SHALLOW LANDSLIDE OCCURRENCE RELATIVE TO FOREST MANAGEMENT INCLUDING CLEARCUTTING, FOREST THINNING

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1. Introduction

Landslides triggered by hydro-geomorphic factors result in sediment disasters. Forest tree root cohesion provides tensile strength to the soil that increase the shear resistance of soil, contributing stability of hillslopes (Imaizumi et al., 2008; Imaizumi and Sidle, 2021). Forest harvesting sometimes increases the landslide frequency due to root decay of harvested trees. Effects of forest harvesting on occurrence of landslides are possibly different among the harvesting methods. To examine the effects of forest managements i.e., clearcutting and forest thinning in the mountain region, occurrence of shallow landslides was investigated in Abe River watershed, Shizuoka prefecture.

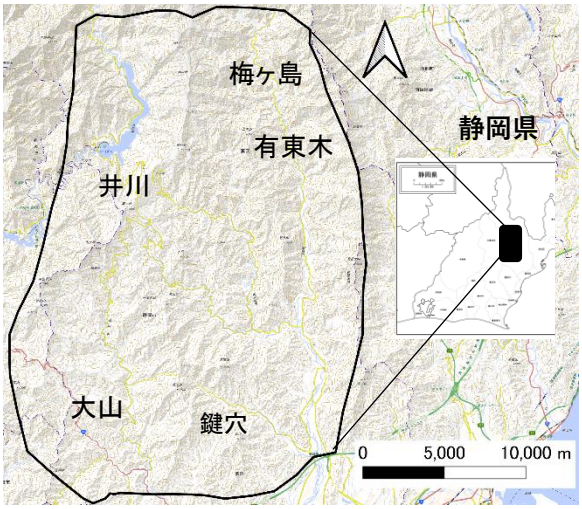


Fig. 1 Study site in Shizuoka prefecture, central part of Japan (GSI map).

2. Study site

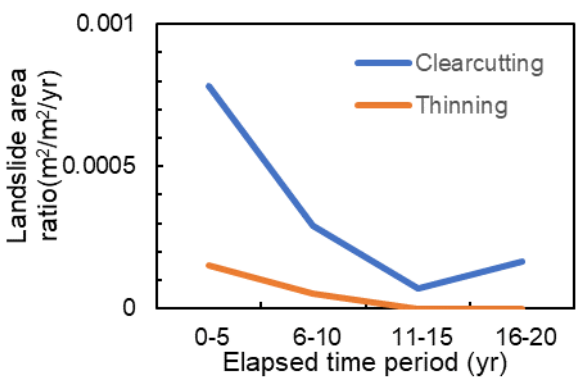
Occurrence of shallow landslides and forest management histories were investigated in Abe River watershed, Shizuoka prefecture (Fig.1). Total area of the study site is approximately 542 km^2. Geology in the study site is mainly composed of Paleogene sandstone and mud stone, named Setogawa group. The study site consists of 6 meteorological stations marking an annual precipitation at AMeDAS of 1740 mm in total of the 6 sites.

3. Methodology

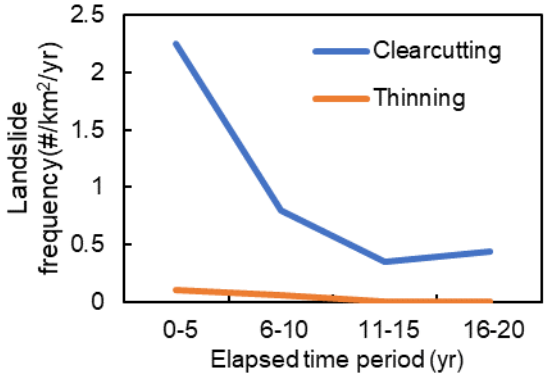
New occurrence of shallow landslides in Abe River basin was investigated using Google Earth Pro images in the period from 2004 to 2021. Timing and location of clearcutting was also assessed using Google Earth images. Forest thinning histories was investigated using Forest Cloud Open System, Shizuoka prefecture. Clearcutting is removal standing trees, while thinning. removal of specified ratio of standing trees (35-40% in study area). Forests that experienced clearcutting and thinning were classified into 4 elapsed time classes: 0-5, 6-10, 11-15, and 16-20 years. Landslide frequency and landslide area ratio in each elapsed time class were assessed using QGIS (Evans et al., 2020). The landslide frequency and area ratio were also calculated in the areas without recent forest management as control areas.

4. Results and Discussion

As a result, total 802 landslides, including 105 landslides in clearcutting and 16 landslides in thinning sites, were mapped in the study site. After clearcutting, temporal change in the area ratio peaked during 1-5 years (7.8 x 10^{-4} m^2 m^{-2} yr^{-1}; Fig. 2a). Landslide frequency was also higher in the clearcutting site during 1-5 years (2.25 km^{-2} yr^{-1}; Fig. 2b). High landslide area ratio and frequency were affected by decay of roots that results instability in the shallow soil of the hillslope initiating landslides (Imaizumi and Sidle, 2021). Both of the area ratio and frequency decreased gradually after 15 years of clearcutting due to the influence of



(a) Temporal changes in the landslide frequency after forest management



(b) Temporal changes in the landslide frequency after forest management

Fig. 2 Temporal changes in clearcutting and thinning

root regeneration after replantation. Besides, thinning exhibits similar trend in landslide area ratio and frequency as the clearcutting (Fig. 2). Landslide area ratio in thinning site was high during 1-5 years (1.4×10^{-4} m^2 m^{-2} yr^{-1}). Landslide frequency in the thinning site was also high in the same period (0.106 km^{-2} yr^{-1}). Due to decay of roots in the site, it results in instability of the soil initiating landslides. Forest thinning landslide area ratio and frequency progressively decreased between 10-15 years and had no mark of landslide occurrence after 15 years of harvesting. Decreasing in the landslide area ratio and frequency were likely affected by root growth of non-harvested trees in thinning areas (Abe et al., 2004). The study clearly compares the effects of different forest management activity in the mountain region evaluating the area ratio and the frequency in the elapsed time period. Comparing clearcutting and thinning, the clearcutting resulted in higher landslide area ratio and frequency. Furthermore, the root degradation and regeneration explain the root reinforcement that provides stability to the shallow soil mantle indicating the importance of forest management in the initiation of shallow landslides.

5. Conclusions

Forest harvesting impact was different between the type of forest management (clearcutting and thinning) on the occurrence of landslides due to root degradation that initiates shear failure of the shallow soil in the hillslope. Based on the slope stability related to root decay and recovery in the forest harvested areas explains the root cohesion and reinforcement that provides tensile strength to the shallow soil in the hillslope (Imaizumi and Sidle., 2021).

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