Bioengineering potential and recovery of vegetation species after shallow landslide

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1. Introduction

The role of vegetation in reinforcing and anchoring the soil contributes in its stability but is dependent of factors such as: strength of roots, root system morphology, distribution and the interaction between roots and soil (Reubens et al., 2007). The root morphology is an important consideration in terms of which forces of the plant structure are transferred into the ground, its shape determine in which way these factors are distributed, the soil holding capacity and stability is also strongly influenced by the symmetry of root system. However the strength of roots is considered one of the most important factors governing soil stabilization and fixation but it depends in factors like species, site-specific characteristics such as growing environment (Gray and Sotir, 1996). This study investigates the interaction between vegetation species and soil after shallow landslide occurrence. The results will clarify the processes of plant roots development and its influences on disturbed soil.

2. Methodology

Study site - The study site is located in the Kamigamo Experimental Forest of Kyoto University, the site was selected on slopes with previous shallow landslide disturbance during heavy rainfall events of 13 to15 of July of 2010.

Vegetation recovery – The condition of the vegetation colonizing the shallow landslide scars was examined by field investigation in September of 2015. The landslide area was divided in 5 plots of 4 m2 according to the landslide scar dimensions. The Importance Value Index (IVI) was calculated from the summation of parameters like: Relative density (R_d), Relative frequency (R_f) and Relative dominance (R_c) from individual species from the plots. The specie with the highest IVI was considered as the leading vegetation in the slope recovery process.

Bioengineering potential – the uprooting strength force of the leading specie was measured using a Push Pull Digital Gauge AIKOH RX-100. Stems were cleared and the dispositive was tied to a strong thread attached to the plant stem and pulled vertically, the gauge automatically recorded the peak Pull out strength force (N) of each specimen tested, the results were considered invalid when the roots or stems broken during the tests. Plant and root morphological characteristics like: height, length of roots, diameter, weight, were measured to evaluate the influence of morphological characteristics on Pull out strength force.

3. Results and Discussion

After the shallow landslide event of 2010, in a five-year recovery period around 60% of the slope was naturally re-vegetated mainly by herbaceous vegetation and small tree specimens. The natural regeneration of the shallow landslide scars was lightly homogeneous with a diversity of only five species colonizing the landslide scar area, the biggest Importance Value Index (IVI) was found on *gleichenia japonica*, an evergreen fern with long trailing rhizomes, with total fronds generally of 1 meter and branches from 20-70 cm, with a distinctive forked frond form, light green color in young specimens and mature specimens can vary from light to dark green color. The parameters obtained from each species are showed in Table 1.

Table 1. Relative density (R_d), Relative frequency (R_f), Relative dominance (R_c) and Importance Value Index (IVI) of the species colonizing landslide scars.

No	Species	R_d	R_f	R_c	IVI
1	*gleichenia japonica*	55.20	100	40.31	195.52
2	*lycopodium cernuum*	4.16	20	2.74	26.91
3	*zanthoxtlum armatum*	11.45	60	8.87	80.33
4	*thremedia triandra*	7.292	80	8.68	95.97
5	*pinus strobus*	21.87	100	39.37	161.24

The regeneration process of a shallow landslide scar is related to site-specific soil properties and external environmental characteristic and overall with the species colonizing the slopes.

Generally the time required to cover a landslide scars according to many authors is from 3 to 5 years, but in the case of the study area the coverage is scarce and flowing water erosion scars can be observed adjacently *gleichenia japonica* specimens with rhizomes oriented downhill, this could contribute to soil loss and make complicated the natural regeneration process.

Pull out strength tests were conducted successfully on 35 specimens of *gleichenia japonica*, the uprooting strength force ranged from 5.60 to 95.80 N and the morphological characteristics as follows: height 3 to 26 cm, root length 3 to 87 cm, diameter of stem 0.54 to 4.42 mm and weight 1.10 to 49.10 gr. The relationship of the uprooting strength and the morphological features showed a positive tendency (Figure 1).

The regression analysis indicated that taller specimens of *gleichenia japonica* with long spread roots are relatively stronger against uprooting actions compared to small plants and short length roots. However, the results of this study suggest that in the case of the studied species the most influential factor is the root morphology instead of external morphological factors.

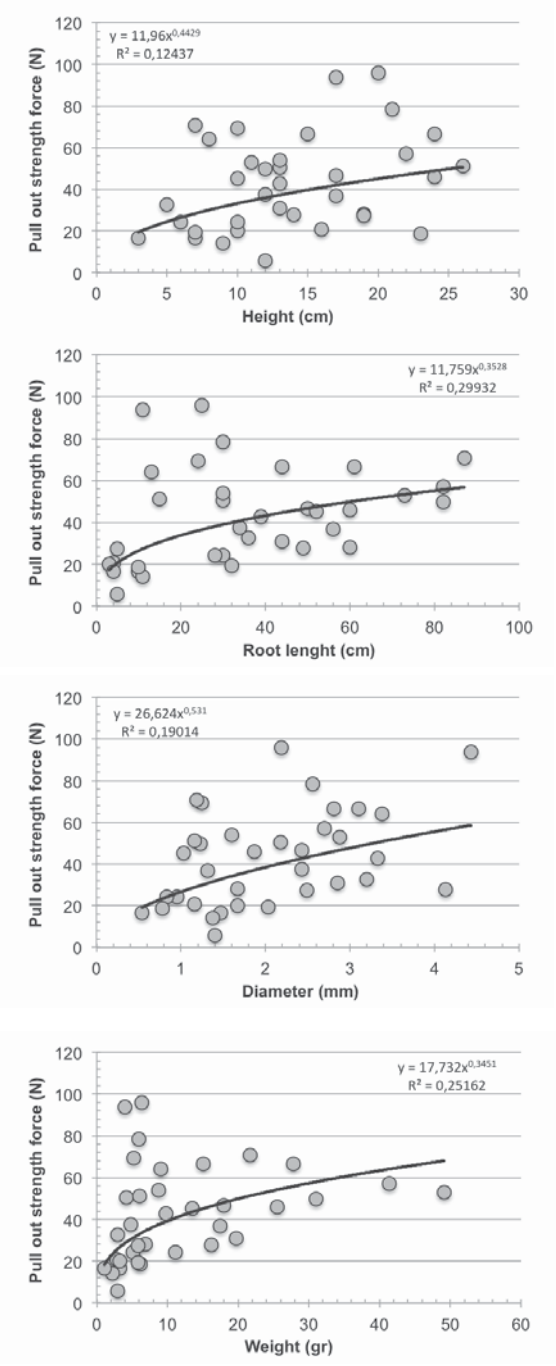

Figure 1. Pull out strength (N) and morphological characteristics of *gleichenia japonica*.

4. Conclusions

The recovery of vegetation species on slopes that have been under shallow landslide disturbance and their pull out strength force as an indicator of potential use of bioengineering practices was investigated. It was found that the dominant species in the disturbed slope was: *gleichenia japonica*. The pull out strength force of the species studied was a direct result of the combination of morphological characteristics, like height, diameter, and weight. However, results suggested that root morphology is a decisive factor on the resistive action of the species to uprooting forces. The biggest pull out strength value was 95.80 N given by a specimen with horizontal root spread. The type of root system of this species (shallow and long) might be causing erosion in the disturbed area when oriented vertical to the landslide scar (downhill), and could protect and hold the soil against surface erosion when oriented horizontal to landslide scar, this is an important consideration for future bioengineering use. When planted properly, *gleichenia japonica* could be considered as suitable species for bioengineering practices and to prevent the surface erosion in disturbed slopes.

References

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