third runs southwest from Ouray to Telluride and down the Dolores River to Dolores, Colo., near Mesa Verde National Park. Trips on these narrow-gage railroads are capable of being developed into a major tourist attraction.

Most of the area is included within the boundaries of the San Juan, Montezuma, and Uncompahgre National Forests and the higher, more remote portions of each have been designated as primitive areas. There is some virgin forest, but the bulk of the timber within the area has little value for timber production. Its primary value is watershed protection. Mining has been important in the past. In the future, recreation probably will be the major value of the area.

Figure 117.—View of Silverton, Colo., from United States Highway 550.

2. Elk Mountain area in the White River and Gunnison National Forests is bordered on the north by State Highway 82 which crosses the Continental Divide near its highest point at Independence Pass, elevation 12,095 feet. The highway is unexcelled for the views it affords of lofty mountains, tumbling snow-fed streams, and forests of pine and aspen. The streams are among the best in the State for fishing.

West of Independence Pass, State Highway 82 descends into the valley of
the Roaring Fork River by easy grades. Aspen, an early mining town located in the valley of the Roaring Fork at an elevation of 7,850 feet, now attracts many visitors who take advantage of the 1,000 miles of trout streams and 25 lakes within a short radius. Dude ranches in the vicinity have access to trails that lead in all directions. In recent years, Aspen has become a popular winter sports center. Just west of Aspen a dirt road leads south along Maroon Creek to Maroon Lake, known for its magnificent mountain setting and excellent fishing.

South of the Elk Mountains region is the town of Crested Butte, elevation 8,867 feet, from which State Highway 135 ascends to Kebler Pass directly north of West Elk Peak. A dirt road leads to Gothic, 9 miles north of Crested Butte, where the Rocky Mountain Biological Laboratory is located.

Near Kebler Pass, at the foot of Ruby Peak, Lake Brennan rests in a pocket on the mountainside, surrounded by a luxuriant growth of alpine-type plants. Further north, Snowmass Mountain, Maroon Peak, and Castle Peak rise majestically to elevations above 14,000 feet. Beyond Kebler Pass, Route 135 crosses a high plateau covered by an abundant growth of flowers, grasses, shrubs, and trees. Dense stands of conifers alternate with aspen-fringed meadows to provide an expanse of charming mountain scenery. The high peaks nearby add to the superlative quality of the landscape. The recreational opportunities of this region seem almost unlimited.

3. The Park Range, located in the extreme northern section of Colorado, with its numerous high peaks and its wooded slopes, offers many possibilities for public enjoyment. Steamboat Springs, located at the foot of the range on the Yampa River, is a popular year-round recreation center. United States Highway 40 provides access to the region and State Highway 129 skirts the mountains on the west to lead to the Hahns Peak country, one of the excellent hunting and fishing areas in the State.

4. White River Plateau in the White River National Forest is one of the fine recreational areas in Colorado, ranging in altitude from 9,000 to 11,000 feet above sea level. Shingle Peak and Sheep Mountain are more than 12,000 feet. The plateau has a delightful cool summer climate. Numerous lakes and streams in a forest setting provide good trout fishing and pleasant camp sites. Deer and elk are plentiful. Trappers Lake, the largest lake in the area, is a summer resort. The main approach by road is from Meeker, Colo., on the west. Other roads lead to the area from the Steamboat Springs region. Trails from Glenwood Springs climb up to the plateau. The central portion of the forest has been designated as the Flat Tops Wilderness Area.

5. The Gore Range south of the Park Range is bordered by State Highway No. 9 along the Blue River, a popular fishing stream. The high crags and deep woods make the Gore Range a valuable recreational area for Colorado.

6. The Grand Mesa, east of Grand Junction, Colo., is 900 square miles in extent and rises 5,000 feet above the surrounding country in splendid isolation. Hundreds of small lakes dot the mesa and many of them provide excellent fishing. State Highway 65 leads to the top of the mesa and provides many interesting views of mountain lakes, meadows spangled
with wildflowers, aspen groves, and fir and spruce forests. Deer and small game abound in the area.

Dams have been constructed at the outlets of most of the larger lakes to increase their storage capacities. Resorts and summer homes have become established on several of the more accessible lakes and Forest Service campgrounds are available. The Grand Mesa area is especially important in providing cool recreation grounds for persons living in the valleys of Delta and Mesa Counties. Colo.

**UTAH**

1. Uinta Mountains. Though now known best by geologists, foresters, and a few fishermen, hunters, and stockmen, the fascinating scenery of the Uintas seems destined to receive much attention. Few areas of comparable size present such a diversified landscape—lofty, bright-colored canyon walls, and giant hogbacks along the borders; and beautiful lakes and streams in the forested uplands.

The Granddaddy Lakes region of the Uinta Mountains, including to the westward the headwater basin of the Duchesne River and to the eastward most of the primitive area of the Wasatch and Ashley National Forests, is one of the most notable and valuable recreational areas in the entire northwestern part of the Colorado River Basin.

The factors which give the region its particular value are numerous and complex. There are many craggy peaks more than 12,000 feet in altitude, and intervening lands of comparatively gentle slopes, at altitudes of more than 10,000 feet. These highlands are cool in summer. They are shaded by forests mainly of spruce, fir, and pine, are abundantly watered by clear streams, and contain a profusion of small glacial lakes with excellent fishing. Granddaddy Lake, at an altitude of 10,300 feet and with a water surface of 170 acres, is one of the largest lakes in the Uinta Mountains. Another feature of the area is the fact that the steepness and ruggedness of slopes and valleys descending from this high area toward the surrounding habitable lands have thus far halted the penetration of roads, even the roughest of wheel tracks, beyond its outer borders. It has been left completely free from the exploitations and irritating reminders of a mechanized civilization that follows wheeled vehicles. By short trail trips from roads that come to its borders, people can plunge into a wilderness contrasting completely with the adjacent country.

2. The Aquarius Plateau-Boulder Mountain area in south-central Utah is a little-known but potentially important recreational area. Numerous ponds and lakes dot the forest-covered tableland of 70 square miles that ranges in altitude from 10,000 to 11,000 feet. From numerous points there are grand views of the colorful lower plateaus stepping down to the Colorado River, the sheer-walled canyons of the Escalante River and its numerous tributaries, the Henry Mountains, the Waterpocket Fold, and the Circle Cliffs. The plateau, with the adjoining canyon lands on the east, provides a combination of scenic and recreational interests ranging from colorful deserts to high cool boreal forests. There is trout fishing in the lakes and streams and deer, elk, and cougar hunting on the plateau.
State Highway 23 on the south and State Highway 24 on the north provide access to the area. A county and U. S. Forest Service road connecting Escalante, on Highway 23, and Torrey, on Highway 20, crosses the east side of the area. It is the most scenic drive in southeastern Utah. Between Escalante and Boulder, the road crosses the Escalante River Canyon and runs along the top of narrow ridges between deep, sheer-walled canyons and provides exceptional views of the colorful desert canyon lands and the high forested plateau. Between Boulder and Torrey the road climbs over the east side of Boulder Mountain. Deep snow makes this section of the road impassable in winter.

3. Monument Valley, intersected by the Utah-Arizona line, is in the north central section of the Navajo Indian Reservation. Utah State Highway 47 crosses the area on its way from Mexican Hat to Kayenta, Ariz. The comparatively level plain rises from altitudes of about 5,000 feet to 5,700 feet at Monument Pass. Individual buttes rise to heights nearly 1,000 feet above the plain.

Monument Valley is the result of a stupendous erosion process that has left weird, wind-blown monoliths, spires, and totem poles standing hundreds of feet above the vast vivid-hued desert floor. Clouds, shadows, and moonlight transpose the forms and colors to create phantasies that are overwhelming. It is an area that should be retained in its desert wilderness character unspoiled by the evidences of modern civilization.

4. Nine Mile Canyon, northeast of Price, contains valuable prehistoric ruins and picture writings. Four types of Pueblo houses have been found here. The area is approached over State Road 53 which leaves United States Highway 50, 10 miles east of Price.

5. Poncho House, located about 15 miles east of Monument Valley, is one of the major cliff dwelling villages in the Southwest.

6. Westwater Ruins, 5 miles southwest of Blanding, and easily accessible,
contain ancient cliff dwellings and an attractive site for picknicking.

7. The Old Cotton Mills at Washington near St. George is a well-preserved building, erected in 1866 for spinning "Dixie Cotton" in the early days of Utah history.

NEW MEXICO

1. Manuelito National Monument Project, bordering the Santa Fe Railroad and United States Highway 66 between Manuelito, N. Mex., and Lupton, Ariz., 17 miles southwest of Gallup, N. Mex., is an impressive archeological, geological, and scenic area proposed for inclusion in the National Park System.

2. Gila Primitive Area in southwestern New Mexico is the largest and most beautiful unspoiled wilderness in the Southwest. Elevations extend from 4,500 feet to peaks more than 10,000 feet. The highest peak, Whitewater Baldy, is 10,892 feet high. No settlements are located within the area, but there are several dude ranches. The wilderness area is fairly well provided with trails, but the area as a whole is practically free from improved roads.

The outstanding topographic feature of the Gila Primitive Area consists of four deep canyons trenched deep into the eastward-sloping plateau by the Gila River and its three head tributaries. Practically all of the rocks exposed on the surface are of volcanic origin. Perhaps the most striking geologic feature is the great number and variety of erosion forms. The volcanic rock acted upon by water, wind, and frost has produced hundreds of unusual and grotesque shapes. The primitive area contains a number of thermal springs. Eight are classified as warm springs and two as hot springs.

The greater part of the area is forested and is preeminently a wildlife country. Large game animals are plentiful and there are many flocks of wild turkey, quail, and other game birds. The canyons are a haven for song birds and the streams teem with trout.

There are numerous archeological sites within the area. Gila Cliff Dwellings National Monument, where are preserved spectacular cliff dwellings set in a unique cave in a vertical cliff, is located in the east-central portion of the primitive area. This area has a very livable summer climate with unusually cool nights for its southern location. It has unlimited resources for recreation, study, and research. With proper development, the area could accommodate a large number of visitors without spoiling its primitive character.

ARIZONA

1. Coronado International Memorial Project. The act of August 18, 1941, (55 Stat. 630), authorizes the President to establish this memorial by proclamation when he has been advised that the Government of Mexico has established, or provided for the establishment of, an area of similar type and size adjoining the area described in the act. The purpose of the proposed project is to commemorate the Coronado Expedition, a significant event in North American history. The area chosen lies partly in Cochise
2. Meteor Crater, one of the most remarkable features in the United States, is famed throughout the world. It is situated in Coconino County, Ariz., in the southern portion of the Colorado Plateau. The crater may be reached by traveling 18 miles west of Winslow on United States Highway 66 and 4 miles south on a dirt road.

The irregular rim of the huge crater, nearly a mile in diameter, rises more than 150 feet above the surrounding plain. The main portion of the rim at an elevation of 5,800 feet is more than 1,000 feet in width, with scattered remnants of debris as much as 6 miles from the crater. The crater floor is flat and approximately 1,500 feet across. There has been considerable speculation as to the probable origin of the crater. Most of the evidence points to a meteoric impact.

Regardless of the origin, the crater contains much in the way of inspirational appeal. If it is the result of an impact of a meteor, as is now generally conceived, it is the largest known crater in the world formed by such a phenomenon.

3. Fort Bowie named, in all probability, for Brig. Gen. George W. Bowie, is located in Apache Pass in the Chiricahua Mountains of southeastern Arizona. It is one of the most famous historic United States forts in the Southwest. Established in 1862, its fame was largely in connection with campaigns against the Apache Chieftain Cochise during the 1860's and early 1870's and the renegade leader, Geronimo, during the late 1870's and the 1880's. With the surrender of Geronimo in 1886, there was no further need for Fort Bowie and from that time to the present it has gradually crumbled into a state of ruin. Few forts in the western part of the United States experienced such an exciting and dramatic career.

The site is reached by traveling 14 miles over a dirt road from the town of Bowie. The elevation at the site is about 4,700 feet. The story of Fort Bowie falls logically into the national theme of "Westward Expansion and the Extension of National Boundaries 1830-90." As a part of that theme, it played an important part in protecting the frontier settler and traveler.

4. Kinishba Ruins on the Fort Apache Indian Reservation is about 16 miles south of McNary, Ariz., 1.5 miles north of State Highway No. 73. It is at an elevation of some 5,400 feet, in the midst of the camps of the Apaches.

Kinishba was the center for a number of developments in pottery making in the Upper Salt and Little Colorado area. Kinishba seems to be the largest continuously occupied pueblo in the area in question. It has been partly restored under the direction of Dean Cummings of the University of Arizona, with Indian enrollees of the Civilian Conservation Corps furnishing the labor, and partly with funds privately donated. The 45-acre tract is well fenced and includes a museum and quarters building.

5. Clear Creek Ruins are located on Clear Creek about 5 miles south of Montezuma Castle National Monument in central Arizona, within the Coconino National Forest. They are of national significance.

The big ruin atop a ridge north of the confluence of Clear Creek with the
Verde River is one of the largest ruins in the Verde Valley. The main portion, comprising some 50 ground floor rooms, is built of limestone and caliche. A number of walls are standing to first-story level; originally, the ruin was at least two-storied. There are 40 or more cave rooms and small cliff dwellings on the south side of the ridge, below and east of the main ruin. The site covers some 30 acres.

6. Chaves Pass Ruins located in the eastern portion of the Coconino National Forest in the Anderson Mesa country some 35 miles southeast of Flagstaff, Ariz., constitutes an archeological site of unusual scientific historical importance. The site is on a good dry-weather road which leaves United States Highway 66 at Meteor Crater Junction and goes south past Meteor Crater to Chaves Pass about 40 miles from the highway. Chaves Pass is one of the few breaks through which aboriginal travel between the Little Colorado and the Mogollon Rim country would have been easy. A number of small lakes are within 5 miles. Vegetation is sparse at the site, but there is a good growth of piñon and juniper and some ponderosa pine in the vicinity.

The Chaves Pass Ruins include two large building blocks of pueblo type, a ball court, and remains of various smaller structures.

The mesa point on which the main Chaves Pass Ruins are situated evidently was occupied more or less continuously from around 1100 A.D. until 1400 A.D.

7. Awatovi, site of the Mission of San Bernardino, is located on the north side of Jeddito Valley in the south-central portion of the Hopi Indian Reservation near the settlement of Keams Canyon. It was one of the largest and most important of the sixteenth and seventeenth century villages of Tusayan, the first one reached by expeditions, and the one most often mentioned in early chronicles. The ruin is in fair condition and extends for a quarter of a mile along the mesa top, and back from the edge for a distance of 250 to 300 yards. Little survives of the mission, founded in 1629. Excavations have been carried on under the direction of the Peabody Museum of Harvard University.

8. The Blue Range area lying largely in Arizona, with a small part extending into New Mexico, includes more than 218,000 acres. It is one of the few remaining large areas of forest land in the Southwest still without roads. It is a region important for its big game and its trout streams, is accessible only by trails, and is the largest available area free from human occupancy and development in the State of Arizona. It extends into New Mexico to within a few miles of the Gila Primitive Area. The area is traversed from east to west by the Mogollon Rim, an abrupt escarpment-like topographic feature forming the southern boundary of the Colorado Plateau. The area above the rim is in the Boreal Zone, while below the rim is a wild and broken country largely in the Transition Zone. Elevations range from 4,500 to more than 9,100 feet. The area's major values are for the protection of the Gila and Salt River watersheds and for public recreation.

9. The Mount Baldy-White Mountain area in east central Arizona adjacent to United States Highways 666 and 73, ranges from 8,700 feet to 11,496
feet above sea level. The topography varies from gently sloping bench at the foot of Mount Baldy to extremely steep, rock-strewn mountainsides cut by deep canyons.

Geological features of spectacular character, including numerous lofty peaks and deep canyons, offer great possibilities for recreational development in the White Mountain area. High altitudes with cool climate, well-forested surfaces, and numerous clear mountain streams where trout fishing is good all tend to make this an excellent summer resort area. Few other localities in Arizona are comparable in quality, and none is nearly as extensive. Development along recreational lines has been considerable during recent years, but only a beginning has been made in the construction of trail systems and camps. Ultimately, this area must be used to meet extensive needs and demands for summer recreation of the people living in the hot lowlands of Arizona.

10. San Franciscan volcanic field. Many geological features of unusual character and general interest are found in the San Francisco Mountains and the surrounding volcanic field. Because of the high altitude of the area, with resulting cool summer climate, this region offers tremendous possibilities for the development of attractive trails to features of scientific interest and for the interpretation of such features through appropriate signs or labels. A start in this direction has already been made by the Forest Service and the National Park Service in their respective areas, but much remains to be accomplished in the utilization of recreational possibilities. This area might be made into one of the fine recreational centers in the basin, especially for horseback riding and hiking.

11. The Mogollon Rim area is located south of United States Highway 66 and extends from a point southeast of Flagstaff, Ariz. to the White Mountains near the New Mexico line.

The rim is the crest of the plateau that divides Arizona into two physiographic provinces—the Colorado Plateau on the north, and the basin and range province on the south. From the Mogollon Rim the drainage is north into the Little Colorado River and south into the Salt, Tonto, and Verde Rivers. The slope to the north is gradual for a distance of 50 miles. To the south the slope is rugged and abrupt, with a fall of 1,500 to 2,000 feet within a distance of a few miles. The greater part of the Mogollon Rim is heavily timbered, with ponderosa pine predominating. Near the crest one finds aspen and spruce; on the lower slopes are piñon and juniper.

An outstanding feature of the area is Clear Creek Canyon. It varies in depth from 400 to 800 feet and in places is less wide than deep. It is practically invisible from any point more than a quarter mile from the rim.

12. Travertine Bridge is located in the central part of Arizona in the Tonto National Forest. The bridge is unique in being composed of travertine rather than sandstone from which most natural bridges are formed. The upper surface of the bridge is approximately 400 feet long and rises about 150 feet above the bottom of the canyon. How the bridge was formed is a matter of conjecture at this time. Not only is the bridge unique in respect to origin, but it is one of the most beautiful natural bridges in the United States. Wildlife is abundant and the area abounds in prehistoric pueblos,
practically all unexcavated.

The bridge is located in very rugged country, and roads through this section of Arizona are of a low standard. The elevation of the bridge in the bottom of Pine Canyon is 4,600 feet above sea level.

13. The Apache Trail—Superstition Mountains area in the Tonto National Forest approximately 40 miles east of Phoenix, Ariz., is of major importance to the people living in south central Arizona. It includes four reservoirs, a scenic highway, and an excellent and varied landscape of mountain peaks, mesas, canyons, cliffs, interesting vegetation, and considerable color. Boating and fishing are available on the reservoirs and accommodations for visitors are provided by private interests.

The main road, known as the Apache Trail, from Roosevelt Lake down the Salt River, skirts the north boundary of the Superstition Wilderness Area. Several roads end within a half mile of the boundary of this wilderness area. Further access is gained by an incomplete system of trails.

14. Oak Creek Canyon is traversed by United States Highway 89. South of Flagstaff, Ariz., the highway drops from an elevation of 7,000 feet to 2,500 feet in lower Oak Creek Canyon. Lookout Point at the head of Oak Creek Canyon, 13 miles south of Flagstaff, is approximately 2,000 feet above the stream bed. The grandeur of the massive canyon walls is enhanced by the many colored ledges and buttes, while the canyon floor abounds in wild flowers.

Oak Creek Canyon was formed by the faulting of Coconino sandstone. This fault, which is apparent—the wall on the right being higher than that on the left—extended for many miles and formed an opening for great volcanic activity. A cap of basalt is visible along both rims at the upper end of the canyon.

Approximately 22 miles from Flagstaff, the color of the sandstone changes from white to red. Scrub oak and buckbrush replace mountain pines. A mile further, a panorama includes the trout stream, steep red cliffs, and the widening bottom lands to the south.

With the construction of the highway have come lodges, tourist camps, swimming pools, and other signs of civilization, in an area that prior to 1930 had been a wilderness retreat.

15. The Kofa Mountains in southwestern Arizona are more scenic than most of the mountain ranges in that section of the State. The highest point, Signal Peak, rises to an elevation of 4,200 feet, some 2,600 feet above the plain. There are precipitous cliffs and gorge-like canyons in this range. A feature of special interest is the grove of native palms growing in a steep narrow ravine, near Signal Peak.

This part of the Kofa Mountains is seldom visited due largely to a lack of drinking water and the excessive heat during the summer months. In addition to the palms and other interesting forms of plant life, the presence of bighorn sheep add interest to the area.

State Highway 95, a fairly good desert road, provides access to the region.
16. Southeastern Arizona Ranges. This portion of Arizona, more than any other, has been developed along recreational lines. The desert valleys between ranges have long been recognized as vacation centers for winter visitors and certain of the higher ranges which are well forested are being used for summer resorts. The Santa Catalinas are an example. Here, as elsewhere in the mountains, the chief difficulty is found in the rather limited space available for development. On the other hand, there is much opportunity for trail development and, to some extent, development of roads to points of unusual interest and significance, especially in the higher, forest-covered ranges.

Geological features of interest are apparent in many parts of this vast area. The semiarid climate causes most outcrops to remain fresh and the vegetative cover to be reduced to a minimum. Thus, complexities of structure and details of rock character are readily observable. Under such conditions it is natural that a large number of persons residing within the region should take a lively interest in geology. One of the principal needs in this connection is the availability of authentic information concerning features of interest. In any program of recreational development careful consideration should be given to ways and means of presenting such information.

NEVADA

1. Hidden Forest in Clark County is a scenic area of virgin timber in a desert region. Approximately 5,760 acres would be suitable for a State park, providing opportunities for sports, camping, and picnicking, as well as relief from the desert heat.

2. Gypsum Cave, about 16 miles east of Las Vegas, Nev., is a large cavern in limestone, about 300 feet long and 120 feet wide, containing cultural material associated with bones of the ground sloth and other extinct fauna underneath Basketmaker and later remains. An antiquity of more than 5,000 years has been calculated on the basis of remains of the "sloth people."

CALIFORNIA

1. Palm Canyon, 7 miles south of Palm Springs, Calif., has been authorized for addition to the National Park System as a national monument when the necessary lands are made available. Here the native Washington-palms are found in abundance over the length of the 14-mile-long canyon. At the upper end of the canyon, a mile and a half beyond the limits of the palms, a 60-foot waterfall starts a crystal clear stream on its way between the rugged white caliche canyon walls. An excellent horse trail follows the east wall, providing views of the many palm groves with their associated desert plant forms.

2. Giant pictographs, works of early inhabitants, are found throughout the lower basin of the Colorado River and adjacent desert areas. Relief designs were made by raking or stacking gravel in lines or piles, and intaglio designs by taking out sections of the black surface cobbles which exposed
the light-colored subsurface. The oldest ones may have been produced by prolonged stamping of feet on the gravel surface, after it had been made soft by heavy rains. The figures represent geometric patterns and life forms. Those of the latter type are of the freshest appearance, probably of Yuman origin.
Chapter XI:
THE LIFE ZONE MAP

METHODS USED

It is realized that the life zone concept is open to serious criticism when used for intensive studies of small areas, and that when used for any purpose it may be open to charges of vagueness. Although the present treatment cannot hope to escape altogether such charges, an effort has been made to designate the limits of the zones as definitely as possible.

It was only after weighing all the factors involved that the decision was made to describe the Colorado River Basin in terms of life zones rather than by plant associations comparable to those used by most ecologists today. The deciding factor was that of simplicity for the benefit of the average nonscientific reader. It was believed that loss of critical definition, resulting from the use of these more generalized zones, would be more than compensated for, in semipopular treatise, by the reduction in number of classifications.

The life zone map of the Colorado River Basin is like nearly all maps of large areas that have ever been made, in that no matter how great has been the expenditure of care and energy to insure its accuracy, someone more familiar with local areas can discover errors of various degrees of importance. In the case of the present map, much less time was available for its preparation than originally had been anticipated, owing to circumstances beyond the control of the Colorado River Survey project. In fact, the life zone study never could have been completed if it had not been for the air surveys, which made possible a fairly comprehensive coverage of the basin within a period of only 9 months. Even so, the final product would have been much less accurate had it not been for the generous help, elsewhere acknowledged in full, of many persons having an extensive technical knowledge of various parts of the basin.

As a first step, all available botanical, zoological, and ecological publications were consulted in order to establish the average elevation boundaries of all of the life zones in the various parts of the basin. By no means all of these publications were specifically concerned with life zones, but since the major plant indicators and association equivalents of the zones have long been recognized, any information on the distribution and elevation of these indicators in various parts of the basin could be translated fairly easily into terms of life zone boundaries. These preliminary data were summarized as follows:
### Life Zones—Lower Limits

<table>
<thead>
<tr>
<th>State</th>
<th>Slopes</th>
<th>Upper Sonoran</th>
<th>Transition</th>
<th>Boreal</th>
<th>Authority</th>
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<td>9,000</td>
<td>Bailey (1913)</td>
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<tr>
<td></td>
<td>West S-facing</td>
<td>4,500</td>
<td>6,800</td>
<td>8,500</td>
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<td>S-facing</td>
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<td>9,500</td>
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<td>Arizona (northern)</td>
<td>N-facing S-facing</td>
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<td>6,000</td>
<td>7,500</td>
<td>Bailey¹</td>
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<tr>
<td></td>
<td>average elevations</td>
<td>below 5,000</td>
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<td>9,000</td>
<td>Shreve (1926)</td>
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<tr>
<td></td>
<td>E. and West N-facing</td>
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<td>6,800</td>
<td>N.</td>
<td>Rasmussen (1941)</td>
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<tr>
<td></td>
<td>West S-facing</td>
<td>----</td>
<td>6,500</td>
<td>S.</td>
<td>(Kaibab Plateau)</td>
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[Elevations indicated in feet above sea level]

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1. Bailey (1913)
2. Shreve (1926)
3. Rasmussen (1941)
4. (Kaibab Plateau)
5. Hanson (1924) (Little Colorado River)
6. Jenks
7. Nichol (1937)
8. Martin and Fletcher (1943)
9. Shreve (1915)
10. Cary (1911)
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<td></td>
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1 Bailey, Vernon, Mammals of the Grand Canyon National Park, U. S. Department of Interior, MS.
2 Disagrees with others on U. S. Zone indicators, of Hall and Grinnel (26).
3 Southern Arizona lone elevation data used, but checked with Grinnel (1933).
4 Areas given instead of altitudes for this zone.
5 None on south slope.
6 Colorado River canyon bottom.
A transparent tracing-cloth base map of the Colorado River Basin was laid over the appropriate Regional Aeronautical Charts (Department of Commerce), which show topographic relief at 1,000-foot intervals. Provisional life zone boundaries, based on the foregoing tabulated data, were drawn on the tracing cloth, using the contours shown on the aeronautical charts as general guidelines. The topographic accuracy of these charts, which are on a scale of 16 miles to the inch, is for the most part quite high even for the more remote, unsettled regions. Contact prints of the completed tracing-cloth map, which measured 34 by 57 inches, were then taken into the field and compared, area for area, with conditions on the ground.

Nearly all of the field checking was done in a two-place light plane at altitudes varying between five hundred and three thousand feet above ground level. Planes of this type, which can cruise up to 6 hours without landing and give approximately 16 miles per gallon of fuel are receiving increasing use in many types of regional surveys and certainly will have an important and permanent place in such work.

Corrections were made as carefully as possible on the field copy of the life zone map while in the air, together with any pertinent notations. Occasionally the changes also were indicated on a set of Sectional Aeronautical Charts having a scale of 8 miles to the inch. Approximately 10,500 linear miles were flown on this reconnaissance project, which pretty thoroughly covered the basin. (Plate 2, in pocket.)

Ground studies are an indispensable supplement to air surveys and should follow them for purposes of verification, but the air surveys should come first because they provide at the outset a visual and mental grasp of the entire region which could be attained only by months or years of ground work. This is particularly true of large unfamiliar regions having a rugged and complicated topography which can be glimpsed only intermittently and at long range by ground travel, but it holds good in any type of country.

A disadvantage of air surveys is that some landscape features, such as potential development sites, appear deceptively small and are in danger of receiving inadequate consideration. With practice, however, supplemented by a checkup on the ground, one learns to make the proper correction for scale. Moreover, the required correction becomes less as one makes the surveys from lower altitudes.

Other disadvantages of air observation, such as the impossibility of making stationary observations are relative (light aircraft usually being easy to maneuver in small circles), and with practice can be greatly reduced. However, the viewpoint of persons on the ground with respect to scenery, and the feeling for the type of recreational use to be made of the area by persons confined to the ground can best be appreciated while one is on the ground. This probably represents the most important advantage of ground studies over air surveys.

The air surveys showed that for many areas the provisional life zone map was surprisingly correct even in minor details, which demonstrates the accuracy of the aeronautical charts and the published ecological studies.
already mentioned. In a few localities actual conditions on the ground differed widely from assumed conditions on which the map had been based. This was particularly true of the Upper Sonoran Zone in the Little Colorado River Basin, which on the first draft of the map was taken from the life zone maps of Merriam (1890) and Swarth (1914) instead of from the altitude table (pp. 220 and 221), with which the maps were in conflict. These early life zone maps had been drawn up before the life zone concept had been fully developed and before detailed studies had been made of this particular basin. Apparently, these writers based the lower limit of this zone on the lower limit of the piñon-juniper belt in the basin, but subsequent studies have shown that this is not the true lower boundary of the zone in this particular area. Lack of moisture is the operating factor at the lower boundary of the piñon-juniper belt in the Little Colorado River Basin, and on the basis of temperature conditions the Upper Sonoran Zone actually extends to a much lower level in this area, as demonstrated by the presence of other Upper Sonoran life zone "indicators" of more elastic moisture requirement.

Some errors were found to have resulted through having taken data from some of the more recent vegetation type maps, but these were few. They arose, no doubt, from the physical impossibility encountered by the type mappers of covering all of the terrain on foot, which occasionally led to misidentification of distant vegetation belts.

By far the commonest source of error in the provisional map arose from assigning, on the basis of topographic data, a higher life zone to an isolated mountain region than actually occurred there. Although special care had been taken to avoid this mistake, the warming effect of large surrounding desert regions often was even more extreme than had been anticipated. This was exemplified in the Kaiparowits Plateau, the Abajo, La Sal, Virgin, New York, Cedar, and other mountain masses.

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