USE OF AERIAL MAPS IN SOIL CONSERVATION STUDIES

by
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The Soil Conservation Service is engaged in the carrying out of a nation-wide program for the control of soil erosion. The program includes the operation of demonstration projects in various parts of the country, the carrying on of work on the entire area of major watersheds in the West composed largely of Government-owned or controlled lands, the mapping of the extent and distribution of erosion, and Federal-aid cooperation with conservancy districts for the purpose of controlling soil erosion. It is contemplated that ultimately work in cooperation with the States and communities will be extended to all lands in need of treatment.

Essentially, soil and water conservation and flood control measures on watersheds involve the reorganization of the use of land and the application of natural and artificial measures so as to prevent the rapid run-off of rain water and cause such water to sink into the ground.

Measures to be applied include the retirement of steep slopes from cultivation, the establishment of crop rotations, strip cropping, terracing, construction of check dams, the establishment of range management practices and similar procedures. The planning of such measures is dependent upon a field by field knowledge of the physical condition of the land and the use to which the land is being put. Among the more important factors which must be determined for any given parcel of land before practical measures for soil conservation can be formulated are the type of soil, the degree and type of erosion, the degree of slope, and the present use to which the land is being put. Such information must be available in map form at large scales and great detail.

The most rapid, economical and effective method of obtaining the detailed land information required by the Soil Conservation Service involves the use of aerial photographic maps, and it has been established as a policy of the Service that such maps will be prepared of all areas in which actual work is to be undertaken and for which either soil conservation surveys or plans are to be prepared.

The aerial photographs and photogrammetric maps used by the Soil Conservation Service fall into two general types which differ as between agricultural areas and grazing or mountainous areas. In agricultural areas, single-lens aerial photographs taken with cameras having a focal length of 8" or longer are obtained on a scale of about 3.17" = one mile. From one set of these photographs detailed base maps are constructed by the radial control method at a scale of 4" = 1 mile. Another set of photographs is enlarged to a scale of 8" = 1 mile.

The enlarged pictures are used by the erosion survey experts as field sheets. The area covered by each photograph is broken up on the basis of field inspection into small land units, each of which has an approximately uniform slope, soil, degree of erosion and land use. Sometimes the individual land classification unit constitutes an entire field; sometimes only part of a field. The boundary of each unit is drawn directly on an enlarged aerial photograph in ink along with a legend giving its characteristics.

After the field recording of the land classification factors, the enlarged photographs are placed in a projector and the land classification boundaries projected onto a base map which has been prepared from a duplicate set of prints. This base map, with the superimposed land classification is then published either as a black and white print with the land classification units differentiated by boundaries and symbols, or with the land classification factors differentiated by colors. These maps are of such accuracy, scale and detail as permits the application of the land classification information to specific fields or parts of fields and thus forms the basis of detailed soil conservation plans as well as being of great use to other land utilization agencies, banks, etc., in evaluating land conditions and other work to which a detailed knowledge of the condition of the land

is essential.

While it is the plan ultimately to publish in completed form conservation maps of all areas surveyed or in which work is under way, it is frequently necessary to utilize the detailed survey information for field activities prior to the completion of the final map. Where this is the case, a duplicate set of 8" = 1 mile enlargements with superimposed land classification data is prepared and used in the field as a working map.

In areas composed predominantly of grazing or mountainous land, such as the major portion of the region lying between the Rocky Mountains and Sierra Nevada, photogrammetric maps are made from photographs that are taken with a camera with focal length of about 6" or longer, at a scale of about 2" to the mile. These photographs are compiled into accurately controlled mosaics at the same scale. In the construction of these mosaics, a basic net-work of geodetic control is installed by the Coast and Geodetic Survey and delivered to the contractor. On the basis of this control, there is then constructed a complete radial control net with 15 points plotted within the area covered by every photograph. Each of the 15 points is required to have an accuracy in absolute position of 1/20 of one inch or better.

One copy of the radial control plot on transparent celluloid is delivered to the Soil Conservation Service. Another copy is used as the base upon which the photographs are mounted to form a mosaic. In mounting, each photograph is ratioed to the best mean scale as indicated by the radial control plot. In areas containing large variations in elevation, the photograph is also corrected for scale errors caused thereby through tilting in a transforming camera. On the completion of the base mosaic, it is copied by 15 minute quadrangles on glass plates at a scale of 1" = 1 mile from which reproduction prints can be made at any scale desired.

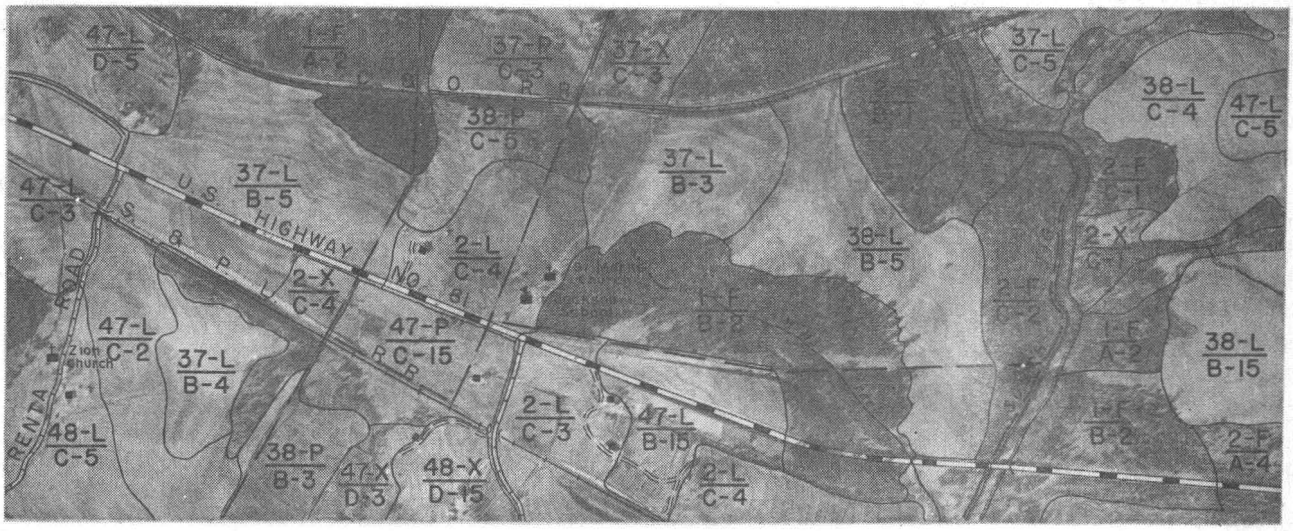
The radial control plot which is delivered to the Soil Conservation Service may ultimately be used for the construction of line maps of the areas involved. On these line maps will be superimposed land use information obtained through the use of the mosaics as field sheets in the mapping of erosion and the establishment of range carrying capacities.

Included in the areas which have been covered by aerial mosaics are some of the wildest and most inaccessible portions of the United States. In certain of the areas difficulties encountered in connection with the installation of control and flying have been enormous as, for example, on the Navajo Indian Reservation and in connection with a pending aerial survey of the watershed of the San Juan River. In spite of these difficulties, the cost of producing such mosaics has ranged in the neighborhood of $6.50 to $8.00 per square mile, including the cost of geodetic control. The estimated additional cost of constructing base maps from the radial control plot is less than $2.00 per square mile bringing the total estimated cost for complete sets of aerial photographs, controlled mosaics, and planimetric base maps to not more than about $10.00 per square mile, at a scale of 1: 31,680 and with no error greater than 1/20" on the radial control plot.

The use of aerial photography in the manner which I have just described has been found to be absolutely essential to the work of the Soil Conservation Service. Without it, necessary basic information of large areas could not possibly have been obtained within the time limits and funds which have been available.

Several factors are responsible for this situation. First of all may be quoted the speed with which information can be obtained. With aerial photographs the rate of photography is limited only by the funds and equipment available. Large areas can be rapidly covered, critical areas established and ground work begun within a short period of time when with ground survey methods the critical areas could not even be determined until after much longer periods required for the completion of mapping work on the ground. In addition to the speed with which they can be obtained, aerial photographs facilitate land classification and mapping work through the very large amount of recognizable detail which is shown and which could not possibly be delineated at any reasonable cost on a map prepared by ground

DETAIL CONSERVATION SURVEY



LEGEND

Key Symbol

$\frac{37\text{-}L}{C\text{-}3}$ = $\frac{\text{Erosion-Land use}}{\text{Slope - Soil}}$

EROSION			LAND USE		SLOPE		SOILS		
1	37	47	L	F	A	C	1	3	5
2	38	48	P	X	B	D	2	4	15

Hard surface roads
Improved roads
Dirt roads
Private roads
Railroads
Property boundaries
Streams, rivers
Intermittent streams
Bldg. ■, church ■, sch. ■

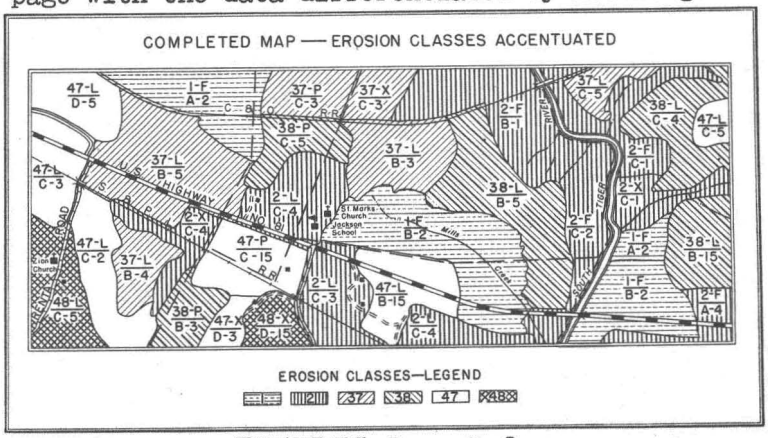
Scale in Feet

1000 500 0 1000

Field Base
for
Detail Conservation Surveys

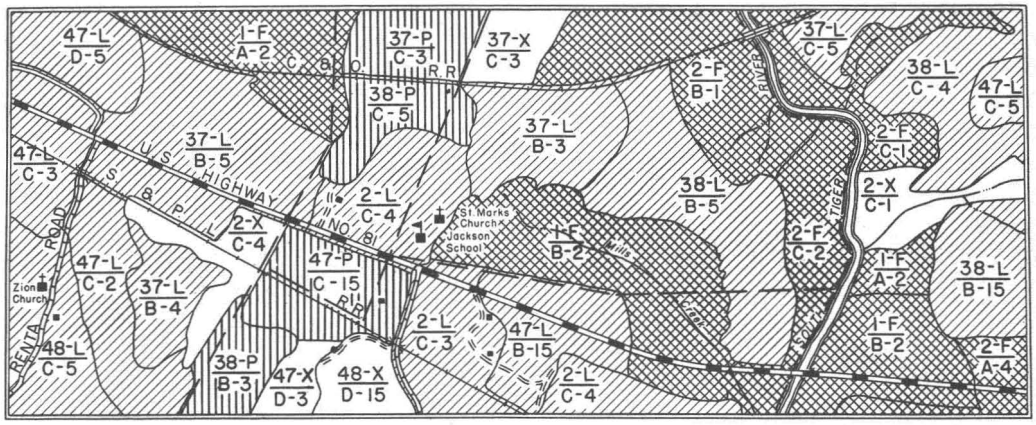
REPRODUCTION OF AERIAL PHOTOGRAPH
WITH LAND CLASSIFICATION DATA AND BOUNDARIES SUPERIMPOSED

From the above aerial photograph a planimetric base map was prepared in the Photogrammetric Laboratory on which was superimposed land classification information. Ordinarily, the four different categories of information would be shown by four different maps, each colored in a suitable manner. Since it is not practical to reproduce in color in this publication, the four finished maps from the above photograph are shown below and on the next page with the data differentiated by hatching.



FIGURES 1 and 2

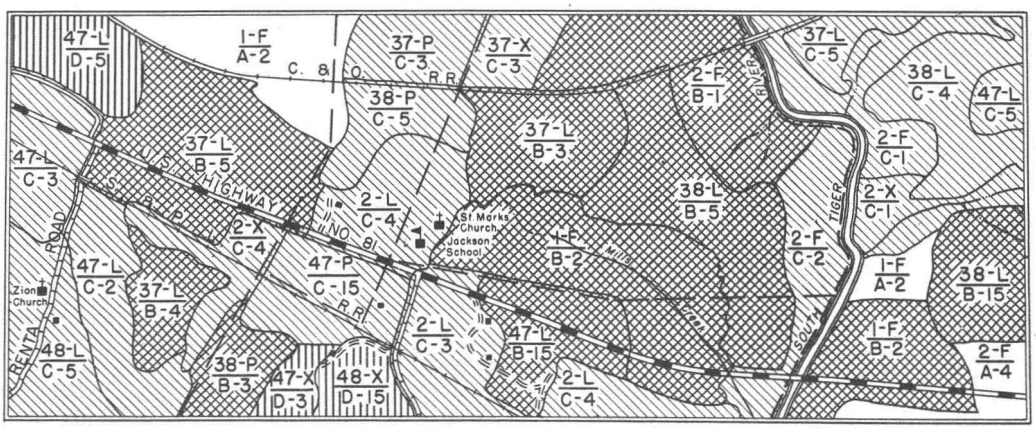
COMPLETED MAP—LAND USE CLASSES ACCENTUATED



LAND USE CLASSES—LEGEND

L F P X

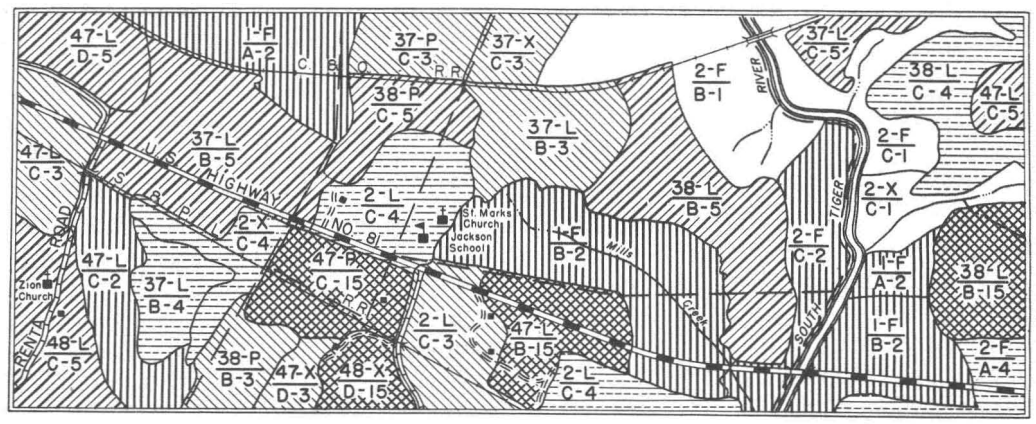
COMPLETED MAP — SLOPE CLASSES ACCENTUATED



SLOPE CLASSES—LEGEND

A B C D

COMPLETED MAP — SOILS CLASSES ACCENTUATED



SOILS CLASSES—LEGEND

1 2 3 4 5 5

FIGURE 3

methods. Thus, a good photograph of an eroded piece of land will not only show all ultural details such as roads, fences, ditches, etc., but also differentiates between land in cultivation, land in pasture or cover crops, land in brush and land in forest. In addition to this information, there will appear on such photographs all gullies of more than very small size, and the delineation of all areas subject to serious sheet erosion where the topsoil has a different color from the subsoil.

When used as field sheets, enlarged aerial photographs have a material advantage over a line map because of the fact that the extremely large amount of detail appearing within the photograph makes it possible for the surveyor who is recording field conditions to locate himself within a few feet on the photographs merely by visual inspection without the use of planetable intersection. This greatly speeds up the rate at which field recording can be accomplished.

The unusual extent to which ground detail appears on photographs is well illustrated by an incident which occurred on one of our projects in Texas. When the aerial photographs of this project were sent to the project manager, he wrote back indignantly to the effect that the photographs were covered with big white splotches and the pictures were light-struck, and he demanded that this condition be corrected. Investigation revealed that the photographs were perfect, that the light splotches and spots of which he was complaining were caused by serious sheet erosion which had washed the black topsoil from much of the area leaving the lighter subsoil exposed. This lighter subsoil appeared in the form of light streaks and spots on photographs, which constituted a perfect map of sheet erosion that had not been fully recognized on the ground due to the concealing effect of crops and to the somewhat gradual gradation from dark to light areas.

Just as erosion and land use features are revealed in agricultural areas, unmapped western areas in which soil conservation work is under way reveal very striking detail in connection with the geology of the country, and erosion conditions very hard to observe on the ground. It is because of this ability to identify geologic structures from the air that aerial photography is used in connection with mineral explorations in many parts of the world.

In addition to the use which the Soil Conservation Service has found for planimetric aerial photogrammetric maps, it has also been found necessary to obtain topographic maps of limited experimental or other special areas. So far, two such maps have been made, both of them by stereoscopic methods from aerial photographs. The most interesting of these maps involves the topography of the Boulder Reservoir to be used as a basis for measuring the amount of silt which is being deposited behind the Boulder Dam. This job involved the mapping of areas, practically impossible to reach on foot, with accuracy which could be obtained by no ground methods unless perchance through suspending the surveyors from cables stretched from rim to rim of the Grand Canyon. Involved in the mapping undertaking were two boat trips down one of the most dangerous portions of the Colorado River.

By the end of the current year, the Soil Conservation Service will have contracted for aerial photographs of something over 300,000 square miles. Ultimately there will be required aerial photographs and large-scale, accurate base maps of the entire area of the United States with the exception of certain mountainous and coastal plain areas.

Photographs and maps are likewise needed by many other agencies and are provided for in the National Mapping Program recommended by the Board of Surveys and Maps and the National Resources Committee. Let us hope that means can be found for carrying forward this program.

In closing this paper I would like to emphasize again the fact that aerial photographs of adequate scales and quality, accompanied in agricultural regions by base maps at a scale of 4" = 1 mile or larger showing all possible cultural details, field boundaries, drainage, type of land use, etc., are coming to be more and more essential in all work relating to the control or use of land. It is my conviction that such aerial photographs and maps must be obtained for the whole country before we can say that programs directed toward correct land utilization,

conservation of natural resources, and flood control are on a sound basis. It would seem perfectly obvious that such programs must be dependent upon the fullest knowledge of the condition of the land and the natural resources dependent thereon. Not only are such maps essential to land utilization and conservation work but also they will repay their cost many times over in direct benefit to the owners of land, all users of land, taxing bodies, engineers and all persons or organizations whose work in any way relates or is dependent upon a knowledge of what actually exists in any land area.

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REMARKS ON THE DEVELOPMENT OF AIR CAMERAS FOR PHOTOGRAMMETRIC PURPOSES

by

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(Followed by Discussion by Lieutenant O. S. Reading)

From a perusal of the various articles composing the highly interesting May and June number of the "News Notes of the American Society of Photogrammetry" it is evident how wide a use is today being made in the United States of America of air photographs for the construction of topographical maps. The air-photographic method is employed chiefly in the case of large regions of which there exist as yet either no maps at all, or only very defective and out-of-date ones. In such cases the principal factor to be considered is that of speed, and it is thanks to photogrammetry that serviceable maps and plans can now everywhere be made in a very limited time. When speed is the main object, the means employed are relatively simple, but there is no mistaking the continual striving after improvement in the apparatus employed. Out of the simple stereoscope, giving only small-sized images, there has developed an improved instrument with optical magnification, which, as its name of "contour-finder" implies, is useful in topographical mapping from photographs. For the taking of measurements from oblique photographs a photogoniometer has been devised, and a mechanical plotter for monocular vision has been constructed, the results obtained from which in practice have been such as to give rise to the hope that a stereo-apparatus, much simpler in design than the stereo-autograph hitherto in use might be designed on the same principle. Much as this is to be desired, however, it has to be borne in mind that the refinements and improvements which are continually necessary in the development of a piece of apparatus often lead eventually to considerable complications. Hence while the results of such studies may be looked forward to with the greatest interest, it will be well not to entertain too high hopes from them. With almost every kind of apparatus for map-making from photographs, the theoretical principle involved is quite simple; the difficulties only begin when it is sought to design a working apparatus embodying the principle.

As regards the manner of representing the ground on topographical plans, it is realized that with simple line drawing very many of the details that appear on the photographs are lost, and it is considered that in the future it is probable that the photographic representation may be retained, only with contour lines added. Modern methods of reproduction would permit of such maps being reproduced without difficulty.

There is, of course, much to be said for this idea, for the photographs always show a very large number of details which must be lost in making the line drawing. But a number of difficulties, some of which are insurmountable, oppose themselves to the exclusive employment of the photographic picture in place of the line plan.

One great difficulty arises from the fact that the photographic picture is a central projection, while the map is a parallel projection, of the terrain, considered as reduced in size. The two projections can only be identical when the land is flat and the axis of the central projection is parallel to the projection-direction of the parallel projection. And as this latter direction is vertical in space, the axis of the central projection, that is, the optic axis of the