69 Monitoring soil erosion on campsites by structure-from-motion photogrammetry: A case study of the current and former Kuro-Dake Campsite in Daisetsuzan National Park, Japan

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Introduction

Camping is one of the popular recreational activities in mountain national parks. However, human activities inevitably cause impacts on natural resources, which includes vegetation loss, soil compaction and soil erosion (Hammitt and Cole 1998). The degraded environment also does harm to users' experiences in return (Daniels and Marion 2006). In order to provide users with high quality camping experiences meanwhile avoid unacceptable impacts on the natural environment, monitoring and maintenance of campsites are necessary.

Researchers in the field of recreation ecology have provided a sort of methods to monitor short-term and long-term changes in the condition of campsites. Methods to detect areal changes in bare ground and vegetation loss on campsites have been widely practiced in previous studies (Marion 1991, Wang and Watanabe 2019). Eagleston and Marion (2017) examined soil loss on campsites by comparing the current soil level around embedded rocks on site with the one recorded in past photographs through visual observation. Wang and Watanabe (2019) adopted Structure-from-Motion (SfM) photogrammetry mapping to obtain detailed profiles of the ground surface on the campsite where gully erosion was observed. However, no studies have been conducted to monitor the volumetric changes in ground surface on campsites that are suffering from soil erosion.

This study aims to detect topographic changes of the ground surface and to quantify the volume of soil erosion on the current and former Kuro-dake campsites in the Daisetsuzan National Park (DNP) by SfM photogrammetry surveys.

Study area

DNP, located in the center of Hokkaido, is the largest national park in Japan. There are 12 unmanaged campsites in DNP and most of them are situated in a fragile alpine setting surrounded by dwarf pinus pumila and other alpine flora. The camping season starts from the end of June and ends in the end of September. During the off-season period, these campsites are covered by thick snow for a half year. Occasional heavy precipitation and continuous supply of snowmelt water in summer have caused serious soil erosion on both trails and campsites. The current and former Kuro-dake campsite are the representative campsites suffering from serious soil erosion. Without formal management and maintenance, the soil erosion on the former Kuro-dake campsite had become more and more serious and some deep gullies emerged across the campsite. As a result, it was closed in 1991. The current Kuro-dake campsite was opened in the next year. After the constant use without maintenance, gully erosion has also been observed on the current site.

Methods

SfM photogrammetry surveys with Ground Control Points (GCPs) were conducted on the current Kuro-dake campsite (in 2017, 2018 and 2019) and on the former Kuro-dake campsite (in 2018, 2019 and 2020). The photographs of the campsites were taken by UAV/pole photogrammetry. For each campsite, three sets of topographic maps were created for the current and former campsites by using the location data of the GCPs which were recorded with a global navigation satellite system receiver (Trimble Geo 7X) on site, respectively (resolution: 1.5 cm and 2.5 cm, respectively). The mappings were completed in Metashape software. Then 3D analysis was conducted in ArcMap 10.8.1 with the topographic maps of different years to identify the elevation changes and to calculate the volumetric changes in ground surface. A minimum level of detection (minLoD) with a 95% confidential interval was used to filter out uncertain elevation changes.

Results and Discussion

Soil erosion on the current Kuro-dake campsite

From 2017 to 2018, vertical erosion of more than 5 cm deep was identified around the gully on the current campsite. The maximum vertical erosion exceeded 15 cm deep at the terminus of the gully (Figure 1a). The volume of soil erosion from 2017 to 2018 was about 2.52 m^3. The gully had remained stable without any elevational changes from 2018 to 2019: the volume of soil erosion was only 0.67 m^3. During the study periods, the average annual use level of the current campsite was around 1158 persons/year. The precipitation data provided by the nearest meteorological station (Sounkyo; 540 m in altitude) show remarkably heavy daily rainfall (116.0 mm) on third July 2018, which may explain the significant soil erosion in 2017-2018. The erosion rate varied during the short study periods, suggesting that long-term monitoring is necessary.

Soil erosion on the former Kuro-dake campsite

From 2018 to 2019, both erosion and deposition were identified on the former campsite. The net volumetric change in the ground surface was -1.55 m^3 showing a little amount of soil loss. From 2019 to 2020, erosion had been dominated, which occurred mainly around the gullies. The maximum vertical erosion attained 20 to 30 cm deep (Figure 1b). The volume of soil erosion was 22.67 m^3. Although the development of the soil erosion on the former campsite did not show consistent speed during the two study periods, the trend is clear: soil loss around the gullies is still continuing after the long-term closure. Meanwhile, in order to verify the influence of precipitation on erosion rate there is a need to collect in-situ precipitation data.

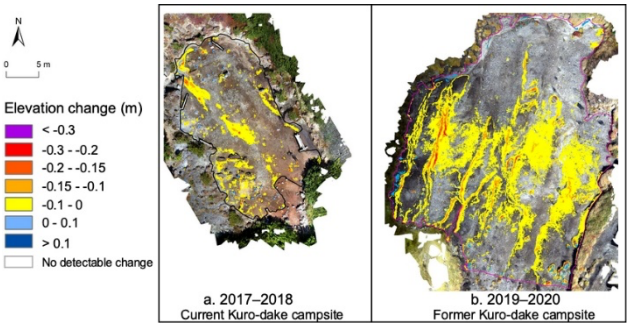

Figure 1. a) DEMs of difference of the current Kuro-dake campsite, from 2017 to 2018 (ortho image of 2018); and b) DEMs of difference of the former Kuro-dake campsite, from 2019 to 2020 (ortho image of 2020).

Conclusions

The monitoring of soil erosion with SfM photogrammetry will provide a better understanding of trends of campsite degradation for national park managers, which is important for future decision-making regarding campsite management and maintenance. Efforts should be taken in stopping/mitigating soil erosion on both the current and former Kuro-dake campsite. Burying the gullies with boulders and setting up boulders or wooden fence at the terminus of the gullies can be one of the solutions to stop/mitigate further erosion. For this purpose, formal management should be introduced to the current unmanaged campsites in DNP.

References

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