Soil erosion studies for management of mountain protected areas: long-term monitoring in Daisetsuzan National Park, Japan, and fast assessment in Shei-Pa National Park, Taiwan

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Mountain trails and campsites with heavy use often face severe soil erosion and vegetation loss. Mountain protected areas in Japan would be one of the best examples to show such degradations. Better management of trails/campsites needs both accurate monitoring methodologies and fast assessment methodologies. This study first reviews the long-term monitoring studies on trail erosion in Daisetsuzan National Park (DNP), Japan, and then introduces fast assessment methodology used in Shei-Pa National Park (S-PNP), Taiwan. DNP has permafrost above ca. 1,600 m, whereas S-PNP has freeze-thaw actions above ca. 3,000 m.

A trail erosion study in DNP started in 1989. Trail erosion monitoring has been conducted by the conventional method of Hammitt and Cole (1998) for a period of 10-13 years and is still going on: the erosion is expressed in the form of “cross-sectional area” of eroded trail surface. The soil erosion varied from 193 to 1,403 cm^2/yr showing the rapid rates compared with those measured elsewhere in the world. Moreover, the rates varied from year to year even at the same site. This means that long-term monitoring is necessary to understand the status of soil erosion. The repeated erosion measurements also clearly show effectiveness of closure of the damaged trails. Three-dimensional stereo photogrammetry was also introduced to estimate the “volume” of erosion and sedimentation.

The rapid erosion rates obtained in DNP are attributed to a combination of easily eroded surface materials (unconsolidated volcanic sediments), great amount of rainfall in the period of the heavy human use (mean precipitation from June to September at an altitude of 1,620 m near Mount Asahidake attains 850 mm), continuous supply of snowmelt water in the period of the heavy human use, or until summer (mean snow depth in early April at an altitude of 1,500 m near Mount Kurodake is about 4 m).

In addition to calculate the erosion rates in the past, some geo-soundings were also conducted in DNP to predict the depth of future erosion. These include electric sounding, seismic sounding, and soil resistance detection by a cone penetrometer: no studies have utilized these methodologies to predict future soil erosion of trails. The depth of unconsolidated volcanic materials along the trail was estimated to be 1.5 m by a handy seismic sounding near the Kurodake Hut. The erosion rate there was estimated to be 10 cm/year (mean), so the erosion would continue until the eroded trail surface reaches the bedrock surface in 2016. If this occurs, the depth of gully would attain about 3.5 m, which means hikers have to walk on the trail bottom with the 3.5-m soil walls: no landscapes could be visible. The results obtained by an electric sounding at this site suggest a better location of a new trail to minimize future erosion.

Fast assessment of trail erosion was conducted in S-PNP, Taiwan in November 2006. This kind of method is utilized mainly for national-park managers, who tend to prefer fast and easy way with simple equipment. The thickness of unconsolidated materials in S-PNP seems to be much thinner than that in DNP, which partly creates great difference in the degradation status in spite of extremely heavy precipitation in Taiwan. Nevertheless, the national park authority of S-PNP is deeply concerned about the trail erosion.

We categorized surface materials (sand, silt, and clay; gravels; and bedrock), types of erosion/degradation (gully erosion; sheet erosion; wet/mud; surface water; multiple trail; width expansion; and root exposure), management measures (stone steps; stone pavement; *in-situ* stone steps; wood steps; and no treatment), and vegetation (dominant species). The assessed trail length was 10.8 km from the trailhead (2,180 m) through the Chika Hut and the 369 Hut to the summit of Mount Syue (3,886 m). We spent only 6 hours and 40 minutes to categorize and describe the characteristics of the trail erosion/degradation for the 10.8-km section. Then, we prepared synthesized diagrams to show the assessed erosion/degradation status. The diagrams demonstrate that the spatial distribution of the different soil-erosion types requires different erosion measures even in the 10.8-km section. Moreover, such measures to be needed are clearly visualized by the diagrams. Fast assessment methodology is preferred and adequate for park managers, so that the development of this methodology will contribute to strengthen better management of national park areas with degradation as well as poor park-management structure, such as in Japan (Watanabe, 2008a).

Soil erosion of hiking trails in DNP has been probably most intensively studied in the world although most results have been published in Japanese (e.g., Watanabe, 2008b). A new geo-oriented approach by a seismic analysis, electric resistivity analysis, and cone-penetrometer analysis can detect future erosion depth of trails and campsites. These methodologies can be applied to areas with land degradation issues in different environments; proposed is development of a joint study in the northern areas of Japan and Finland as a part of protected-area management studies.

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