Investigating the Relationship Between Tree Height and Landslide Occurrence in the Ikawa Catchment, Central Japan

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INTRODUCTION

Landslide occurrence in forested terrain can have large impacts on future soil productivity and the quality of water that drains from the catchment. In this study, the relationship between tree height and shallow landslide occurrence in the Ikawa catchment is investigated to gain a better insight into the distribution of landslides and the spatial distribution of landslide depth in relation to tree height based on GIS analyses and field surveys.

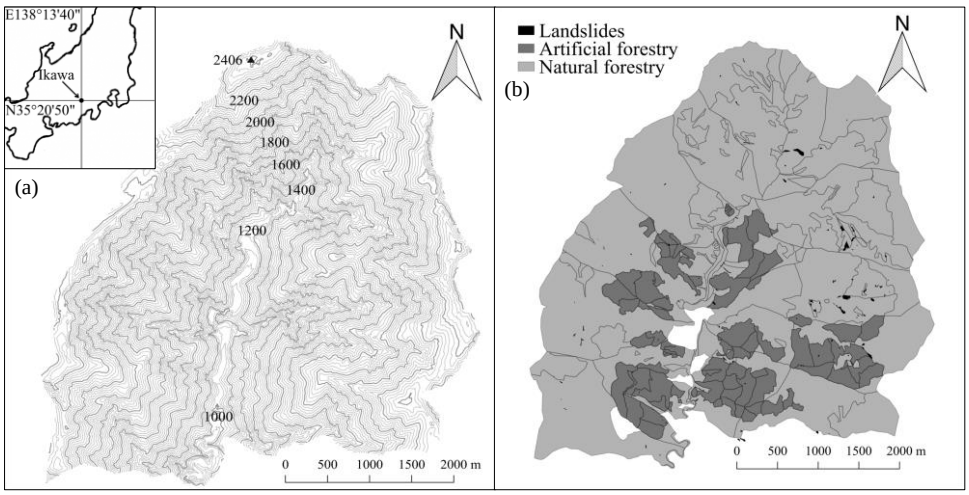

Fig.1 (a) Location and a 20m contour map of the Ikawa catchment, (b) Distribution of artificial and natural forest in the Ikawa, and landslides to have occurred in the period 2008-2014.

STUDY SITE AND METHODOLOGY

The Ikawa, located in Northern Shizuoka prefecture, central Japan, in the upper reaches of the Ohi River has a catchment area of 17.6 km^2 (**Fig.1**). The geological unit is the Shimanto Cretaceous strata composed of sandstone and shale. The elevation ranges from 900 m a.s.l. to 2406 m a.s.l. The mean slope angle throughout the catchment is 40.3°. The catchment received an average of 2800 mm of precipitation annually in the period 1993-2002. The catchment comprises 17% artificial forest (Japanese cypress, Japanese cedar, larch), 77% natural forest (e.g. deciduous broadleaf trees, fir, tsuga), and the remainder is occupied by landslides and the riparian area. Landslides that occurred in the period 2008-2014 were analyzed using GIS. Landslide depth was measured by calculating the difference between airborne LiDAR DEMs for before and after landslide occurrence, and tree height was calculated using LiDAR point cloud data. Field surveys were conducted to

seven of the identified landslides where landslide depth, length and width were measured, along with tree height in the surrounding area. The landslide depth and tree height measured during field surveys will be used to establish a margin of error for the data from GIS analysis.

RESULTS AND DISCUSSION

To generate landslide ratio results, landslides were grouped together based upon mean tree height within the landslide scar prior to landsliding and total area for each group was divided by the total area of the Ikawa forest with the same tree height (**Fig.2a**). The results show that landslides occur more frequently in shorter forests, highlighting the reported increase in landsliding that is seen in many areas following harvesting. As tree height increases, landslide ratios decrease, indicating that landslides occur less frequently in taller forests. This is likely due to trees stabilizing features being accentuated as they grow, leading to further changes to slope hydrology, with larger trees having higher interception and evapotranspiration capacities, and to the further reinforcement of slopes by root networks. Landslide depth analysis aimed to establish a relationship between tree height and landslide depth (**Fig.2b**). The random distribution of results and high P-values, 0.158 for natural forestry and 0.966 for artificial forestry, shows that there is no correlation between landslide depth and tree height, and therefore that the depth of landslides is not controlled by tree height. This study chose to focus on the relationship between tree height and landslide occurrence to attempt to establish a relationship between landslide depth and tree height, rather than evaluate the other topographic features which can affect the occurrence of landslides, such as slope angle or water convergence.

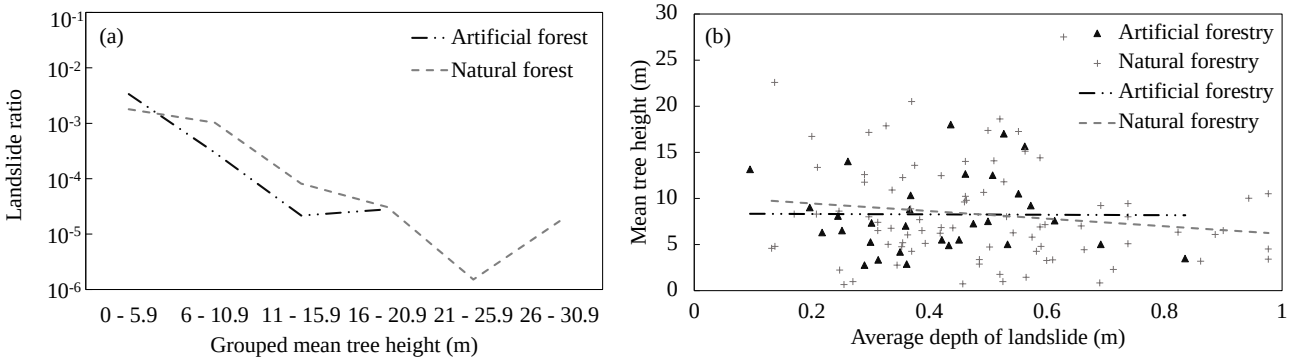

Fig.2 (a) Landslide ratios in the Ikawa forest, calculated for the artificial and natural forest.(b) Results of landslide depth analysis, comparing landslide average depth to mean tree height within the landslide scar prior to landsliding.

SUMMARY AND CONCLUSION

Increasing tree height strongly correlates with reductions in landslide frequency, suggesting that slope stability increases alongside tree height. However, landslide depth analysis indicates that landslide depth is not controlled by tree height and is therefore controlled by other factors. This indicates that while tree height has an impact upon the occurrence of landslides, the depth of the landslides that do occur is independent of the height of trees.

Keywords: LiDAR, landslide depth, tree height