come if this opportunity is wasted. Mr. Chairman, you may go as far as you like in your Committee on Map Planning. There are plenty of good capable men to put through any plan you make for accelerating the mapping of this country.

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THE AERIAL MAPPING PROGRAM OF THE SOIL EROSION SERVICE
by
Charles W. Collier

The Soil Erosion Service was established in the Department of the Interior shortly after August 25, 1933, for the purpose of administering Public Works funds which had been allotted to the control of man-induced soil erosion. An initial allotment of $5,000,000 was made for the work, and from time to time additional allotments have been made, bringing the total funds available to $20,000,000.

The magnitude of the problem with which the Soil Erosion Service is attempting to cope is indicated by the following representative statistics relative to the seriousness of erosion caused by improper methods of cultivation, forestry and grazing, and by man-induced fires: More than 35,000,000 acres of agricultural lands have already been essentially destroyed. Of the approximately 413,000,000 acres now susceptible to cultivation, all but less than 150,000,000 acres will have been virtually and permanently destroyed or severely depleted within the next fifty to seventy-fire years unless some means can be found to combat and control the erosion responsible. The annual direct cost to the farmers of this destructive phenomenon is at least $400,000,000 in soil values washed away. Incalculable additional losses are involved in the silting of reservoirs and stream channels, the abandonment of farms, the impoverishment of entire regional populations and in other indirect effects.

Reservoirs are silting at alarming rates. For example, the great Elephant Butte Reservoir will be silted to 70% of capacity within 60 years, at the end of which time the total water storage will be reduced to one year's draught, and thereafter irrigated lands under the project will have to be progressively abandoned, until at the end of 93 years the Reservoir will be completely filled and the capacity reduced to zero. Extensive grazing resources are being almost completely destroyed. Entire regions are headed for virtual abandonment.

The program of the Soil Erosion Service involves the establishment of a series of demonstration watersheds on agricultural lands ranging in area from 50 to 300 square miles, and the undertaking of control operations on approximately 24,500 square miles of the Navajo Indian Reservation and 22,000 square miles in the Gila and San Pedro watersheds in southern Arizona and New Mexico. In each of these projects, a strenuous attempt is being made to put into effect a comprehensive, well-rounded program of land utilization and erosion control with measures adapted to the specific needs and adaptabilities of the land. Areas unsuitable for agriculture are planted to grass and trees. Proper crop rotations are instituted. Agricultural methods are reorganized. Overgrazing is controlled. Engineering structures such as terraces, check dams, etc. are built.

The method of procedure in each of these areas is approximately as follows:

(1) Detailed surveys are made covering the type of soil, the degree of erosion, the degree of slope, and the type of vegetation on every portion of the area.

(2) On the basis of these surveys, the land is classified as to the type of use to which it can be put and as to the character of erosion-preventing procedures which must be applied.

(3) On the basis of the land classification, contracts are entered into with the owners of private lands under which the owners agree to take out of cultivation such lands as are not suitable to agriculture, to revise their agricultural practices in accordance with Soil Erosion Service recommendations and to contribute such labor and materials as they have available to the work which needs to be done. The Soil Erosion Service in its turn undertakes to make all necessary plans, to assist the cooperating land owner in reorganizing his farming practices, to furnish certain seeds for the planting of lands retired from cultivation to erosion-resisting crops and for establishing crop rotations, and to assist in carrying out the necessary erosion control works through the contribution of labor, materials and engineering supervision. In the case of undertakings on public lands or Indian Reservations, there is no necessity of entering into contracts and the work is carried out entirely at Federal expense.

Very early in the program, it became evident that adequate detailed, large-scale maps were essential to the necessary survey and planning procedures. Such maps were not available for any area where work was undertaken. The best existing maps were U.S. Geological Survey topographic maps which were far too generalized to be satisfactory. In the West, large areas of the Navajo Indian Reservation were practically unexplored, and the only available maps were extremely small in scale and meager in detail. After considerable investigation, it was decided that the cheapest, quickest and most satisfactory method of obtaining the needed maps was by means of aerial surveys.

In the East, detailed maps were needed with a scale of at least 1:6,000. It was decided that rather than construct large-scale line maps, the actual photographs enlarged to the proper scale would be used. The initial projects were mapped at a flying scale of approximately 1:20,000. Mosaics were then constructed and divided by a superimposed grid. Each section of the grid was then enlarged onto a celluloid negative at the final scale.

From the celluloid negative, contact photographic prints were made for field use, as also were blue prints where many copies were needed.

The initial method of aerial mapping described above proved unsatisfactory for a number of reasons. First of all, the inevitable mismatches in the mosaic, which at the scale of 1:6,000 were greatly enlarged, interfered with mapping in the field and were a source of continuous and crippling annoyance to engineers who were unfamiliar with the limitations of the method. Secondly, the process of mosaic preparation and enlargement from the mosaic resulted in the loss of essential detail.

As a result of these inadequacies, the initial method was abandoned, and since then direct enlargements from the aerial negatives have been used, rather than enlargements from the mosaic. Each project is furnished five sets of these enlargements from alternate negatives. The prints are used as plane table sheets in the field and have proved to be highly satisfactory. Inasmuch as the land classification work being done involves a compromise between many factors and because of the complexities involved, it is in general not accurate within limits of less than 5% to 8%. The displacement errors occurring in the photographs have not been sufficiently serious to cause trouble.

The mapping needs on the Navajo Indian Reservation differed considerably from those on the agricultural regions of the East. Here maps of a much smaller scale could be used. Furthermore, the area to be covered was so tremendous and the existing maps so inadequate that individual photographs could not be used satisfactorily and it was essential that an assembled map be compiled. After some study it was decided to fly the area at a scale of 1:31,680 or larger and to assemble the photographs into a single mosaic on a polyconic projection to be reproduced in units of fifteen minute quadrangles. Accordingly, bids were advertised for, on the basis of which a contract was awarded to the Fairchild Aerial Survey Corporation of Los Angeles.

The methods used in making the survey have been as follows:

(1) Five control strips were flown east and west at intervals of approximately 40 miles.

(2) Triangulation control points were established near the ends and the middle of each control strip.

(3) From the triangulation stations, control was run east and west along the control strips by means of carefully adjusted radial control plots.

(4) The actual photographs from which the mosaic was assembled were flown due north and south with a Zeiss Topographic four-lens mapping camera. From the four untransformed negatives for each picture were then made four positive glass plates. These four glass plates were then inserted in a specially con-

structed transforming apparatus and transformed to a single composite negative. From this composite negative, contact prints 9.8 inches by 9.8 inches were made, in all essential respects the equivalent of single lens contact prints.

(5) From the transformed composite four lens prints, a complete radial control network was run north and south between the control strips.

(6) On the resultant radial control net, the component prints of the mosaic were laid, every print being ratioed to the best average scale and corrected to compensate for errors introduced by the mean slope of the ground.

(7) As quickly as the respective parts of the mosaic were completed, they were reproduced on glass negatives at a scale of one inch equals one mile. Each of these negatives were carefully blended to eliminate tone difference between the component prints of the mosaic and are used for projecting the reproductions of the mosaic at any desired scale and for making contact prints thereof.

The mosaic maps resulting from the above procedure have proved to be highly satisfactory. The errors are for all practical purposes limited to displacement errors within individual prints and are not sufficiently large to interfere with the use for which the maps are designed. The quadrangle sheets are used extensively in the field for the assembling of erosion data and for the preparation of soil surveys, vegetation surveys, etc.. It is contemplated that the entire edition of fifteen minute quadrangles will be reproduced by half-tone processes, with all drainage accentuated, and with roads, culture and place names superimposed in a second color.

The Navajo survey proved such a success that it has been decided to extend this character of work to all of the western grazing areas on which the Soil Erosion Service sets up projects. Thus, on the Gila River and San Pedro watersheds where work was recently undertaken, the first step was to advertise for bids on the type of survey described above. The contract was again awarded to the Fairchild Aerial Survey Corporation on the basis of competitive bids.

It is hoped that the Soil Erosion Service program will be eventually expanded to cover all lands in the United States subject to erosion. This eventually will have to be done if large regions are to be saved from impoverishment and virtual abandonment. When the work is so extended, aerial surveys will be made of all areas upon which work is carried out. This means, for example, that large additional regions of the grazing lands in the West will probably be mapped by methods similar to those used on the Navajo Reservation. In the East, large areas will be mapped by methods similar to those already being utilized, although of course, new developments in aerial mapping may considerably modify the details of procedure.

One phase of the Soil Erosion Service mapping program not referred to above relates to the construction of contour maps. The photographs taken of the Navajo survey are adaptable for use in the Stereoplanigraph for the construction of such maps. At the time of issuing the advertisement, it was not known whether any such contour maps would be needed. However, it developed that such a map was necessary to the functioning of the Mexican Springs Experiment Station, just north of Gallup, New Mexico, which is working on detailed scientific studies covering a watershed of some 128 square miles. This map was recently completed and is discussed in Mr. Leon T. Eliel's article in this issue of "News Notes".

THE STEREOPLANIGRAPH

by
Leon T. Eliel

(Paper presented at meeting of the Society on October 23, 1934)

Any photogrammetric machine such as the Stereoplanigraph is merely the mechanical means for recording what the eye sees, what the brain conceives, and directs the hands to perform. The machine is designed around these human factors and a proper evaluation of the machine must have roots in a thorough understanding of these human elements.

On first thought, the stereoscopic function of the eyes seems quite apparent. Obviously, we think the closer an object, the greater the convergance of the eye axes. This, we assume, is interpreted by our brain in terms of relative distance.

It is commonly believed that when using a stereoscope, an object appears at the point of intersection of the eye axes. Diagrams illustrating this phenomenon are plentiful throughout the literature on this subject.

That this situation is much more complicated than suggested by these random thoughts is at once brought home to us when we see a trained stereoscopic observer view a pair of pictures without a stereoscope under conditions where the axes of the eyes actually diverge 10 or 15 degrees. Where, now, does this observer see his apparent stereoscopic image? If our first theory were correct, the imagine would appear to be behind him. This, we know, is not true. It is therefore safe to assume that stereoscopic vision is a much more complicated subject than appears from casual inspection.

When the axes of the observer's eyes are diverging, one of two things must be occurring to enable him to see stereoscopically. Either the brain is exercising some marvelous interpretive power quite beyond our comprehension, or what is more probable, the lens of the eye is willfully distorting into a prismatic shape. The latter assumption seems borne out by the fact that ability to view pictures stereoscopically with divergent eye axes is greatly enhanced with practice. Furthermore, this ability