Ground penetrating radar can detect roots of *Pinus thunbergii* in a coastal forest

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ABSTRACT

According to the Kyoto protocol, root biomass of forest trees must be evaluated to determine carbon storage in forest ecosystem. Recently, non-destructive method using ground penetrating radar (GPR) can be used to detect coarse roots of forest trees. However, the successful application of GPR in root detection has been site specific and we still need to clarify which site conditions are available for root detection using GPR. The experiment was carried out in a coastal forest of 10-yr-old *Pinus thunbergii* grown in coastal sandy soils. Three 1 × 4 m plots were set and three transects 4 m long were established in each plot. Radar profiles were collected along transects using a field-portable GPR system with a 1.5-GHz antenna. After GPR scanning, the vertical distributions and diameters of all roots were recorded down to a depth of 30 cm. We clearly detected more than 70% of the roots greater than 10 mm in diameter but only 6% of the roots less than 10 mm. These results support the previous results that can be detected roots greater than 5 mm in diameter but the detection rate of these sized roots is only about 20%.
KEYWORDS: ground penetrating radar, *Pinus thunbergii*, root biomass, root distribution, coastal forest

1. INTRODUCTION

Tree root biomass which accounts for 20-40% of the forest tree must be considered in the report of the Kyoto Protocol. However, coarse roots have been usually measured by destructive excavation. Recently, non-destructive method using GPR can be used to detect coarse roots. This method is easier than the traditional method and merits for measuring live roots without harvesting. Using 1.5 GHz GPR, the roots as small as 0.5 cm in diameter were detected within the upper 30 cm of the soil profile (Butnor et al. 2001). This result suggests that the detection rate of roots with the minimum threshold diameter such as 0.5 cm is lower than that of the larger roots. The objective of this study was to clarify the detection rate of roots classified with the diameter class using 1.5 GHz GPR. We compared vertical root distributions of *Pinus thunbergii* in a Japanese coastal stand with those detected using GPR.

2. MATERIALS AND METHODS

The experiment carried out a coastal forest of 10-yr-old *P. thunbergii* grown in coastal sandy soils. The line thinning at 30% was done six month before the experiment. The mean height and stem

diameter of the tree were 5 m and 6.7 cm, respectively. The stand density was 4700 no/ha. Three 1 × 4 m plots were set between the thinning and unthinning trees and three transects of 4 m long were established 25 cm apart in each plot. Each transect was scanned by 1.5 GHz GPR. After scanning, we excavated down to the 30 cm depth in each transect and the vertical distribution of roots was recorded. We harvested 33 roots each of thinning and unthinning trees to measure water content. We calculated the detection rate of roots in each diameter class by the following equation;

Detection rate (%) = 100 × (the number of roots detected by GPR) / (the number of excavated roots)

3. RESULTS AND DISCUSSION

Although the root water content affect the detection of the root by the GPR (Hirano et al. 2009), those of the thinning and unthinning trees were 67% and 73%, respectively and no significant difference was observed. Therefore, we did not differentiate the roots of the thinning and unthinning trees in our further analysis. The detection rates of the roots with more than 1.0 cm in diameter were about 72%, but those with 0.5-1.0 mm in diameter was only 22% (Figure 2). These results support that GPR can detect the roots with 0.5 cm in diameter as previously reported by Butnor et al. (2001). However, we clarified here that the detection rate was too small about 20% and this can be affected to estimate root biomass by GPR. The numbers of roots in all transects were smaller with increasing the root diameter. We recorded 93 roots with the 1.0-2.0 cm diameter class but only five roots in the 4.0-5.0 cm class. However, the detection rates of roots larger than 1.0 cm kept higher values about 70%. The detection rate of roots depending on the diameter can contribute to accurate estimates of root biomass using GPR.

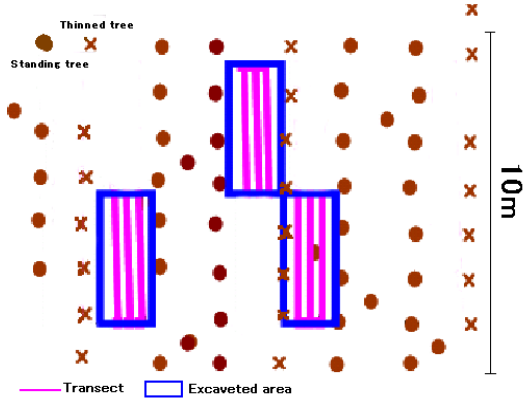

Figure 1. Location of *P. thunbergii* trees and the plots for GPR scanning.

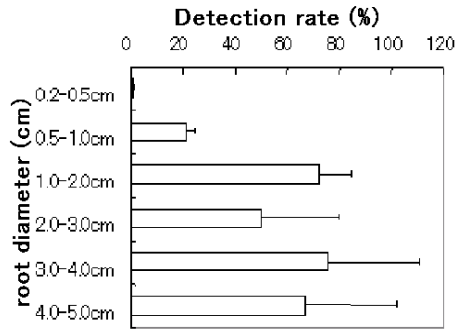

Figure 2. The detection rates of roots with different diameter classes by GPR (n=3, mean+1S.D.).

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