An Extreme Close-Range Photogrammetric Method for Monitoring off-Highway Vehicle Use on Rangeland

Introduction

Rapid population increases in the western United States have resulted in tremendous growth in off-highway vehicle (OHV) use on public lands. Accurate detection of erosion and soil displacement rates is essential for monitoring the effects of this activity on the environment. The hypothesis of a Bureau of Land Management (BLM) pilot study is that extreme close-range photogrammetry can detect changes in surface soil elevations to subcentimeter accuracy for a hillslope and submillimeter accuracy for plots as large as 5 m^2.

Materials and Methods

Extreme close-range photogrammetry is defined as that having a distance of less than 50 m from camera to object. A calibrated camera is used to capture x, y, z coordinate data in a series of oblique orientation, overlapping photographs, which are taken of the subject area with circular reference targets, circular coded targets, and an object of known dimension placed within the target area. A permanent, fixed point is also needed as a reference for elevation.

In August 2005, five permanent, variable-sized plots were established north of Montrose, Colorado. Two of these sites were located in intermittent channels that deeply dissect the mesa-dominated landscape in the Dry Creek OHV area. The Mancos shale hillslopes of the Falcon Road open OHV area in the Gunnison Gorge National Conservation Area (NCA) contained three sites. The sites were resampled in September 2006.

Laptop computers with 3DM Analyst Suite software (Adam Technology, Australia) were used to create ten digital terrain models that consisted of a closely spaced grid of thousands of x, y, z data points. The three-dimensional digital terrain datasets were analyzed in ArcGIS using ArcMap and ArcScene. A tin surface was created and converted to a grid, and a hillshade was generated from the grid for each dataset. The surface grids for 2005 and 2006 were compared to determine changes in soil surface features.

Results

All five sample plots exhibited loss and gain of soil as summarized in the Table. The soil losses and gains on the Mancos shale hillslopes in the Gunnison Gorge NCA were high. Most of the losses are attributed to soil displacement by spinning tires. The soil losses and gains were also high for the sites in Dry Creek basin. Some of the gains are due to stream deposition and some of the losses are due to rock displacement. Spectators to the OHV events in Dry Creek basin are contributing to the soil loss by climbing the steep side slopes of the drainageway.

Table. Soil Loss and Gain (in meters).

Site	Total area (m^2)	Loss area (m^2)	Loss volume (m^3)	Gain area (m^2)	Gain volume (m^3)	Loss volume per area (m^3/m^2)	Gain volume per area (m^3/m^2)
Falcon	3,041.34	1,187.29	35.71	1,847.97	61.17	0.030	0.033
Falcon II	436.55	281.87	11.55	154.13	4.02	0.041	0.026
Beyond Falcon	1,557.26	202.80	4.58	1,352.29	50.50	0.023	0.037
Scratch and Dent	104.94	52.82	1.48	51.86	1.59	0.028	0.031
Calamity	111.02	71.24	2.82	39.52	2.02	0.040	0.051

Conclusions

Extreme close-range photogrammetry was used to determine soil loss and gain rates to subcentimeter accuracy for hillslopes on five OHV sites. The Adam Technology 3DM software quickly and efficiently processed the digital photogrammetry data for the project. Refinement of the 2006 sampling techniques will further enhance the efficiency and completeness of data processing, accuracy of the data, and repeatability of the process. The extreme close-range photogrammetry methodology has promising potential application for assessing the effects of erosion caused by a variety of soil-disturbing activities.

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