

Use of exposed roots to estimate soil erosion on hiking trails of Mt. Yotei, Japan
(羊蹄山の登山道における土壌侵食の推定への露出した樹木の根の利用)

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Soil erosion on hiking trails decreases in environmental values of national parks. To understand soil erosion, it is important to assess its rates in a rapid, cost-effective, and accurate manner. Soil erosion often causes common root exposure on the surface of hiking trails if the erosion occurs in forest areas. The root exposure is a prerequisite for the use of dendromorphology. This study estimated the average erosion rates on three hiking trails in Mt. Yotei, Hokkaido, based on exposed roots of Ezo spruce (*Picea jezoensis*) by adopting the approach of dendromorphology. This study also determined the topographic characteristics of the sites where soil erosion occurred by means of 3D point clouds obtained from a terrestrial laser scanner (TLS). The studied three trails are Makkari Trail (MT), Kutchan Hirafu Trail (HT), and Kyogoku Trail (KT). Furthermore, this study determined the exposure time of the roots by analyzing the changes in the area of earlywood cells and latewood cells; and determined the root whorl and soil surface height data based on TLS and calculated the average erosion rates. A total of 21 samples were used in this study, including 10 in MT (from 413m to 557m), 5 in HT (from 564m to 590m) and 6 in KT (654m to 857m).

The main results show that the earlywood area of each tree's annual ring area decreases substantially in the third year before exposure. This is probably due to the decrease in the thickness of the topsoil and the deterioration of the ability to regulate temperature and humidity, which is most likely to lead to an increase in the magnitude of temperature and humidity variations in the root system, resulting in a decrease in the area of the earlywood cells. The presence of pronounced resin duct (PRD) was detected in 62.3% of the samples during the three years before exposure, which indicates that PRD has a positive effect on the root exposure. More severe eccentricity and lower erosion rates were exhibited in some partially exposed samples, while smaller eccentricity and higher erosion rates were exhibited in some fully exposed samples. Also, for intact exposed roots, eccentricity can help reconstruct the erosion process. Fourthly, the estimated average erosion rates for the three hiking trails (MT, HT, and KT) were 15.71 mm/y and 16.35 mm/y, and 10.95 mm/y, respectively. No significant correlation between the slope and the soil erosion rates was found in this study.