*A Comparison of Two Basic Theories of Land Classification and Their Adaptability to Regional Photo Interpretation Key Techniques**

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SUMMARY: *The classification of land into units is useful in the analysis of regions. Systematic methods of describing terrain have been investigated by many men. Davis was the founder of a school which is widely accepted. Two other geographers took his fundamental principles and digressed in different directions. Fenneman used multiple subdivisions, dividing continents into physiographic provinces, sections and districts. Bowman divided physiographic provinces into topographic types. The latter has been the basis for land classification surveys in the United States for the last 35 years. It is particularly well suited to photo interpretation methods because the types are easily recognized on air photos, and because the types are homogeneous. However, physiographic subdivisions are very diverse and it is difficult to make generalizations about them which will apply to a specific site. Two partial regional keys, one adapted to Fenneman's methods and one adapted to Bowman's methods, illustrate the advantages and disadvantages of each method of regional study. The first keys out the Navajo Section of the Colorado Plateau. The second keys out the basin type of the same plateau. The two end products are compared for homogeneity and pertinence in the solution of photo interpretation problems.*

ONE OF the problems of regional photo interpretation is to divide regions into units which will simplify analysis. If it is desired to study single subjects, such as geology or industry, the decision is not difficult and it is determined by the subject matter. But if the aim is to study all of man's activities the problem soon becomes an analysis of how man uses the land, or man's environment. This is admittedly a complex subject and governed by many factors. The object of any regional subdivision is to find the most homogeneous units, and, at the same time, units which are significant at the broad regional level, and, when air photos are used, units which are well suited to study in air photography. Description and classification, of course, are only initial steps in the analysis of the activities on the earth. They help the geographer to group like things and related things together so that their relationships may be better understood. Many schemes have been devised by geographers to accomplish this task, and two of the most promising are presented in this paper and are compared. A brief account of the background behind the development of these methods will help in understanding them.

* A contribution of Commission VII, Photographic Interpretation, International Society of Photogrammetry.

[1] This article presents the view of the author and does not necessarily reflect the views of the U. S. Forest Service.

The Development of Two Land Classification Theories

For centuries geographers have striven to classify land and so to better understand the earth around them. From Julius Caesar, who divided Gaul into three parts, to Amerigo Vespucci, who divided the new world, from Captain Cook to Admiral Byrd, each has tried to label and describe the land masses of the earth. Most of the early classifications of land were haphazard and without a scientific basis.

Early in this century Davis (8) developed a systematic method for classifying land forms based on the way each developed through geological history. This method was accepted by many both in the United States and abroad, and it became the foundation of a whole school of physiography.

The Davisian theory of land form classification was expanded to apply to whole regions by two of his disciples, Bowman and Fenneman. Bowman (3) divided the United States into physiographic provinces, each of which had similar geological structures which had been acted on by the same processes and were in similar stages of development.

Several years after this pioneer effort, Fenneman, as chairman of a committee of the Association of American Geographers, reworked the same ground and refined the classifications (9), dividing each province into sections and these again into districts. The committee intended that these subdivisions should form a universally recognized framework within which geographers could make regional studies. The theory behind this work was that geological formations influenced other geographical relationships creating regional unity. However, it was evident that both Bowman and Fenneman went far beyond what Davis had intended, since his system was designed to explain land forms—usually the landscape within view—and not whole regions. Nor did Davis relate other geographical elements to land forms.

Following World War I American geographers began to take increasing interest in human ecology following the lead of European geographers such as Ratzel, Vidal de la Blache, and Bruhnes. These men focused their attention less on the geological past and more on the geographical elements which associate themselves together on the land. They regarded the physiographic landscape not as the subject for primary study but as the stage on which man plays his part. Each of the physical elements of the landscape was important only as it affected man and influenced his development patterns and his way of life. Men who espoused the cause of human geography complained that physiographic classifications were too broad and lacking in pertinence. Peltier (11) argued that:

> "the degree of generalization used by Bowman and Fenneman . . . does not permit the examination of areal relations with the phenomena of human occupance. . . . The categories of landforms useful for chorographic scale studies leading to the recognition of physiographic provinces are too highly generalized to match with specific features developed by man: such as fields and farms, roads and settlements, or cities and factories. . . . The categories determined on generic principles overlooked too many slight variations of slope to be applicable to the topographic or detailed large-scale study of areal relations."

Even before other American geographers began turning to human geography, Bowman began going through a metamorphosis of his own. His *Forest Physiography*, published in 1914, in which he delimited the physiographic provinces of the United States, was largely based on the observations of Powell and other field men of the U. S. Geological Survey, whose attention was naturally drawn to structural similarities from one locality to another. When Bowman described regions which he himself had explored, his descriptions reflected what attracted his greatest interest: the human relationship to his environment. As a result of field work in South America his writings in 1916 (4) show that he was repeatedly struck by the close correlation between topographic features and the activities of man. He continued to make physiographic descriptions in the Davis tradition, but he never again drew a physiographic subdivision line. He finally dropped physiographic descriptions altogether in his last South American regional study (5) in 1924. He devoted most of his energy to the discussion of the relationships between earth and man. By 1920 the full impact of their meaning had become apparent to him, when he prepared Chapter VII of Brunhe's English edition of *Human Geography* (7). In this study he described Peru as having two broad natural regions: the Maritime Andes and the Eastern Andes. Within these regions he described the dominant "topographic types"[1] and their relationship to agriculture, settlement, pastoral life, and communications between groups. These topographic types represented such recurring features as high plateaus, basins, canyons, snow-covered mountains, etc. He used several techniques to illustrate these relationships, the most effective of which was the "regional diagram," as shown in Figure 1, a composite sketch map representing a typical situation, showing the topographic types and how they combined with other factors to affect man's use of the land from place to place in the region.

Bowman's classifications were based on three basic principles. The first is one of the fundamental tenets of the science of geography, and may be called the principal of relationships. *The physical elements of the earth are related to each other and to social forces which affect the land, permitting correlations to be made between the land and human activity.* For example, in appraising the damage done by a forest fire the relief, soil, vegetation cover and the climate are all related, and they in turn are related to the economic value of the timber and the watershed. These relationships permit a classification of terrain[2] according to its physical and economic values.

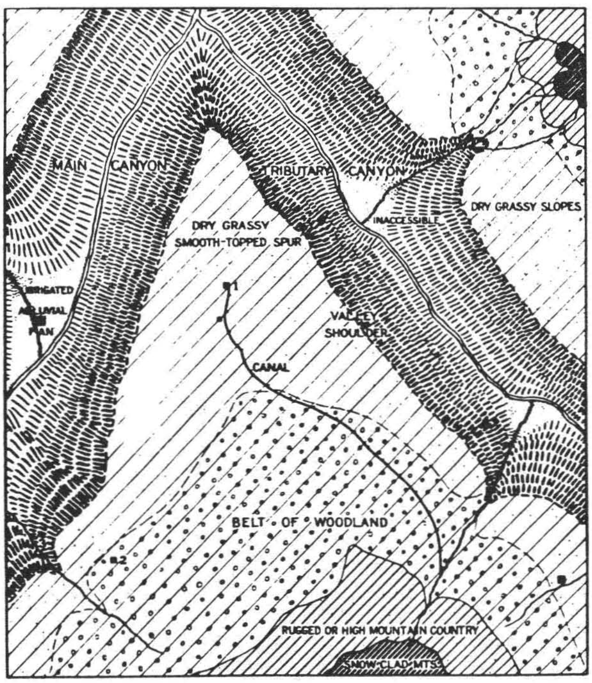

FIG. 1.—Regional diagram representing the deep canyoned country of southern Peru (4). The dark hatchures represent the canyon type, where settlements are located on the only agricultural land, the open diagonal crosshatch represents the plateau type, used for pasture, and the close diagonal crosshatch represents the mountain type. (From Bowman's "The Andes of Southern Peru.")

The second principle was first expressed by Bowman himself (6). *A given composition of the physical elements of the earth is repeated essentially from place to place over a region, with the result that types of natural*

[1] The term "topographic type," "natural land type," "landscape type" and "terrain type" are used synonymously in this paper.

[2] The term "terrain" is used in its broadest sense in this paper to include the entirety of the physical and cultural landscape.

landscape are in varying ways combined with environmental associations to form types of cultural landscape. Physiographers have long used the "typical formation" device in classifying land forms (although the term "type" has seldom been used) in order to simplify descriptions. A land form might be called a "coastal plain" or a "syncline" or a "block fault mountain," which established its type, making unnecessary the complete description of each and every land form in an area. Bowman broadened this usage to include all the elements of the landscape. An important feature of Bowman's principle is its restriction to a given region, because elements which are related to each other in one region may be related to each other in different ways in another region. For example, ocean winds may produce rains and productive agriculture on one side of a mountain range, and leave a desert on the other.

The third principle is the principle of dominant control. *In each locality one geographic element, or combination of elements, is dominant and exercises control over man's use of the land.* Bowman felt that the topographic type, with contributing influences from water supply and local climate, was usually the dominant element in the primitive and undeveloped areas he examined. In the following comment (2) he uses the term "soil" in its broadest sense meaning "land":

> "Men are rooted to the soil upon which they were born to a much greater degree than is generally believed. Not all can live in the most attractive places; a large part of the human race must struggle with its environment and bear the marks of the struggle; an appreciable part regards its home land, though a desert, as the part most favored by providence, and succumbs, if need be, rather than migrate to an unfamiliar land."

In accepting the dominant influence of one factor, however, Bowman never lost sight of the environment as a whole. There is not doubt that in other localities where control shifts from topographic to economic or political factors his classifications would reflect these influences also.

In the period following World War I Bowman was one of the leading geographers in the western hemisphere. His influence was widely felt, and his philosophy can be seen in the design of many of the long series of land inventory and classification surveys conducted during the period between the two great wars. One of the first was the Michigan Economic Land Survey which was started in 1922, when the economic liability of millions of acres of cutover timberlands became a tax delinquency problem of major proportions. Sauer, one of the men involved in the survey, an early student of landscape types, was motivated by much the same view of geography as was Bowman. Early in the planning stage the Michigan survey seemed destined to become little more than a soil survey. Sauer (12) appealed for a broader geographic viewpoint, and he, with other geographers from the University of Michigan, were influential in developing a study of all the geographic influences affecting man's use of the land. The survey of soil, vegetation, farm use, etc., which followed resulted in a combination of associated features which was called the "natural land type," in which conditions were fairly constant. Veatch (13) describes the results of this survey and the eleven land types which were found. They were given composite names such as the Lake Bed Clay Plains Type, the Rolling Clay Plains Type, the Sandy Hill Land Type, etc. These were used as the base for classifying land-use and economic influences which affected the inhabitants of the land type.

During the years since the monumental Michigan project, it has become the prototype for resource management planning throughout the United States, notable among which were the various Tennessee Valley Authority, Resettlement Administration and Soil Conservation Service surveys. A modification of the method was used by Stamp (14) in the British Isles, and it became the basis for national land-use planning. Although Stamp recognized the physiographic provinces of Britain he ignored them and turned instead to ten selected "land types."

Perhaps as a reaction to the human geographers Atwood focused attention once again on physiography in 1940, but he took a more broadly geographic view than his predecessors, who largely ignored man and his works, by attempting to draw much closer correlations between human activity and geology than physiographers had previously done (1).

In trying to bridge the gap between physiography and humanity Atwood refrained from following Fenneman's over-simplified delineation of sharp subdivision lines, recognizing the complexity of the landscape associations which affect man. The geologist can draw sharp lines with impunity, but not the human geographer, who must recognize the blending of influences and draws his lines to represent transitions where there is a correspondence of many factors.

The Terrain Type and the Air Photo

The earlier land classification surveys were made by ground methods, but as air photography became available photo interpretation was gradually adopted as a tool. It was an ideal combination of theory and practice because the air photo was especially well suited to show spacial relationships and the multitude of details which make up the elements of terrain.

In practice the terrain type is remarkably flexible and can be broadened to the regional level or narrowed down to show great detail, depending upon almost any criteria. It can involve any combination of features which are associated together and which are repeated again and again over the landscape. It can include such specialized groupings as forest cover types and crop classifications, or broad types such as lands suitable for settlement and those to be reserved as wild lands. Probably the outstanding advantages of the terrain type technique are the ease with which most types can be recognized on air photos, and the relative environmental homogeneity of the type, which permits specific interpretations of ground conditions to be made.

The terrain type method has been widely used for the classification of terrain for military purposes. Best known of these applications is the world wide Strategic Engineering Survey made by the U. S. Geological Survey for the U. S. Army Engineers. It classified geographical regions into broad terrain types which could be related to trafficability and construction problems.

Physiographic Subdivision and the Air Photo

All geographers did not adopt the classification of land by types, however. Fenneman's system of multiple physiographic subdivision has seen wide application, especially by physical geographers, who used it as a tool for geographic description. The broad description of regions seems to be the best use to which it can be put and it has been widely successful. Physiographic subdivisions have also been used in military intelligence surveys, one of which was the Joint Army Navy Intelligence Study of worldwide coverage during World War II. Geographic regions were delineated on topographic lines, then subdivided, and a description was supplied for each area. However, the technique has rarely been used in photo interpretation studies, principally because it is a tool for generalized descriptions of regions, and not for the analysis of spot locations. The air photo is not a generalization except at the smallest scales. At operational scales it inescapably narrows the field of interest very quickly to specific images. Physiographic subdivisions, as broad generalizations, have heterogeneous elements and many diverse conditions, making it impossible to use their descriptions to analyze specific sites. For instance, if a subdivision contains high mountains, plateaus and deep basins it is difficult to make generalizations which will fit any particular site. Such subdivisions usually cannot be recognized on air photography because of this diversity.

Examples

Geographic problems are difficult to examine in the abstract and examples seem to be essential for understanding. Regional photo interpretation keys have been used in the following illustrations as the vehicle for regional analysis. Although the regional key is still in a developmental stage, it has already proved itself an extremely effective means for analyzing the geographic associations of a region. The two keys used herein are fragmentary and are only intended to show how each example keys out one of its end products, so that they may be compared.

The Fenneman approach has been adapted to photo interpretation, and it is demonstrated by keying out the Navajo Section of the Colorado Plateau shown in Plates 1 through 4. In addition single representative oblique photos[1] are used to

[1] The author is indebted to the Air Chart & Information Center of the U. S. Air Force for the trimetrogon photography used here, and to the Division of Forest Economics, U. S. Forest Service, for help in preparing the plates.

explain each of the other sections of the province shown in Plates 5 through 7. An adaptation of the methods of Bowman and the Michigan Economic Land Survey is demonstrated by means of a key to the terrain types of the Colorado Plateau, keying out the basin type, shown in Plates 8 through 13. This is followed by single oblique photos representing each of the other terrain types, shown in Plates 14 through 16, so that their characteristics may be understood. Keys to geographic areas are usually part of a more extensive series of keys, including keys to the individual elements of terrain, with which the area keys are coordinated. Collectively this group of mutually supporting keys is known as a "regional key."

The terrain types used herein are preliminary selections and revisions could be expected following extensive study. It should be kept in mind that although the types have been given geomorphic names they are not merely land form types but *associations of many related terrain elements.* These basic types could be further broken down into land-use classes if an intensive survey were to be made, but in any broad land-use survey they could form the foundation for understanding man's environment. Despite the importance of the physical elements no attempt has been made to limit man's environment to physical geography alone, and social factors are recognized wherever they apply.

The Colorado Plateau is one of the physiographic provinces described by both Bowman and Fenneman, and it was chosen as the region for demonstration because the author knows many parts of it intimately after spending 6 years on it as a land manager. Much of this time was spent in the study of ecological relationships involved in the complex range management problems of that region. Photo interpretation was one of the methods of investigation used by the author, and air photos were constantly carried in his saddle bags. This province makes a good example to illustrate differences in terrain because the environmental contrasts between its types reach great extremes. There are similar contrasts in other regions but they are muted by gradual changes in relief and climate, making analysis of associations more complicated.

Physiographic Subdivision

ADVANTAGES

1. Physiographic subdivisions permit complete description of a region, with each unit receiving its appropriate share of attention. When information on an area is sought, either to plan operations within it, or to investigate activity in the area, it is merely necessary to turn to the right page and a description of the area is found. Where complete photo coverage is available experienced analysts can do the photo interpretation for each area in advance and can present a complete analysis ready-made for the user. This can be mapped on mosaics so that the location of each terrain condition is unmistakable. This, of course, would be very time consuming and expensive.

2. The subdivision method highlights changes in conditions in various parts of a region. One area is either drier or wetter, colder or warmer than another, and these differences inevitably affect the environment and man's use of terrain. Therefore, if climate is a controlling factor, serious consideration should be given to subdivision by either physiographic or climatic subdivisions. Regions may also show economic changes from locality to locality. These changes are not necessarily coincident with physiographic subdivisions, but physiographic barriers and avenues of movement frequently contribute to economic unity.

3. Research for this method is simplified by the existence of many physiographic studies, which may be reorganized and condensed to suit the needs of a regional key.

4. The physiographic type of key is simple and straightforward and is adopted to use by many levels, from students to advanced researchers.

DISADVANTAGES

1. Since physiographic subdivisions contain many land forms and are vague and unrecognizable on air photos, the investigator must depend upon a regional map as a key to his air photos. He is first of all exposed to two sources of error, map location and photo location errors, either of which can upset his estimates.

(*continued on page 156*)

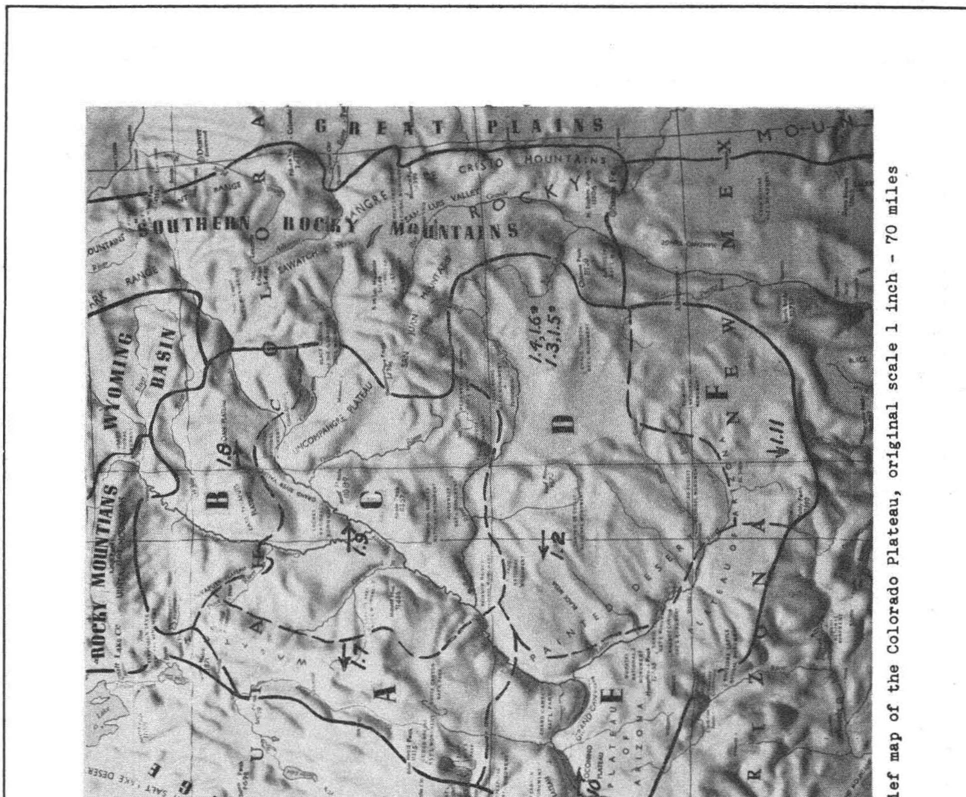

PLATE 1.—This map performs as a photo interpretation key. The interpreter determines the section in which his photos are located, then turns to the section description for more information. In effect the map tells him that here are areas of relative uniformity.

COLORADO PLATEAU

The Colorado Plateau is a region of high plateaus, cut by deep canyons, and studded by isolated mountains. It is located in the "four corners" area of Arizona, New Mexico, Colorado and Utah (see Fig. 1.1) and covers some 130,000 sq. mi. It is a dry, sparsely settled region where lack of water precludes large scale agriculture and settlement, but its wealth of natural resources is bringing rapid development.

RELIEF - The region is underlain by nearly horizontal beds of sandstone, shale and limestone, which form elevated plateaus. Many isolated areas have been uplifted forming high mountains, which have either retained their sedimentary covering or have weathered until basaltic laccoliths remain. The upper sedimentary strata of the plateaus are resistant to erosion and their surfaces have a mature drainage system of winding draws and shallow lakes. Where these strata have been worn through erosion has accelerated creating canyons. These exposed faces are more vulnerable to weathering so canyon walls and fault scarps are crumbling and retreating. There has been considerable volcanic acivity in the region and many of the plateaus have high volcanic mountains towering above them, and the surrounding area is covered by cinder cones, lava flows and volcanic necks.

DRAINAGE - The region is drained by the Colorado River and its tributaries. The swift current of the Colorado carries a heavy load of silt which keeps its channel cutting ever deeper. The main tributaries, the Little Colorado, the San Juan, and the Green Rivers flow inward into a wide basin in the center of the region and then join the Colorado just before it enters the Grand Canyon. Perennial streams are rare.

CLIMATE - The region has a semi-arid climate, which is extremely variable and strongly influenced by elevation. Elevation creates climatic zones, with a subarctic climate on the higher mountains, which rise above 12,000 ft., a temperate climate on the high plateaus from 8,000 to 7,000 ft., and a semi-desert climate below 7,000 ft. The mountains receive large amounts of precipitation, ranging up to 40" annually, which is about equally divided between summer rains and winter snows. The high plateaus received 20" - 30" annually, and lower elevations receive between 5" and 20". Droughts of long duration are common. High summer temperatures in the low elevations cause strong updrafts, creating local convectional storms. The storms generally form over the higher elevations then drift over other areas. This gives the higher elevations almost daily rains during the summer, but the lowlands have a progressively smaller chance of getting the benefit of these drifting storms the farther they are from the high country. There are strong winds in spring which disturb the formation of updrafts, and as a result there is a period of drought through June each year.

SOILS - The soils of the region are generally thin, poorly developed residual clays and sandy clays resulting from the wasting of sedimentary rock. Due to the light rainfall many of the soils at lower elevations are alkaline, producing little more than alkali tolerant shrubs. Slow soil movement before the disturbance of vegetation filled many basins with deep, fertile deposits of soil, but since the advent of white men and their herds heavy grazing has reduced the vegetation cover and many of these deposits are now cut by deep gullies. Other basin soils have been irrigated and are extremely productive. Most of the volcanic areas are so recent that soils have not yet formed, except where fine cinders and ash fell. This material acts as a mulch and makes agriculture possible in some unirrigated places.

NATURAL VEGETATION - The mountains and high plateaus of the region have a zone of heavy coniferous forests. The forests are composed of spruce and fir on the mountain tops, with open stands of pine covering the high plateaus. At lower elevations there is a zone of open savanna composed of low pinon, juniper and grasslands. Open rangelands of sparse weeds and shrubs cover many low plateaus and basins, with barren lands at the lowest elevations.

RURAL CULTURE - Livestock raising is one of the principal occupations and isolated ranches are found throughout the region. Large numbers of cattle and sheep are grazed on the high plateaus and mountains in summer and on the low plateaus and basins in winter. Many marks of this activity are visible, such as earth tanks, windmills, corrals and fences. Indian reservations occupy large areas and have very primitive settlements. Some are pueblos of adobe houses, while other areas have scattered circular huts called "hogans". Many people are engaged in timber cutting and sawmilling or in fuel wood and post cutting. Oil and gas production, and more recently the processing of uranium, is rapidly expanding. Small settlements are often found around these processing plants, but more often settlements are supported by a combination of activities and are located at transport junctions.

URBAN CULTURE - Large settlements have sprung up near irrigation and road and rail junctions, which has placed most of them in the low basins where these occur. These settlements are laid out in a characteristic gridiron pattern, oriented to the railroad, with large blocks and wide streets, without shade trees.

TRANSPORTATION - There are only four rail lines in the region and they follow routes through the lower basins where they are paralleled by paved highways. An open net of other paved roads branches off from these axes, and large areas are served by low standard dirt roads. Rut roads and trails serve the mountains.

PLATE 2.—Regional description. This text stays at a general level, describing the region as a whole. These broad generalizations are later amplified.

COLORADO PLATEAU
NAVAJO SECTION   SECTION D

The Navajo Section,in the south cenral part of the region, covers about ¼ of the region and is its largest subregion. It is an area of widely varying conditions, ranging from high, forested mountains to barren deserts. Culturally it varies from the rural slums of the Navajo Reservation to booming oil, gas and uranium towns.

RELIEF AND DRAINAGE - The subregion is composed of many high isolated sandstone plateaus, surrounded by retreating escarpments and rock terraces, and deeply cut by canyons. Great dome uplifts have elevated some areas creating isolated mountains. Between the plateaus and the mountains are broad basins, which vary from high valleys below the plateau scarps to low deserts. The basins are drained by dry washes where flash floods are a constant hazard in summer. The upper San Juan drains the northeast corner of the subregion and supplies the only stable source of irrigation water. The Chama and Little Colorado drain the balance.

SOILS AND VEGETATION - The soils of the high plateaus are relatively undisturbed and are protected by a forest cover, but the soils of the lower plateaus and basins are eroding badly due to many years of overgrazing. Much of this area is at a low elevation with a semi-desert climate, and there is a precarious moisture balance between what is adequate for drought and alkali resistant shrubs and complete desert conditions. Many of the lower areas, like the Painted Desert, are without any vegetation and are eroding severely.

RURAL CULTURE - In recent years the timber resources of the high plateaus have been developed to supplement unreliable returns from livestock raising and farming, and modern sawmills and lumber yards can be found in a number of places. In the higher basins, where rainfall is adequate, the range shrubs have in places been plowed up and the land converted to grass or dry farming. Although much of the subregion is unsuited to any form of agriculture, there are many irrigation projects where water from the upland snowmelt is impounded. Oil, gas and uranium development is increasing and oil rigs and pipelines appear on otherwise worthless lands. Coal mining is important in the northern and southern parts, where carboniferous strata turn up to the surface.

URBAN CULTURE - There are only a few towns in this sparsely settled subregion. They are of two types, the rail and highway towns, such as Durango and Gallup, and the irrigated valley towns, such as Farmington and Aztec.

TRANSPORTATION - The main line of the Santa Fe R. R., paralleled by US Hy. 66, crosses the low basins on the southern edge of the subregion, and several improved highways branch off from this. Narrow gauge mining railroads radiate from Durango. Unsurfaced dirt roads,leading into the high country,are poor because of the adobe clay soil, becoming impassable after rains. Travel in the back country is by horse or 4-wheel-drive vehicle, and the covered wagon of a century ago is still the standard mode of travel in the hinterlands. Rough trails provide the only access to many areas.

Fig. 1.2 Typical view of the Navajo Section. It has isolated mountains, such as Navajo Mountain in the distance, high, cool, forested mesas cut by canyons, such as Black Mesa at the left, and hot, semi-desert basins. The limiting factor is water and it is carefully conserved. The earth tanks in the foreground catch summer rain for stock water, and water is collected in Kayenta Wash to irrigate a small acreage. Navajo Reservation at Kayenta, Arizona. October 1947.

PLATE 3.—If the interpreter's photos fall in Sec. D he turns to this page, after reading the regional description, and gets a more detailed description of the section as a whole.

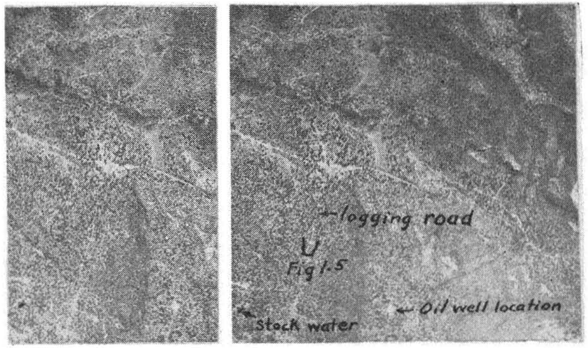

Fig. 1.3 High forested plateau. The domed area at the right has been drilled for oil. The soil is quite shallow and red sandstone is exposed on the surface in many places. The mesa has been selectively logged, under Forest Service supervision, removing about 50% of the timber volume. It is a naturally open stand of pine, with many openings which are covered with grass, providing summer range for cattle. French Mesa near Gallina, New Mexico. June 1952. Scale 1:40,000

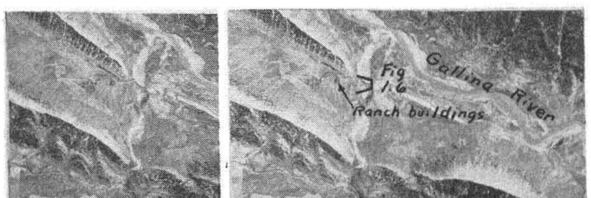

Fig. 1.4 Upturned sandstone strata in an uplifted area. The valleys between are filled with a deep accumulation of sandy clay weathered from these formations. The soil is fertile but lack of water makes productive agriculture impossible. The Gallina River flows only in spring and after summer storms and is filled with coarse alluvium. Near Llaves, New Mexico. June 1952. Scale 1:40,000

Fig. 1.5 Log hauling following timber cutting. The uncut timber in the background still provides a forest cover and will grow faster as a result of this thinning. Another cut can then be made in 25 years. Roads are easy to build over these mesas and trucks are frequently able to maneuver through the woods without a road. Gallina, New Mexico. September 1949.

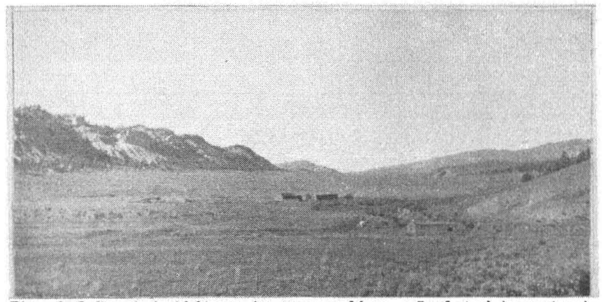

Fig. 1.6 Ranch buildings in open valley. Isolated homesteads of this type are common in the Navajo Section. This homestead could not produce enough to support a family and was abandonned. It is used **now** as a temporary camp for sheepmen. Chacon Ranch, Llaves, New Mexico. June 1948.

PLATE 4.—These verticals and ground photos illustrate the previously stated generalizations, then show variations from them. They progress from small scales, depicting land forms, to large scales showing culture, covering several pages.

COLORADO PLATEAU
HIGH PLATEAUS OF UTAH SECTION A

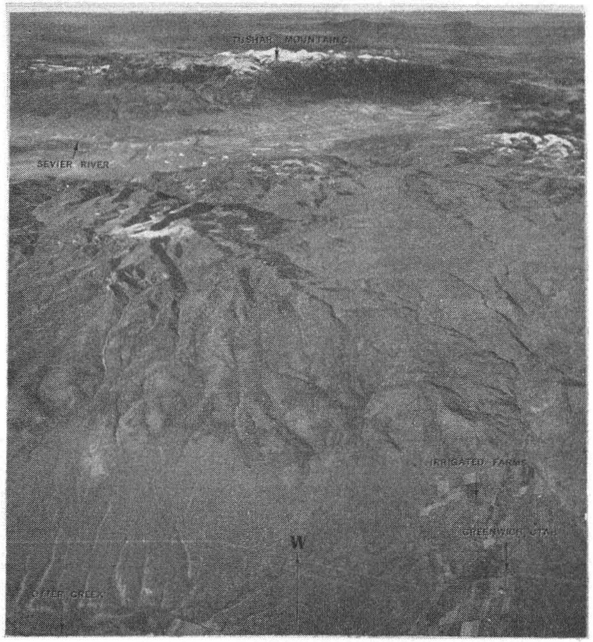

Fig. 1.7 The High Plateaus of Utah. This section is characterized by rough and broken north-south trending plateaus divided by faults. They have nearly horizontal strata, dipping slightly to the east, with lava caps in many places. There are a number of elevations over 12,000 ft., such as the Tushar Mountains in the distance, which have glacially carved valleys and lakes. Basins as low as 6,000 ft. lie between these plateaus, and they contain a few small Mormon settlements, limited irrigation, and the routes of travel in the section. A railroad comes up the Sevier Valley and ties the section economically with the Salt Lake area. Otter Creek Valley, Utah. October 1947.

COLORADO PLATEAU
UINTA BASIN SECTION B

Fig. 1.8 The Uinta Basin. This is a deeply dissected structural basin with strata dipping slightly to the north. Several rivers cross the section, such as the Colorado and the Green, and they have broad irrigated valleys where most of the settlement of the section is located. In the foreground are deep canyons up which minor roads lead to cattle ranches. The plateau tops, which are close to 8,000 ft., are largely covered by oak brush which succeeded pine forests following fires. They are now used largely as summer range for cattle. Roan Plateau, west of Rifle, Colo. May 1948.

PLATE 5.—Representative views of Sec. A and B. These would be the introductory photos for their respective sections, followed by verticals and ground views. It will be noted that, though the rock structures vary, the cultural, climatic, soil and vegetation associations are repeated essentially from section to section.

COLORADO PLATEAU
CANYON LANDS SECTION C

Fig. 1.9 The Canyon Lands Section. This area is extremely diverse. Many parts of it are in the low basin of the Colorado River, seen in the foreground, and its barren, rocky plateaus are cut by intricate patterns of winding canyons. This area is very arid and streams and springs are very rare. A number of narrow valleys have level bottoms, such as Moab Valley in the background, and they have been developed for irrigation. In the eastern part of the section there are very wide irrigated valleys near Grand Junction. Providing further contrast are the local uplifts with forest clad slopes, such as 13,000 ft. Mt. Peale in the background, over which a local storm, created by updrafts, is forming. Near Moab, Utah. October, 1947.

COLORADO PLATEAU
GRAND CANYON SECTION SECTION E

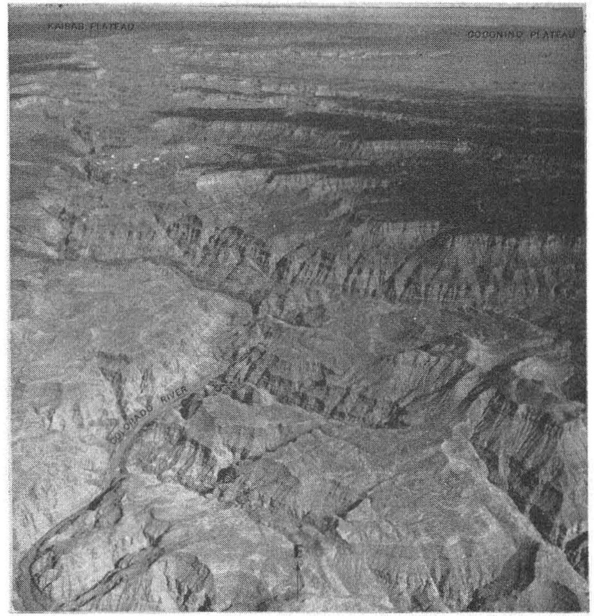

Fig. 1.10 The Grand Canyon Section. The Colorado River has carved a 4,000 ft. trench through high plateaus, dividing the section into two great plateau systems, the Kaibab and Coconino Plateaus, seen in the background. The surface of the upper strata is resistant to erosion but the exposed faces weather rapidly. Limestone strata near the surface inhibit surface drainage and the underground drainage creates numerous springs. There is great contrast in local climate in the section, with its cold mountains, rising above the plateaus in places, its cool, forest clad plateaus, and its hot, barren canyons. Lower Grand Canyon, Arizona. October 1947.

PLATE 6.—These two sections have great variety in their features, but they vary from other sections mainly in local climate.

COLORADO PLATEAU
DATIL SECTION SECTION F

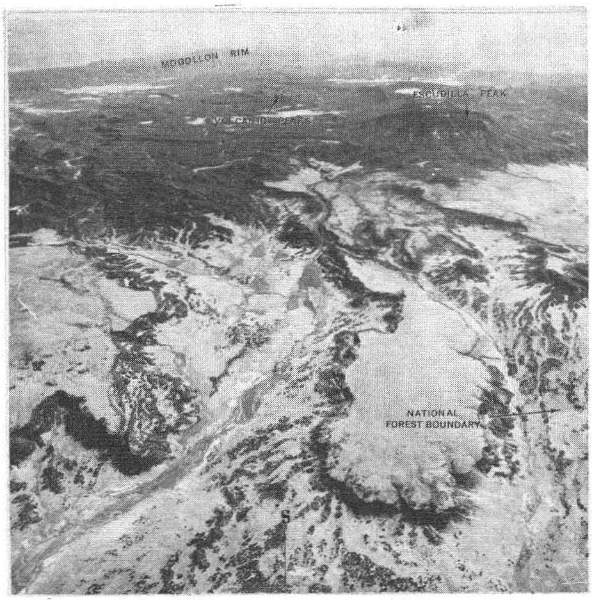

Fig. 1.11 The Datil Section. This section is similar to the rest of the province, but it is relatively high and has many volcanic features. In the background is the 11,000 ft. eroded volcanic cone of Escudilla Peak. Its north slopes were recently burned off by a disasterous forest fire, the scars of which are visible. Surrounding it is an 8,000 ft. pine forested plateau, covered by volcanic cones and capped by lava. A lava cap has prevented the erosion of the low mesa in the foreground. In the background is the Mogollon Rim, which is the province boundary, dividing it from the desert country to the south. This is largely national forest land, which has had better protection from heavy grazing than the lower lands in the foreground, and the difference in vegetation cover is visible along the boundary fence. Southeast of Springerville, Arizona. October 1949.

PLATE 7.—Many of the characteristics of other sections, especially Sec. E, are present here, making it difficult to find distinctive features.

Map errors are the result of faulty information on areas where there is incomplete coverage by photography and modern maps. In such areas subdivision lines depend upon inaccurate base maps, and frequently upon the field notes and rough sketches of geologists and explorers, which often represent changes in terrain diagrammatically. Examples are available where the maps of different men who sketched the same features show them many miles apart. A desert area, which the author recently attempted to delineate, was shown on the best source maps in locations which varied in places by as much as 100 miles. Only one photo mission crossed the desert and no explorer had ever mapped it in its entirety. Physiographic lines in other poorly mapped areas commonly err by as much as 10 to 20 miles. The photo interpreter, especially the inexperienced man, who is in greatest need of guidance, places his trust in the key and he is needlessly misled, or thrown into confusion on discovery of these errors. He then loses confidence in the entire key. Photo locations are likewise open to error, though less frequently. They depend upon the pilot's trace of his mission, which is subject to error under difficult flying conditions. If the interpreter is without accurate large scale maps for orientation he is forced to accept these locations. Again he is led into the possibility of a false estimate or into disillusionment.

Another source of error is the use of chorographic scales for regional maps to delineate terrain changes which can be seen in detail only at topographic scales. Semple (13) expressed the problem this way:

"Nature abhors fixed boundary lines and sudden transitions; all her forces combine against them. Everywhere she keeps her borders melting, wavering, advancing, retreating. If by some cataclysm sharp lines of demarcation are drawn, she straightway begins to blur them by creating intermediate forms, and thus establishes the boundary *zone* which characterizes the inanimate and animate world."

In these broad zones of transition terrain characteristic of one area frequently interlocks like a jigsaw puzzle with terrain characteristic of another. The interpreter who tries to analyze a photo near one of these boundaries is very likely to find in his photos an outlier or protruding tongue of another area which is much different from that described for this location. As a result the inexperienced interpreter submits a false report, and the experienced man discovers his mistake, but makes a mental reservation regarding the value of the key. Figure 2 illustrates the problem.

2. The greatest disadvantage of physiographic subdivision is the lack of homogeneity within any large area such as one of Fenneman's subdivisions. Any subdivision of the earth which does not follow generic land form lines has many terrain conditions within it. Definite ground conditions and associations cannot be described and only broad generalizations can be given. Nor can deductive methods for making an exact interpretation be outlined, like those described by the author in a previous paper (10). Since each major land type has its own associations and ground conditions, the key is forced to spell out the conditions found on each land type within the subdivision, a situation involving voluminous repetition from one subdivision to another, or to give vague generalizations. The latter alternative is the natural choice. To overcome this objection the physiographer can continue to subdivide his land units until he reaches a unit which is homogeneous. If he should attempt to subdivide the Navajo Section into homogeneous units, he would find he had perhaps 10 uplifted mountain areas, on which the associations were essentially the same,

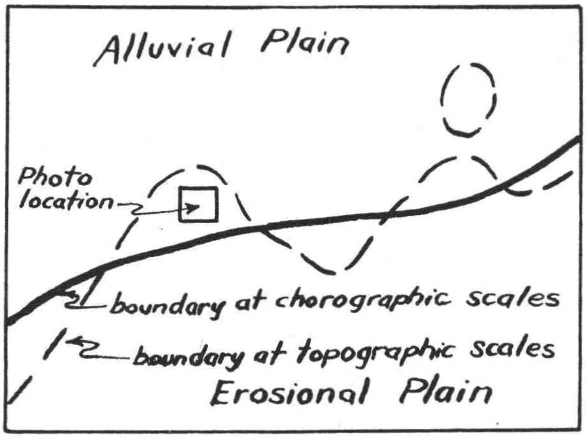

FIG. 2.—Two boundary lines represent the same topo graphic change at different scales. The smooth line is an average location which may be inaccurate at any given point if examined at a topographic scale. Here a photo falls within an erosional plain, but the regional map tells the interpreter that it is on an alluvial plain.

and perhaps 100 high plateaus with similar associations. This would give him far too much repetition, and he would be forced to describe the *typical* situation. In other words, there is apparently no compromise between "too large" and "too small" which does not involve voluminous repetition, unless one resorts to types.

However, there are some regions where topographic changes are relatively minor and the land surface is relatively uniform, as in a level desert region, where dominant control shifts from topography to climate and water supply. In such cases the use of physiographic subdivisions should be considered.

(*continued on page 167*)

COLORADO PLATEAU

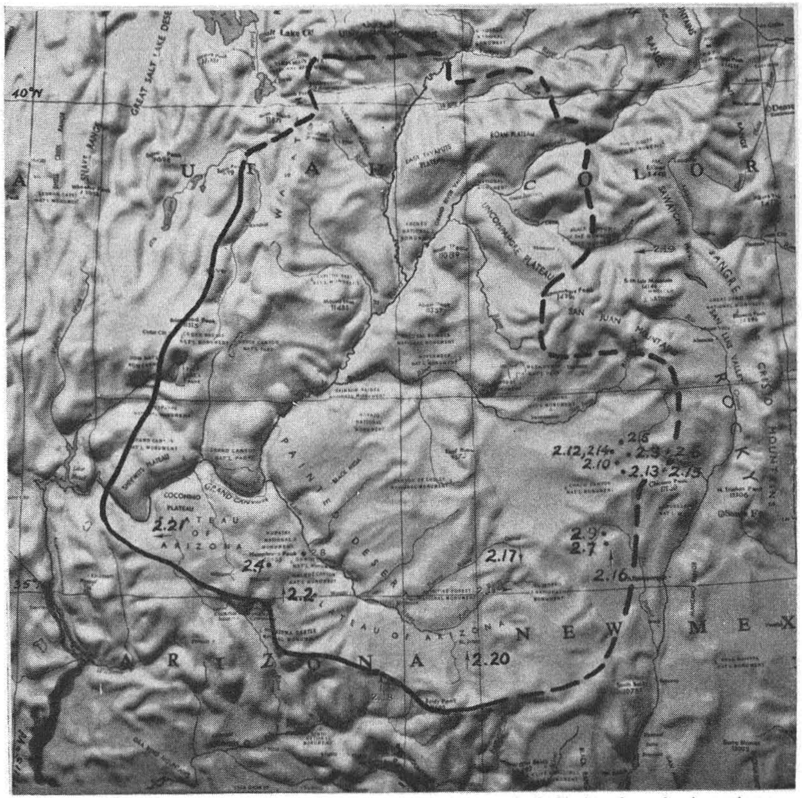

Fig. 2.1 Colorado Plateau. Dash lines indicate indefinite boundaries where information from this key becomes unreliable. Scale 1" - 70 miles

The Colorado Plateau covers the "four corners" area of Arizona, New Mexico, Colorado and Utah and covers some 130,000 square miles.

<u>RELIEF</u> - The region is underlain by nearly horizontal beds of sedimentary rock which form elevated plateaus. Many isolated areas have been uplifted forming high mountains. The exposed sedimentary strata of the plateaus are quite resistant to erosion and their surfaces have a mature drainage system, but when they are cut through erosion accelerates creating canyons. These exposed faces weather causing their scarps to retreat. There has been volcanic activity in the region and many of the plateaus have volcanic mountains on them, and the surrounding area is covered by cinder cones, lava flows,etc.

<u>DRAINAGE</u> - The region is drained by the Colorado River and its tributaries. The main tributaries, the Little Colorado, the San Juan, and the Green Rivers flow inward into a basin in the center of the region and then join the Colorado before it enters the Grand Canyon.

<u>CLIMATE</u> - The region has a semi-arid climate, which is extremely variable and is influenced by elevation. Elevation creates vertical zones, with a subarctic climate on the higher mountains, which are over 12,000 ft., a temperate climate on the high plateaus from 8,000 ft. to 7,000 ft., and a semi-desert climate below 7,000 ft. The mountains receive up to 40" of precipitation annually, about half of which falls as winter snow. The high plateaus receive 20" - 30", and lower elevations receive between 5" and 20". High summer temperatures in the lowlands cause updrafts creating convectional storms, which form over the high elevations then drift over other areas. There are strong winds in spring which disturb the formation of updrafts, which causes a period of drought through June each year.

PLATE 8.—This key operates entirely differently. The map is merely for orientation. The regional description, however, has the same function as in the previous key and does not vary significantly.

SOILS - The soils of the region are generally thin, poorly developed residual clays and sandy clays resulting from the wasting of sedimentary rock. Due to the light rainfall many of the soils at lower elevations are alkaline, producing little more than alkali tolerant shrubs. Slow soil movement before the disturbance of vegetation filled many basins with deep, fertile deposits of soil, but since the advent of white men and their herds heavy grazing has reduced the vegetation cover and many of these deposits are now cut by deep gullies. Other basin soils have been irrigated and are extremely productive. Most of the volcanic areas are so recent that soils have not yet formed, except where fine cinders and ash fell. This material acts as a mulch and makes agriculture possible in some unirrigated places.

NATURAL VEGETATION - The mountains and high plateaus of the region have a zone of heavy coniferous forests. The forests are composed of spruce and fir on the mountain tops, with open stands of pine covering the high plateaus. At lower elevations there is a zone of open savanna, composed of low pinons, junipers and grasslands. Open rangelands of sparse weeds and shrubs cover many low plateaus and basins, with barren lands at the lowest elevations.

RURAL CULTURE - Livestock raising is one of the principal occupations and isolated ranches are found throughout the region. Large numbers of cattle and sheep are grazed on the high plateaus and mountains in summer and on the low plateaus and basins in winter. Many marks of this activity are visible, such as earth tanks, windmills, corrals and fences. Indian reservations occupy large areas and have very primitive settlements. Some are pueblos of adobe houses, while other areas have scattered circular huts called "hogans". Many people are engaged in timber cutting and sawmilling or in fuel wood and post cutting. Oil and gas production, and more recently the processing of uranium, is rapidly expanding. Small settlements are often found around these processing plants, but more often settlements are supported by a combination of activities and are located at transport junctions.

URBAN CULTURE - Large settlements have sprung up near irrigated land and road and rail junctions, which has placed most of them in the low basins where these occur. These settlements are laid out in a characteristic gridiron pattern, oriented to the railroad, with large blocks and wide streets, without shade trees.

TRANSPORTATION - There are only four rail lines in the region and they follow routes through the lower basins where they are paralleled by paved highways. An open net of other paved roads branches off from these axes, and large areas are served by low standard dirt roads. Rut roads and trails serve the mountains.

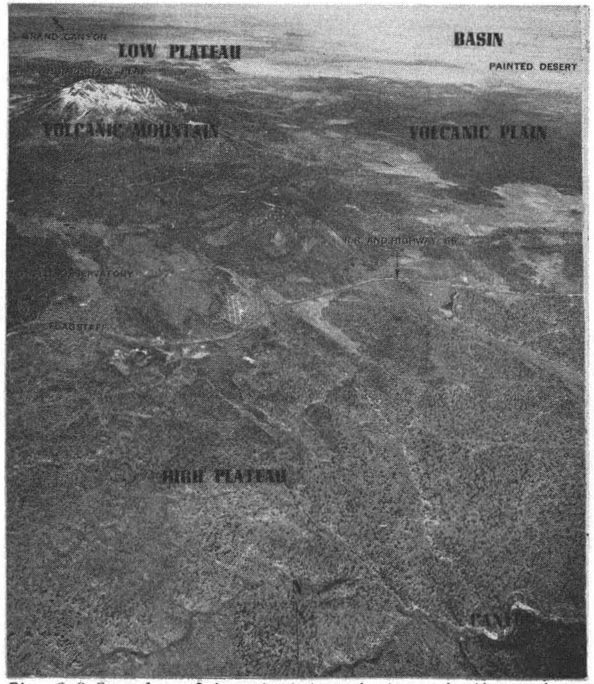

Fig. 2.2 Examples of important terrain types in the region. The HIGH PLATEAU in the foreground is level and covered with a pine forest, depleted by heavy cutting. To the right is the head of a CANYON, which becomes much deeper as it nears the plateau rim. In the background is a **VOLCANIC MOUNTAIN** which rises to 12,600 ft., producing a marked change in climate and vegetation. It is surrounded by satellite volcanic cones, and a VOLCANIC PLAIN, covered with cinder cones and recent lava flows, extends off to the right. Beyond the plain is the broad BASIN of the Little Colorado and the Painted Desert. Beyond the mountain is a LOW PLATEAU covered with low pinon-juniper. The only important type absent is the UPLIFT MOUNTAIN type. Flagstaff, Arizona. April 1949.

PLATE 9.—The oblique photo shown here acts as a rough pictorial key, allowing the interpreter to visualize the range of conditions in the region as he reads the regional description.

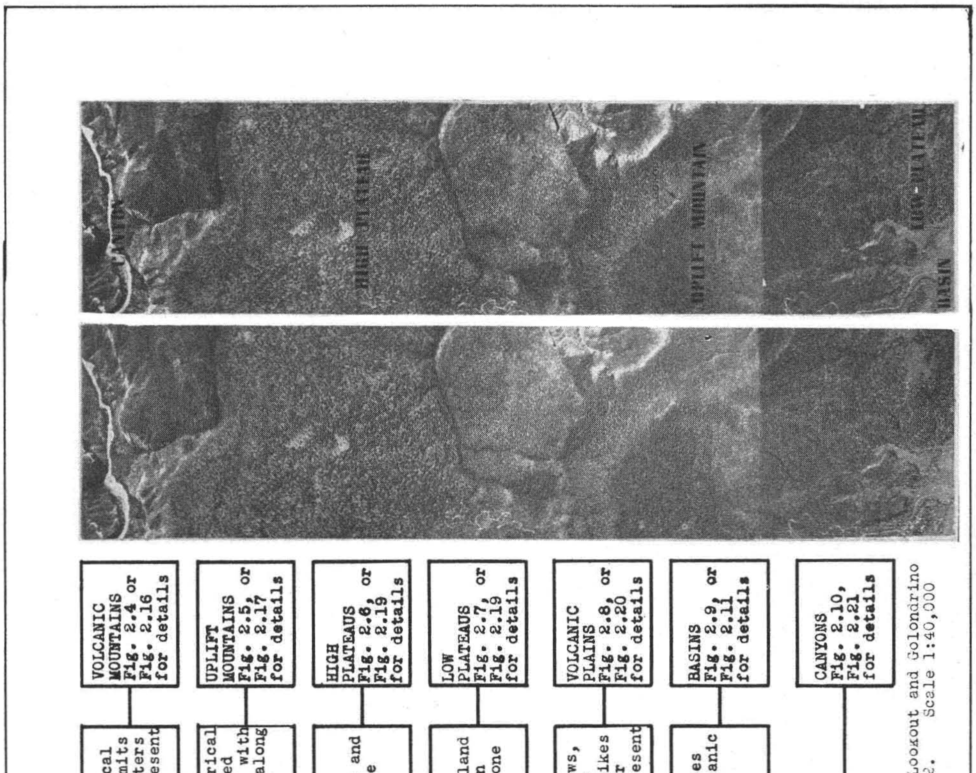

Fig. 2.3 Composite of 5 types. Deadman Lookout and Golondrino Mesa, near Llaves, New Mexico. June 1952. Scale 1:40,000

PLATE 10.—The interpreter then follows this dichotomous key through from left to right, and determines his terrain type. It is important that he compare his type with others which look similar so a composite stereogram shows the types side by side for comparison.

COLORADO PLATEAU
EXAMPLES OF TERRAIN TYPES

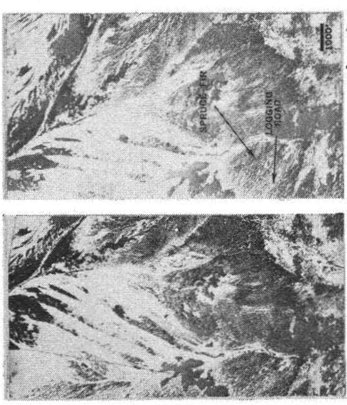

Fig. 2.4 Volcanic mountain. An avalanche scarred cone rising to a breached crater at Humphrey's Pk. at 12,600 ft. Flagstaff, Arizona. April 1949 Scale 1;40,000

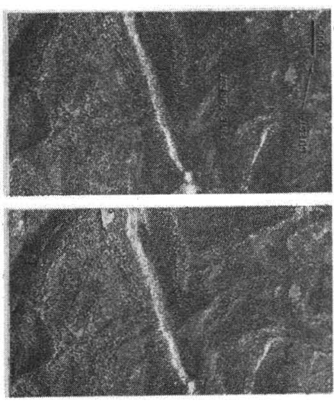

Fig. 2.5 Uplift mountain. Tilted sandstone strata rise to the weathered fault scarp of Gallina Mountain at 8,980 ft. Near Llaves, New Mexico. June 1952. Scale 1:40,000

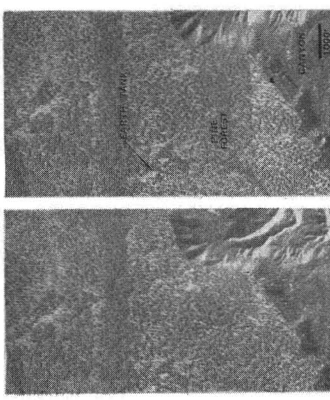

Fig. 2.6 High plateau. Horizontal strata at 8,000 ft. create a level plateau with an open pine stand and bunchgrass. Near Llaves, New Mexico. July 1935. Scale 1:32,000

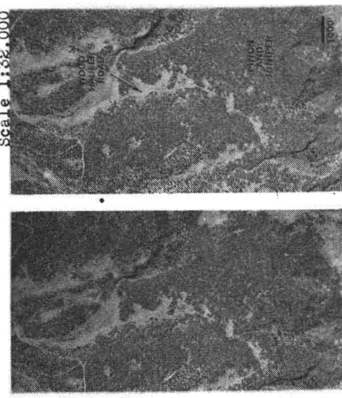

Fig. 2.7 Low plateau. This woodland covered mesa at 7,500 ft. is the lava capped lower slope of Mt. Taylor. Near San Mateo, New Mexico. April 1949. Scale 1:40,000

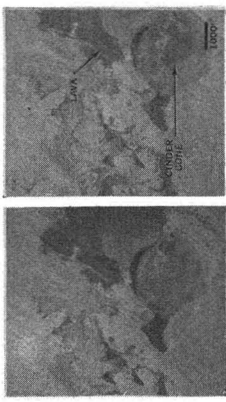

Fig. 2.8 Volcanic plains. Waste lands of lava and cinders at 5,000 ft. Northeast of Flagstaff, Arizona. April 1949. Scale 1:40,000

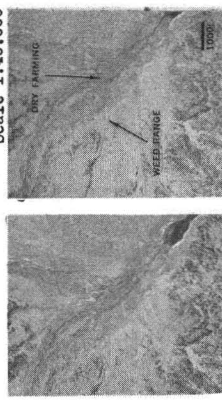

Fig. 2.9 Basin. Eroding, overgrazed rangelands at 7,500 ft. Near San Mateo, New Mexico. April 1949. Scale 1:40,000

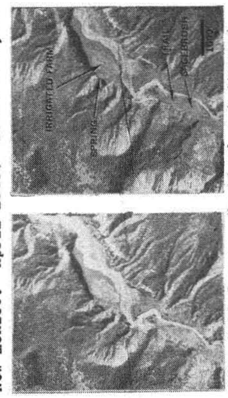

Fig. 2.10 Canyon. Vertical cut through soft sandstone at 7,000 ft., with sandy dry wash in bed of Gallina Canyon. Near Llaves, New Mexico. Scale 1:32,000

PLATE 11.—These seven stereograms show a sample of each type, with a few of their associations, so that the interpreter can check the findings secured from the dichotomous key. Vegetation is an important indicator of type, but it cannot be accurately identified by these annotations alone. He needs to turn to a supporting vegetation key to make sure of his identification.

COLORADO PLATEAU
BASIN TYPE

RECOGNITION FEATURES
1. Wide valleys, nearly level, with gently sloping valley sides.
2. Deep gully erosion frequent.
3. Vegetation usually low brush or sparse weeds, occasionally covered by open woodland, frequently barren.

VARIATIONS
1. Upper basins under scarps of plateaus, 6,000 - 7,000 ft.
2. Lower valleys of rivers, 5,000 - 6,000 ft.
3. Deserts in lowest valleys, 4,000 - 5,000 ft.

ASSOCIATIONS
Climate - semi-desert. Light scattered electrical storms from July through September with occasional heavy downpours. Dust storms in spring. Light snow does not remain after winter storms. Annual precipitation 5" - 15".

Soils - mostly alkaline clays. Composed of weathered sandstone, shale and limestone materials washed down from plateaus, forming deep sandy clay deposits. Alkali excessive in basins without good drainage, making soils infertile and water bad. Much coarse alluvium deposited in dry washes. Sheet and gully erosion frequently severe. Soils very slick when wet. Clays used to make adobe bricks.

Water Supply - dependent on deep wells, reservoirs, earth tanks and cisterns. Minor drainage channels are dry washes during most of year, with water flowing only after summer storms. Rivers usually aggraded with silt and coarse alluvium.

Vegetation - cover of sagebrush frequently found in upper basins. Open woodlands of pinon-juniper occasionally found on edges of upper basins. Lower basins have bitterbrush and shadscale brush on alkaline areas, and a sparse cover of weeds elsewhere. Used as winter range for cattle and sheep. Some areas being reseeded with range grasses or unirrigated crops. Frequently large areas are barren.

Culture - Agriculture usually irrigated. Some dry farming, in upper basins, raising small grains and beans. Some large commercial irrigation, depending on reservoirs. Large settlements occur at road and rail junctions, or in irrigated valleys. Many ranch headquarters and small towns also found. Some small wood-using industries depending on plateaus for raw material. Some oil wells, natural gas wells and pipe lines. Uranium processing plants springing up.

Transportation - Main paved roads and railroads use this terrain type principally. Cattle shipping points found along rail lines. Wide "dips" required in roads to allow passage of flash floods. Flash floods disrupt travel on minor roads in summer.

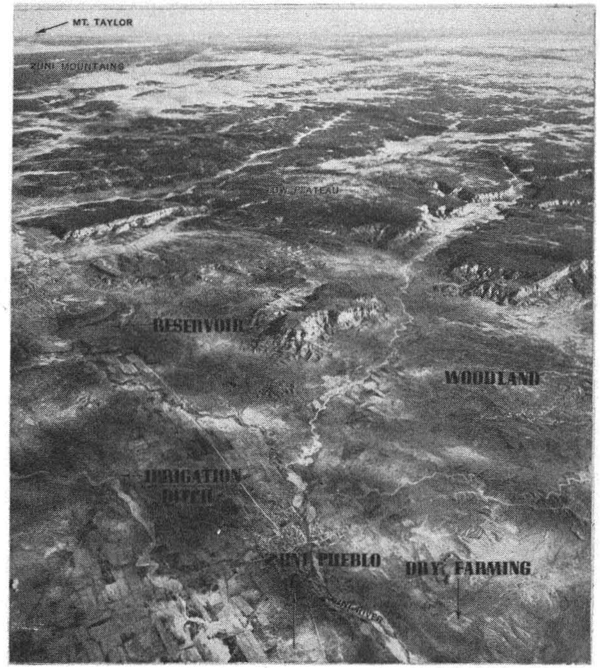

Fig. 2.11 The basin type. This basin at 6,500 ft. elev. is filled with weathered rock waste from receding escarpments around it, which ranges from adobe clay on the flats to coarse alluvium in the dry washes. The basin is irrigated by trapping summer rainfall behind a dam at the left, but it can only supply part of the water needs, and dry-farming is being attempted at the right. In the lower center is Zuni Pueblo made up of adobe clay houses. The Zunis are a progressive tribe and have been peaceful agriculturalists for generations. The basins are the favored sites for road locations in much of this region. New Mexico. December 1948.

PLATE 12.—If the interpreter has discovered a basin type in his photos he turns to this page and verifies this determination by first checking the recognition features. Then he gets very specific information on what to expect in his photos and how to deduce what activities are taking place.

COLORADO PLATEAU
BASIN TYPE

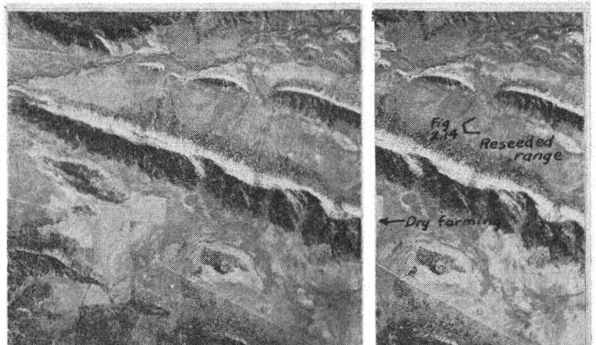

Fig. 2.12 A small basin crossed by the cuestas of an uplift mountain above it. This basin is without irrigation, but at 7,000 ft it receives enough rainfall for marginal dry farming Farmers make an occasional bumper crop of beans or grain, but there are many lean years between. The soil is a deep sandy clay and has a natural cover of sagebrush and grama grass. Overgrazing in recent years has depleted the grass cover and caused severe erosion, with vertical walled gullies up to 20 feet in depth. To reverse this trend the sagebrush has been plowed up, many of the gullies dammed and the area reseeded to range grasses. This has become a common practice in the basins of this area. The activity can be identified by its association with a sagebrush cover and deep, vertical gullies, both of which indicate deep, fertile soils. In some areas grain crops are planted following plowing. Llaves, New Mexico. June 1952. Scale 1:40,000

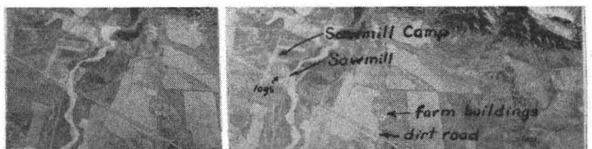

Fig. 2.13 Dry farming settlement and sawmill camp. These lands yeild poor returns and the settlers depend on livestock raising and logging to supplement their income. The sawmill seen here is similar to the mill in Fig. 2.15. Llaves, New Mexico. June 1952. Scale 1:40,000

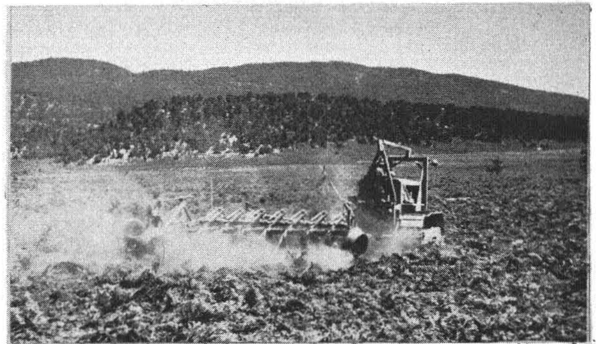

Fig. 2.14 Sagebrush being turned under with a heavy disc plow. This area can also be seen in Fig. 2.12. This is national forest land and range improvement is being done by the U. S. Forest Service. An increase of grazing capacity here will help relieve grazing pressures elsewhere. July 1949.

Fig. 2.15 Sawmill located in basin. This mill depends on pine timber from the national forest nearby. Large stocks of logs are accumulated each summer to carry the mill through the winter, when snow is too deep in the woods for logging. Mill waste is burned in the pit in the background. Beyond the mill is marginal farm land. Gallina, New Mexico. August 1949.

PLATE 13.—Vertical stereograms and ground photos now illustrate each important variation and association to be found in the type, and this usually requires several pages. They go into detail about ecological indicators and typical cultural features, showing how one depends on another.

COLORADO PLATEAU
VOLCANIC MOUNTAINS

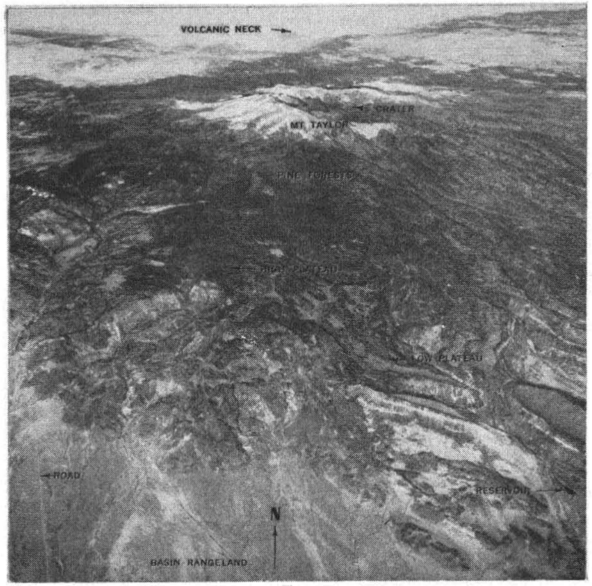

Fig. 2.16 Volcanic mountain type. This volcanic cone, with an elevation of 11,400 ft., erupted above a high plateau, covering its sandstone strata with a lava cap. The plateau has a cover of pine, which gradually changes to fir, spruce and aspen on the mountain slopes. The timber is low in quality because of the poor lava soils. Extensive grasslands at upper elevations, caused by old burns, provide summer range for cattle and sheep. The local climate is subarctic with deep snows in winter and cool summers. Precipitation averages between 30" and 40". Movement over terrain of this type must be by trail or by steep logging roads. Mountains of this type provide water for irrigation because of the large amount of rainfall, but water is scarce at higher levels because of the porosity of the rock.
Mt. Taylor, near Grants, New Mexico. April 1949.

COLORADO PLATEAU
UPLIFT MOUNTAINS

Fig. 2.17 Uplift mountain type. This 8,700 ft. mountain is an elongated dome from which the upper sedimentary rock has weathered, leaving cuestas on all sides. It has a vegetation cover of pine forests of good quality and high economic value, and its open parks provide summer range for cattle. The local climate is temperate with moderate snowfall in winter and warm summers. There are moderate summer rains and precipitation amounts to 20" - 30". Movement over this terrain may be over a network of good timber access roads with their many minor spur roads. A fire lookout is located on the highest peak. Springs and running streams are scarce and frequently dry up in summer. Zuni Mountains, near Grants, New Mexico. April 1949.

PLATE 14.—These two types are very distinctive and their homogeneity simplifies interpretation of activities on them by eliminating many possibilities.

COLORADO PLATEAU
HIGH PLATEAU TYPE

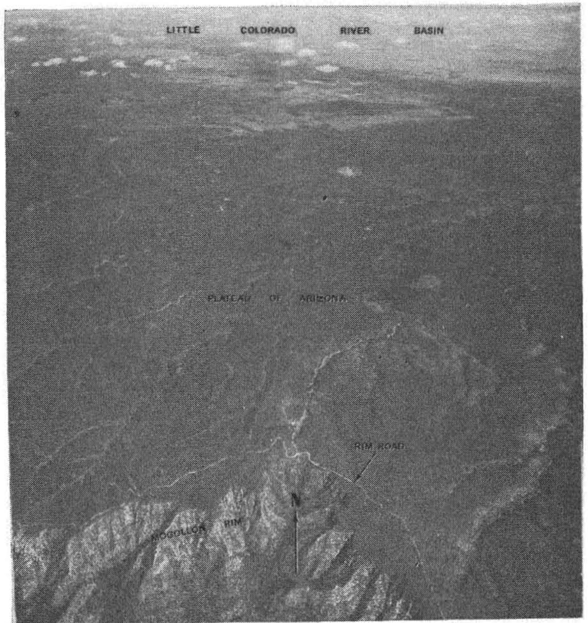

Fig. 2.18 High plateau type. This sandstone plateau, at an elevation of 8,000 ft., is heavily forested with high quality pine timber. The escarpment in the foreground is the Mogollon Rim which forms the south boundary of the province. The local climate is temperate with warm summers and moderate winters. Thunderstorms provide considerable rain in summer and there are heavy snows in winter. There is a network of poor roads, which are being developed into high standard logging roads as the virgin timber receives its first cut. The plateau is very sparsely populated, but a few small settlements may be found, such as logging camps, summer ranch headquarters, ranger stations and small communities subsisting on a combination of dry farming, livestock raising and sawmill work. Near Showlow, Arizona. October 1949.

COLORADO PLATEAU
LOW PLATEAU TYPE

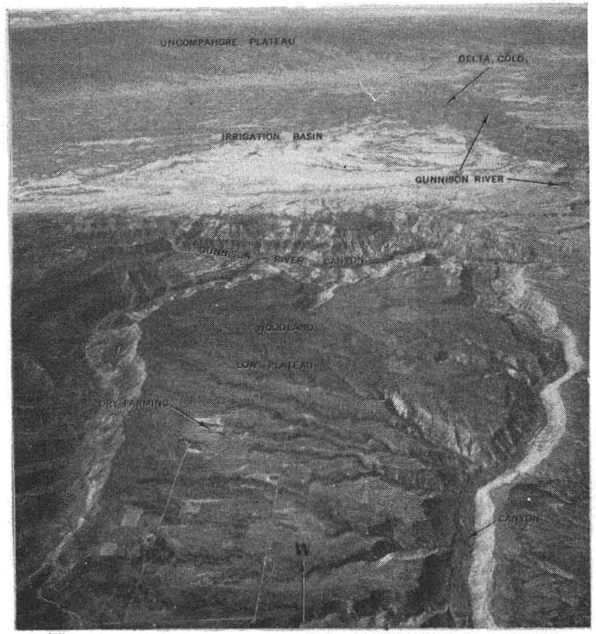

Fig. 2.19 Low plateau type. This 7,000 foot plateau has a vegetation cover of pinon-juniper woodland and open grassland. Pinon and juniper are short and crooked and are usually used for fuel wood and fence posts. The grasslands provide spring and fall range and occasionally winter range. This type of land has an adobe clay soil and is occasionally plowed for planting range grasses or for dry farming. The local climate is a transition between temperate and semi-desert. Snow does not last after winter storms and light rains may be expected from July to September. Precipitation averages 15" - 20", but is erratic. The plateaus may be crossed on the rut roads used by wood haulers or on low standard farm roads. Near Delta, Colorado. October 1947.

PLATE 15.—These two terrain types are superficially similar, but their differences in vegetation make them distinctive. They each have a narrow range of associations usually found on them only.

COLORADO PLATEAU
VOLCANIC PLAINS TYPE

Fig. 2.20 Volcanic plains type. This is an area of lava flows and cinder cones, at an elevation of 7,000 ft. in the vicinity of volcanic mountains. Vegetation is completely lacking or extremely sparse, and the land cannot be used as livestock range. The soils are undeveloped and composed of well drained cinders and fragmented lava. The climate is a transition between temperate and semi-desert. Snow does not remain after winter storms and light rains fall sporadicly from July to September, usually coming as thunder storms. Roads are infrequent. Occasionally roads lead to cinder pits for road surfacing material. Lava beds are almost impassable. Water supply is precarious. North of Springerville, Arizona. October 1949.

COLORADO PLATEAU
CANYON TYPE

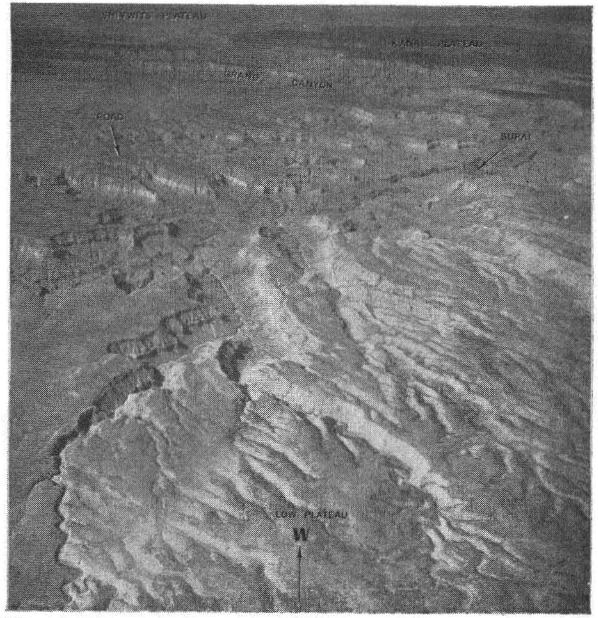

Fig. 2.21 Canyon type. This is a deep canyon cut through horizontal sandstone strata at elevations between 5,000 and 3,000 ft. Vegetation is almost entirely lacking, except in wide canyon bottoms, which may have a brush or sparse grass cover, used for winter range. Soils are absent except in flat bottoms which have alluvial deposits of sand and silt. The climate is arid with precipitation of 10" - 15", with warm winters and hot summers. No agriculture is found except in occasional fields in wide bottomed canyons where there is irrigation. This canyon is inhabited by the Havasupai Indians, who irrigate the lower canyon bottom. Supai, Arizona. October 1947.

PLATE 16.—The volcanic plain is a hybrid type which is usually found as a part of an upper basin, but its distinctive characteristics leave no doubt as to its identity. The canyon type is very distinctive and it has only a very narrow range of associations.

3. It is necessary to use an essay key format in the construction of regional photo interpretation keys by the physiographic subdivision method because of their broad generalizations and many exceptions. An essay key is the weakest type of key and the least adapted to rapid and accurate identification of images.

4. The physiographic method is best suited to description and is not adapted to analytical photo interpretation. A classification which is purely descriptive and which does not teach the deduction of a dynamic changing process is tied to a definite period of history and soon becomes obsolete.

The Terrain Type method

ADVANTAGES

1. The outstanding advantages of using terrain types is the ease with which they can usually be recognized on air photos; this contrasts sharply with the many problems of depicting the boundaries of physiographic subdivisions on maps. Terrain types are recognized for what they are regardless of location. Mistakes are less likely because the analyst interprets directly from the photos.

2. When the photo interpreter has followed his key to a solution, and has identified his terrain type, he has before him a relatively homogeneous unit. Quite specific directions can be given for deducing the ground conditions of this area by means of its associations. Usually this is not difficult because the range of associations within each type is narrow.

3. Terrain types can be interpreted by systematic keys, such as dichotomous or integrated selective keys. Such keys are well suited to provide rapid and accurate solutions by means of scientific methods of reasoning, instead of a ready-made solution filled with inherent errors which the interpreter is powerless to evaluate.

4. Terrain type keys are geared to evaluate changing conditions. The interpreter is not provided with a ready-made solution because it is recognized that the terrain type has dynamic forces constantly at work on it, such as climatic and economic changes, which combine in infinite variations. Instead he can be guided into thinking the problem through for himself. This deductive process is based upon the ecology of the site, which in turn is closely tied with the climate, the geological origin, and the resulting soil and vegetation mantle. This provides a key which can withstand the changes of time and can justify the heavy expense involved in its preparation.

DISADVANTAGES

1. The terrain type key does not give descriptions of all areas, just typical areas. It provides a procedure for the analyst to make his own description based on guided research of an original nature.

2. The terrain type key is not designed to describe localities where there are environmental differences from the region as a whole. This can be avoided by selecting regional boundaries which do not include great variations in this respect.

3. The construction of terrain type keys is difficult because original research must be done to develop the types and their associations. These are hardly ever found in geographic descriptions, which usually describe regions, locality by locality.

4. The deductive process which associative methods require is not well suited for use by the neophyte. It requires a background in the natural sciences, as well as good logical reasoning powers. The neophyte needs a different kind of key than the natural science specialist. He needs most of the terrain elements identified and explained for him. The experienced man is helped by this review, but his need is for condensed reference material and an explanation of the ecology of a new region. This dilemma can be partially solved by a division of responsibility, with the inexperienced interpreter limiting his effort to the recognition of images and the natural scientist making the interpretations of the significance of these identifications.

Conclusions

This study is not intended as a presentation of positive proofs but as a thought-provoking problem-analysis illustrating two methods of geographic study. Each requirement may demand a different kind of geographic technique. If the requirement is for training, where the task is essentially one of description and the provision of a geographic background, and where a high degree of accuracy is not needed, then the physiographic method may be entirely adequate. If, however, the key is to be used at an operational level where accuracy is essential and where analytical interpretation must be done, then there is little question that the terrain type method has much to offer. It should be noted that the terrain type method can be used for both general classes of requirements, while it is doubtful if the physiographic method can be used for both.

The use of a method which is not adapted to photo interpretation procedures can lead to a weakening of the final product. Therefore the selection of the vehicle which will best accomplish a land classification task, whether it is for civil or military purposes, is something needing considerable study.

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