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DEGRADATION, REHABILITATION, AND CONSERVATION OF SOILS

Evaluation of Erosion Intensity and Dynamics Using Terrestrial Laser Scanning

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Abstract— A new method of instrumental measurement of the intensity of rill and linear erosion on slopes by the method of terrestrial laser scanning is proposed. This method was tested on four plots in 2012–2016 with the use of Trimble™ GX, Trimble™ VX, and Trimble™ TX8 laser scanners. The terrestrial laser scanning is characterized by a high precision and rapidity, which could not be previously achieved by other devices. It has a number of advantages: registration of various types of erosion of temporary water streams; measurements from a distance without the disturbance of the studied surface and providing the safety of works; and calculations of morphometric parameters of slope using a high-precision digital model of topography. The given examples show that this approach may be applied to assess the denudation-accumulative balance of the moved soil material on slopes, to determine the dynamics of amount of deposits on different parts of a slope as a result of different kinds of surface runoff, and to identify spatial regularities of the formation of the network of rills and gullies. In addition, laser scanning makes it possible to perform an integral assessment of the combined impact of the entire combination of exogenous processes developed on slopes and affecting the soil cover. The observations on test plots showed a rather great role of autumn rains in the total soil loss from erosion. The data obtained were used as the basis for the elaboration of practical recommendations concerning the survey organization and monitoring of erosion with the use of laser scanning.

Keywords: field laser scanning, soil erosion, mapping

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INTRODUCTION

Erosion processes on slopes (soil loss and gully formation) have been studied for a long time all over the world. There are a lot of approaches for the assessment of erosion intensity. Their reviews are given in numerous published works of Russian and foreign scientists [2–6, 26]. Nevertheless, problems of the quantitative evaluation of erosion intensity in different parts of the modern hydrographic network, which includes erosional forms of different morphologies created by the surface runoff, have not been solved. In fact, none of the existing methods provides comprehensive data on erosion rates and their spatial–temporal dynamics on different parts of slope. This complicates the development of reliable erosion models and measures to control this process. The difficulties of the determination of slope erosion intensity are related, on the one hand, to a very small (less than 1 mm/yr) amount of eroded soil in the area of rill erosion, and, on the other hand, to extremely strong destruction of soils as a result of gully erosion [4]. The difficulties of erosion survey are enhanced by a large number of factors, which affect it, and a great variability of the process in space and time. At present, new high-precision instrumental methods of erosion monitoring appear (unmanned aerial vehicles and geodetic equipment). Their potential should be evaluated, and adequate methodological approaches should be developed.

The aim of this work was to elaborate a method of the quantitative evaluation of the intensity and dynamics of erosion by temporary water streams on slopes with the use of field laser scanning.

OBJECTS AND METHODS

We studied erosional processes related to the activity of temporary water streams on slopes, including rill, channel, and gully erosion. The works were performed on test plots in the forest-steppe zone in the east of the Russian Plain (within the Republic of Tatarstan).

Attention to the laser scanning method is related to a number of its fundamental advantages over other methods of erosion assessment: fast measurements without loss of accuracy, elaboration of a complete digital model of the object; performance of the work under any lighting conditions; possibility of survey of remote and complex objects, full automation of measurements, measurement of geometric parameters on the obtained digital 3D mode, and storage of 3D data on the object in a digital form.