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THE USE OF A STEREOSCOPE IN AERIAL PHOTO INTERPRETATION

by

M. Zsuzsa

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By: M. Zsuzsa

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ABSTRACT

Aerial photographs taken from the watershed of the Lokos rivulet (Megye Nograd), the Kisasszony forest in the Bugac area, the Visegrad-Nagyvillam area, and of some other areas in Hungary were interpreted with the aid of the Stereoscope. The maps were presented and discussed. The techniques involved in interpretation of the photographs with the aim of establishing the altitude fluctuations were described in detail. The results were utilized in soil-erosion studies. Orig. art. has: 5 figures and 15 pages.

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THE USE OF A STEREOSCOPE IN AERIAL PHOTO INTERPRETATION

Dr. M. Zsuzsa

A great deal of attention was focused on aerial photo interpretation, a relatively new field of research, at both the Twentieth International Congress of Photogrammetry, held in Lisbon in 1964, and the International Geographic Congress which was convened in London. The existence of a similar trend has been noted in foreign literature. Not only is more literature being written about the analysis of aerial photographs, but many comprehensive studies are being conducted as well. These include such works as a Manual of Photographic Interpretation by R. N. Colwell, Aerial Photographic Interpretation – Principles and Applications, by D. Lauder, The Use of Aerial Photographs in Relation to Soil Erosion and Soil Conservation by P. Buringh and A. Vink, as well as numerous ITC publications.

It is important that we keep pace with the rest of the world in this area. It was with this objective in mind that I conducted extensive research on soil erosion, geomorphology, and the mapping of slope inclinations. I have studied many different areas of the country and have chosen to discuss the three following typical types of terrain: palaeogenetic hilly country, a lowland sandy region, and a volcanic mountainous area. A stereotope was used in the analysis of all three types of terrain.

Measurement of the slope gradient has been employed as a means of studying soil erosion through analysis of aerial photographs. My first research efforts in this area were made possible by the cooperation of the Institute of Soil Science and Agrochemical Research of the MTA [Hungarian Academy of Sciences]. My assignment was to prepare a slope-inclination map of the watershed of the Lokos rivulet in Nograd using a scale of 1:25,000. (Two small sections of this map are shown in Figs. 1 and 2.)

I was provided with aerial photographs taken in 1956. Since the stereotope could not accommodate paper prints greater than 23 × 23 cm, the 30 × 30 cm photographs, taken in 1956 with a Zeiss camera (f = 200.75), had to be scaled down. Thus, instead of using a scale of 1:20,000, a new ratio between 1:28,000 and 1:35,000 was used. Naturally, picute quality suffered as a result of this reduction in size. The accuracy of reproduction was not satisfactory even though dimensionally-stable Agfa Correctostat paper was used. The eight-year-old negatives had not been stored under optimum conditions. As a result, their dimensions had been appreciably altered and this had a deleterious effect on picture quality. Most of the pictures were taken when the axis of the camera was tilted more than 4° from normal. This further reduced the accuracy with which the photographs could be interpreted. In 1956, minor control points were plotted for use with first-order, stereo-plotting machines; therefore, in many cases they did not meet the requirements of a stereotope. Unfortunately, there was a wide range of contrast in the pictures. In some places contrast was too high, while in other places it was so low that photo interpretation was impaired. Obviously, all of these factors made it impossible to attain the same degree of accuracy which might have been obtained under optimum conditions.

The slope-inclination map was prepared in the following manner. First, the minor control points were plotted on the reduced-scale photograph. Then, with the aid of a coordinate grid, the points shown on the stereographic projection were plotted on an Astralon sheet using a scale of 1:25,000. Next, the 20-km coordinate system and the aerial photograph were prepared for interpretation. This was followed by the elevation and azimuth orientation of the stereoscopic model.

Roads and railroads were the first planimetric elements to be mapped. Then, the boundaries of residential areas, watercourses, and still-water regions were drawn in. The boundaries of forests were the only lines of cultivation to be mapped. The mapping of valley networks provided an outline of the morphological picture, while the details were filled in by spurs and ridges. Finally, surfaces having uniform gradients were grouped together and their direction of slope was noted. Determining the direction of slope was not always a simple task. When a surface had several directions of slope, only the steepest slope was used. Although the stereoscopic effect made it easy to distinuish between the various slopes, these smaller deviations were all placed in one category because of limitations imposed by time and the use of a 1:25,000 scale.

The gradient was measured by setting the floating mark on the highest point of a slope and then obtaining a reading from the parallax screw rectifying computer. Then the floating mark was moved to the lowest point on the incline, while the distance between these two points was traced by a pantograph. Here, another reading was obtained from the parallax screw. Then, one of the values was subtracted from the other and the remainder was multiplied by the previously obtained parallax constant; i.e., the value was found on the graph which had been plotted for photo interpretation purposes. The parallax constant of the relative heights was obtained by subtracting the rated parallax of the four minor control points and the difference in elevation above sea level. In this way, the relative difference in elevation of a given slope was determined in meters. Then, the base of the slope was measured with a glass straight edge, graduated to 1 mm intervals, and this quantity was then multiplied by the value of the 1:25,000 ratio. The percentage of slope was obtained from its difference in elevation and the horizontal distance of its base. These measurements were repeated several times when large surfaces were being examined. The results of these calculations were classified in the appropriate slope categories (in accordance with agricultural standards, these categories are the following: 0-5%, 5-12%, 12-17%, 17-25%, and above 25%). In order to facilitate photo interpretation, each slope was color-coded as soon as its gradient was determined.

On the basis of my experience, I have estimated that it takes a single worker 14-15 days to produce a single 1:25,000 scale map of slope gradients. Naturally, if the work is not devoted exclusively to the mapping of slope gradients, the time requirements will be reduced because the time allotted for the orientation of the stereoscopic model will be spent on a variety of tasks.

The aerial photographs prepared by photogrammetry were compared with field photographs and a slope-inclination map prepared from a topographical map by the Soil Science Division of the Institute. An agreement of approximately 80% was found between the two maps, even though the map prepared from aerial photographs was produced under unfavorable conditions.

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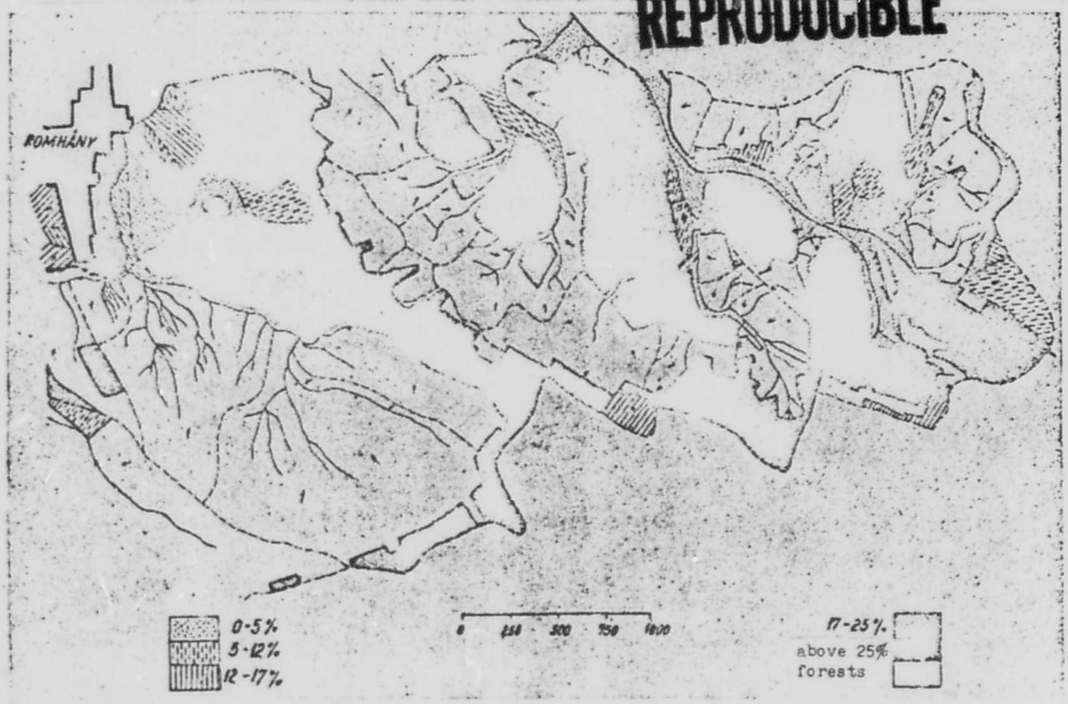

Fig. 1. Excerpt of a slope-inclination map of the southeastern portion of the Lokos rivulet watershed region.

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Fig. 2. Excerpt of slope-inclination map of the southwestern portion of the Lokos rivulet watershed region.

Figure 1 shows the eastern portion of a map of the Lokos rivulet watershed region as it was originally drawn up for interpretation. Not only are the boundaries of forests, residential areas, rivulets, and slope categories depicted, but valley networks, spurs, and a dense network of still-water regions can also be seen; i.e., the development of erosion is evident in agricultural areas and in forests as well. It should be noted that the relative difference in altitude of the Romhany region is high and, as a result, its slopes are steep.

Figure 2 shows the southwestern portion of the Lokos rivulet watershed area. This map was prepared from a fair drawing of the Soil Science Institute in which only the slope categories, the direction of slope and the location of forests were marked. Valley networks, ridges, and watercourses were not included.

It has been found that not only is the stereotopic method a rapid and simple means of plotting a map, but it affords a high degree of accuracy and an abundance of detail as well. A map produced in this manner can be broken down into slope categories and the direction of slope, the location of permanent and periodic watercourses, and the development of fluvial erosion can be depicted. The low contrast and the small scale of the aerial photograph made it impossible to map soil erosion as well. Nor was it possible to analyze the boundaries of cultivated areas since those shown in the photograph were not representative of the current situation. (The 1956 pictures were taken of segmented land plots which no longer exist.)

Although the mapping of slope gradients is only one facet of soil erosion analysis, such a map can supplement scientific ground photographs by providing geodetic data. At the same time, it can furnish information which will be useful in land surveying and soil conservation.

My second project was not directly related to soil erosion; nevertheless, it did shed some light on the subject. The map shown in Fig. 3 was prepared in order to aid in the agricultural research conducted by the Institute of Scientific Forestry. It depicts the morphology and slope relationships of the sandy lowlands of the Kisasszony Forest situated in the Bugaci region.

A stereotope was used to interpret the two 1:12,000-scale photographs taken in 1962. Although the stereotope is designed for use with small-to-medium scales, a satisfactory degree of precision was attained with a 1:5000 scale.

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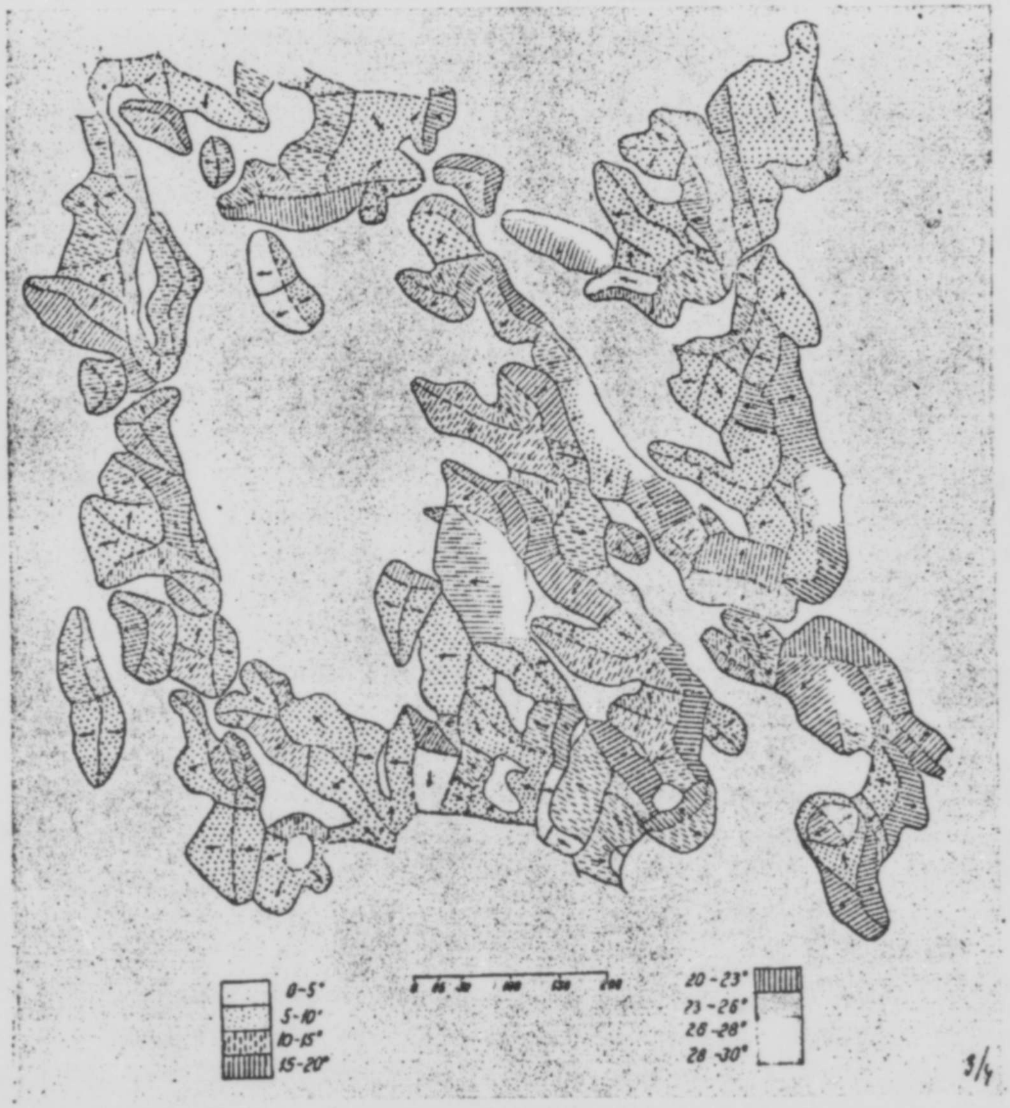

Fig. 3. The gemorphological structure and slope relationships of the sand dunes in the Kisasszony Forest of the Bugaci region.

The pair of 23 × 23 paper prints met the requirements of the stereotope in that camera tilt did not exceed 4° when the two pictures were taken. Precision was diminished since dimensionally-stable paper was not used in the development of the contact print. The plotting was accomplished on an Astralon sheet. Photo interpretation was impaired since in many places the ground surface was obscured by dense forests.

The technique used to analyze the photographs has already been described. The nature of the sandy terrain and the use of a small, 1:5000 scale map made it impossible to depict certain planimetric features; however, the territory covered by forests and barren stretches of sand could have been mapped.

Here, the emphasis was on the morphological structure of sand formations and on the measurement of slope gradients. First, the base lines and crests of individual sand dunes were mapped and then the major spurs, valleys (formed by sand dunes), and the boundaries of bodies of water were drawn in. These slopes, whether arranged in a single row or in a stepwise pattern, were classified according to their gradient. Then, the slope direction of the rows of sand dunes was noted. The distinguishing of very small slopes was made possible by the distortion of the stereotope and by its orthogonal viewing system.

After the morphological structure had been mapped, the slope gradients were measured by the previously described technique. This time, a new measuring scale was used and the slopes were classified differently. The following categories were used: 0-5°, 5-10°, 10-15°, 15-20°, 20-23°, 23-26°, 26-28°, 28-30°, and above 30°.

A cursory examination of the first three figures will reveal that the third map presents a more complete picture of slope gradients than do the maps in Figs. 1 and 2. In Fig. 3, individual slopes, especially the steep ones, are frequently broken down into several small categories. This did not in any way complicate the measurement of gradients.

It is worthwhile to take a closer look at these slope categories. Slopes greater than 30° do not occur in the sandy regions where bushes and trees are prevalent. Even 28-30° and 26-28° slopes are rare in these areas. As for large sand dunes, their steeper sides, which are sheltered from the wind, tend to fall into the 23-26° or 20-23° category. On the other hand, the steeper sides of small dunes are generally characterized by slopes of 15-20°. The low-gradient sides, which are exposed to the wind, generally have slopes of 5-10° or 10-15°; however, a gradient of 15-20° is not unusual. The rows of sand dunes are situated in the north-to-south and northwestern-to-southeastern directions.

There was not enough time to give more precise directions. The map shown in Fig. 3 represents four days of work. It should be added that no speed records were broken since this was my first attempt to produce such a map.

Needless to say, the production of this map is only one of many steps involved in a forest survey; nevertheless, it does provide an accurate picture of geomorphological structure and of slope inclinations. It also supplies a wealth of information on climatic conditions and serves as a valuable source of other data required in photo interpretation.

The two following maps (Figs. 4 and 5) depict the Visegrad mountain range in the Fellegvar and Nagyvillam area. Not only were slope inclinations shown on this map, but soil erosion and lines of cultivation were represented as well. In order to avoid overcrowding the map, the slopes were shown on one sheet, while soil erosion and the lines of cultivation were mapped on another. If the two sheets are placed side by side, more information can be obtained than from any of the previous maps.

A stereotope was once again used in the interpretation. The 19 × 19 cm photographs used in the analysis were taken in April of 1964. Some of the contact prints were developed on dimensionally-stable paper. The aerial photographs were based on a scale of 1:17,000, while a scale of 1:10,000 was used in their interpretation. On the whole, the pictures were well suited for photo interpretation. The only difficulty encountered was that the foliage of forests situated in lowlands frequently obscured the view of the ground.

Fig. 4. Slope relationships in the Visegrad-Nagyvillam region.

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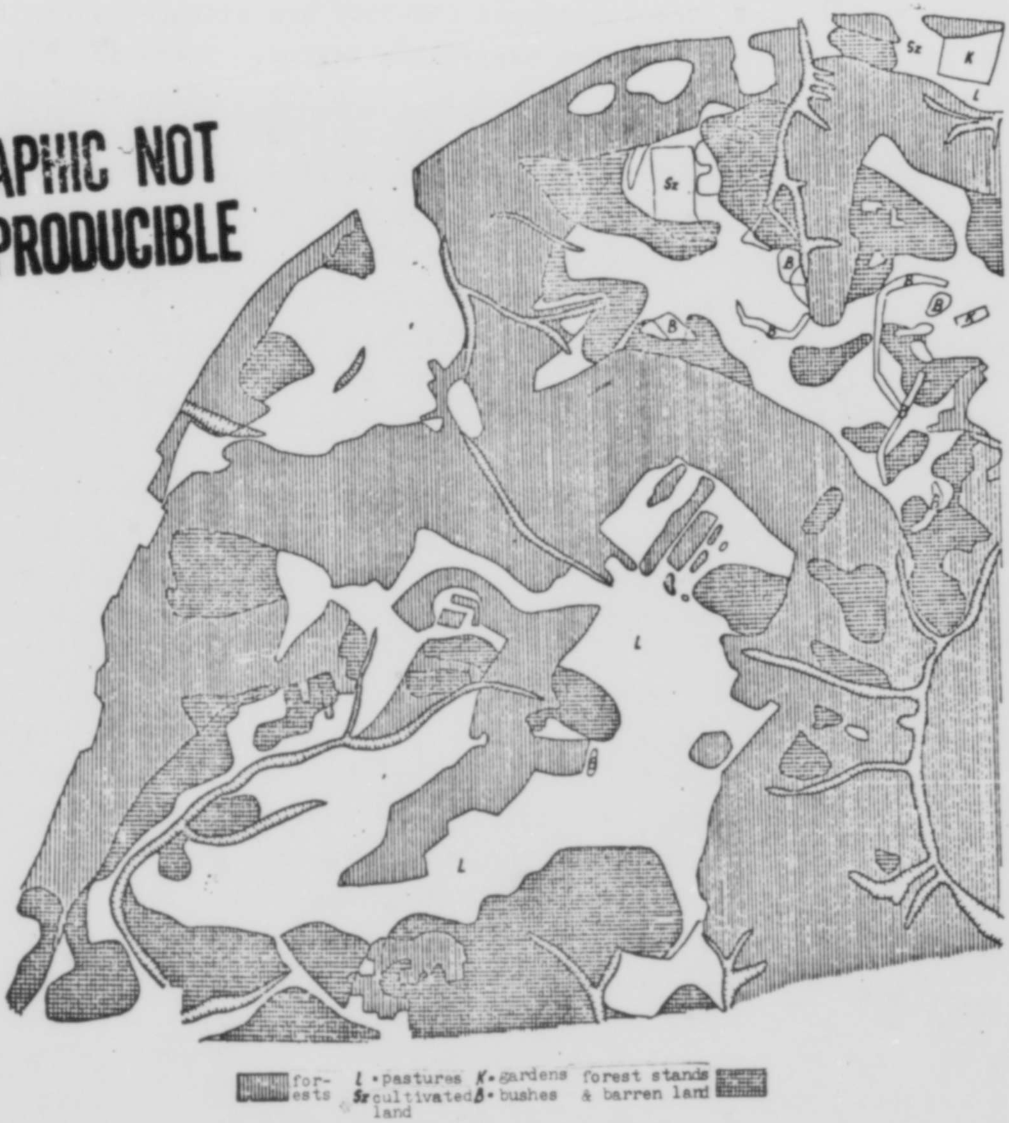

Fig. 5. Lines of cultivation and soil erosion in the Visegrad-Nagyvillam region.

The slope gradients were measured and divided into the following categories: 0-5%, 5-12%, 12-17%, 17-25%, 25-35%, 35-50%, 50-75%, and above 75%.

Agricultural standards were applied to the low-gradient slopes, while broader groupings were used for the steep slopes. As can be seen in Fig. 4, the steepest slopes (50-75%) are situated along the banks of the Danube and in the Nagyvillam region. There is only one slope which is steeper than 75% and it is on the western side of the hill upon which the Fellegvar castle is situated. Very little vegetation can be found on this slope which consists mainly of barren rock and patches of grass. The sides of deep valleys fall into the 35-50% category, although slopes of 25-35% are also common. In fact these two slope categories can be said to typify the entire region. More gently sloping surfaces are definitely in the minority. Most of this rolling land, especially that which is near the Danube, has been reserved for farming, while plateaus are used as pastures.

Also represented on the map are planimetric features such as roads, boundaries of residential areas, a few buildings, the castle ruins, and the site of stone quarries. Naturally, the valley network and ridges are also shown (along with the slope categories).

A comparison of the two maps will show that the lines of cultivation are influenced by the slope gradient. Pastures, farms, and gardens are found where the gradients are low, while steeper slopes are covered with forests. Obviously, the density of these forests varies with the slope category and with climate. The fact that soil erosion occurs on forest land and on farmland is indicated, on the one hand, by the dense network of ravines found in deep valleys and, on the other hand, by the barren, rugged terrain found on very steep (35-50% and 50-75%) slopes. It should be noted that this bleak terrain is most frequently located on slopes facing west or southwest. This sparcity of vegetation is due to the infrequent, but very heavy rainfall. On the other hand, since there is so little plant cover, there is nothing to prevent these downpours from quickly streaming down the hill and washing away the arable soil. This further aggravates the situation.

This map can only give limited information about the erosion of arable soil. If greater detail is required, a soil profile should be consulted. Nevertheless, the use of such a map can be a valuable prelude to more extensive studies since it points out the places where soil conservation is required and indicates what measures should be taken.

A question which has heretofore been ignored will finally be answered. What exactly is the role of slope-inclination maps and slope categories in soil erosion studies and how important is aerial photo interpretation?

Soil erosion is overwhelmingly influenced by the nature of rainfall (its intensity and duration), as well as by the gradient and length of a slope. The slope gradient determines the momentum with which torrents of water will stream down the hillside and, as a result, it also determines the amount of damage which will be done. The steeper and longer the slope, the greater the speed with which the water flows and the more soil it carries with it. In order to conduct soil erosion studies or implement soil conservation techniques, the length and gradient of each slope must be known. Clearly, a map showing these features could be very useful.

The practice of categorizing slopes was originally intended for use in agricultural studies in order to identify land fit for cultivation. Although soil erosion is negligible on slopes of 0-5%, the degree to which it is a problem on steeper slopes determines what type of machinery and conservation techniques can be employed. For example, machinery can not be used on slopes with gradients exceeding 25%. Here, agricultural production is only possible after the necessary preparations (e.g., terracing) have been made.

The relationship between the gradient of a slope and soil erosion has been studied both at home and abroad (Mattyasovszky, Stefanovits, B. Kovács, Motoc, and Trasculescu). Hackman has used aerial photographs to measure angles of slope. He even designed a stereo-slope comparator for this purpose. Buringh, Lauder, Vink, and Spurr used aerial photographs to examine the role of slope in soil erosion.

These examples make it clear that aerial photographs can be valuable aids in the mapping and studying of slopes. The degree of slope can be accurately measured with the aid of a stereotope and high-quality aerial photographs (the use of standard slope categories is optional). By studying the light patches on an aerial photograph, the development of soil erosion and the proliferation of water-worn ravines can be mapped.

I believe that this type of map can serve as valuable reference material for scientists engaged in agricultural and forest soil conservation.

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