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Ground Penetrating Radar (GPR) for Forest-based Research

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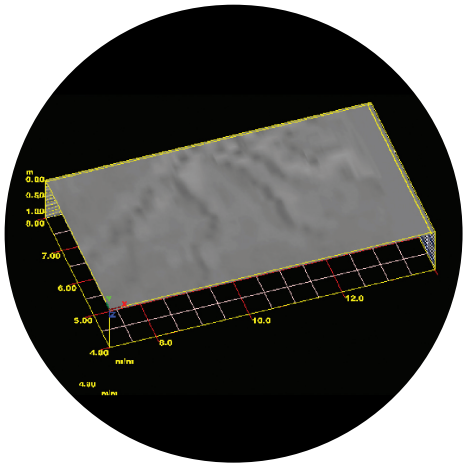
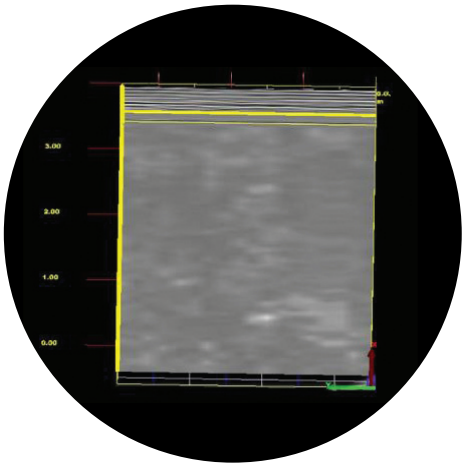
Ground penetrating radar (GPR) is an electromagnetic imaging technique that can be used to detect buried objects or hidden structures. It has been used in geological research, archaeology and in recent years, has been identified as having the potential for forest-based research. Understanding the extent of tree root systems is important in an urban environment as trees and infrastructures are situated at close proximities to each other. The use of GPR technology is quick and non-invasive, compared to alternatives of air spading, which are generally destructive and labour-intensive.

Fig 1. Tree root survey using the GPR

The Centre for Urban Greenery and Ecology (CUGE) has evaluated the potential of GPR for the purpose of tree root mapping in a two year study. Two ground-coupled antennas (frequencies 400 and 900 MHz) were used. The following is a synthesis of the findings.

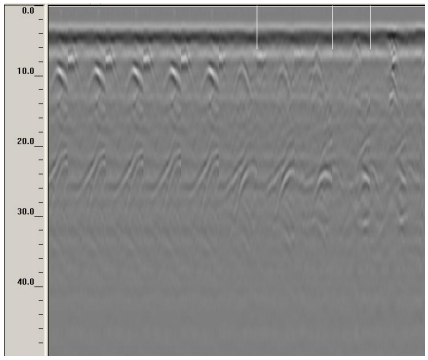
The study has allowed CUGE to identify the uses and limitations of the GPR for tree based research. GPR was not designed and manufactured with the intention for root mapping. Therefore, the GPR will not map all roots – it will only pick up the larger roots (≥5 cm diameter) with the precise size mapped depending on the antenna used. A range of environmental and rhizospheric conditions can also potentially affect the resolution of radar profiles. For example, our studies confirmed that soil composition can cause background noise that interferes with the resolution of the recovered results. The experiments conducted suggest that soils with higher sand content are highly electrically resistive and are amenable to radar investigations. However, one should not rule out the possibility of radar investigations on clay loam soils (with heavy organic matter) as experimentation to fine tune the GPR by improving the quality of the data through advanced digital processing techniques to correct for distorting effects has been successful. Experiments with the GPR operated on several sites around Singapore have yielded radar profiles of varying resolutions. In some instances, the scan may generate images which shows an obvious presence of roots (Fig 2) whilst an image with no obvious signs of roots or any other buried objects can also occur (Fig 3).





Left to Right: Fig 2. GPR scan with obvious presence of roots; Fig 3. GPR scan with no sign of roots

A common misconception is that the data derived from the GPR resembles those seen with electromagnetic radiation (X-ray). The output from an X-ray and the GPR is quite different (Fig 3 & 4). The data derived from the GPR gives less detail as compared to an X-ray scan. The main working tool for GPR operators is no more than a collection of radar traces, one after another in a 2D plot (Fig 4). However, the GPR exceeds an X-ray scanner in that it has the ability of picking up objects at much greater depths and can be used on a range of terrains (surveying large areas) without disruption. The GPR is also highly portable and is designed to withstand outdoor usage. X-ray scanners, on the other hand, tend to be bulky and are less mobile.

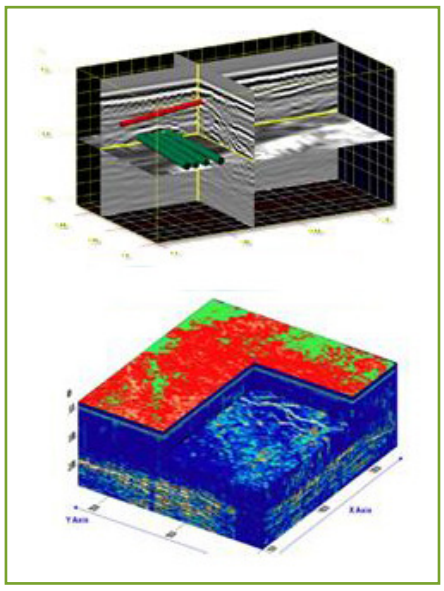


Left to Right: Fig 4. X-ray scan; Fig 5. Radar traces from a GPR scan

The key to confident correlation of radar data to actual roots in the soil comes with time and experience. The conclusions drawn so far are that in the right conditions, the GPR can be used to effectively identify the presence of roots and also their depth in the ground. The experimentation has so far yielded two user manuals which simplifies the operating procedures of the GPR so as to encourage increased utilization. The manuals are available from CUGE Research.

Manuals for GPR hardware and software.

Radan Software Manual



Ground Penetrating Radar Manual