

# Sustainable Diagnosis of Emerging Infectious Diseases of Trees Using Radar

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## Global Rising of Emerging Infectious Diseases of Trees



**13-Fold Increase Globally From 1995 - 2010**



**Recent Outbreaks Almost Brought Species to Extinction**



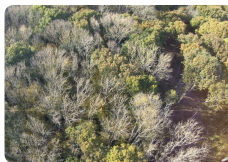
**International Traveling**



**Climate Change**



**Global Timber Trade**



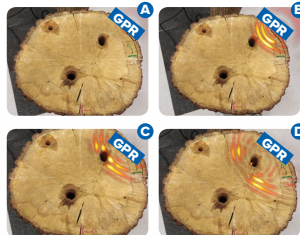
**Figure 1:** Kent Downs Forest, United Kingdom. More than half of the ash trees are currently infected.



**Carbon Dioxide Released From Dying Forests Equals The Emissions From 11 Million Cars**

## Ground-Penetrating Radar: Background and Principles

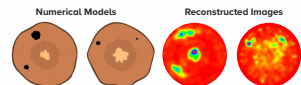
- Mature methodology that has been successfully applied to a wide-range of sensing problems.
- Minimum computational and operational requirements.
- Trivially deployable equipment.
- Good resolution that can effectively resolve small targets and early tree decays.



**Figure 2:** Basic principles of ground-penetrating radar. An electromagnetic wave is propagating inside the tree. In the presence of a target a reflection occurs that propagates back and measured by the receiving antenna.

## Numerical and Experimental Validation

Our lab, The Faringdon Centre, has been active on sensing technologies with applications to forestry and arboriculture applications. Novel processing frameworks have been developed, fine-tuned for detecting early decay within tree trunks with various shapes and sizes. The developed methodologies have been successfully validated using numerical, experimental and real-field case studies.



**Figure 3:** Two numerical case studies illustrating the capabilities of ground penetrating radar coupled with the developed processing scheme.



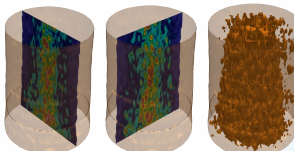
**Figure 4:** Laboratory experiments that involve two tree samples with artificially created decay. All the decay have been successfully detected using the developed processing scheme.

## Case-Study: Diseased Tree at Gunnersbury Park, Ealing, London



**Figure 5:** A) The investigated tree was brought down and subsequently B) Divided into slices for validation purposes. It is apparent that there is a dominant decay that extends along the main axis of the trunk.

- The developed processing scheme has been applied to a diseased tree at Gunnersbury Park, Ealing, London (Fig. 5).
- A dominant decay has been detected that extends parallel to the main axis of the tree (Fig. 6).
- The tree was taken down after the completion of the measurements and subsequently divided into different slices (Fig. 5).
- The reconstructed decay using the developed methodology was confirmed (Fig. 5,6).



**Figure 6:** The reconstructed internal structure of the investigated tree using ground-penetrating radar coupled with the developed processing scheme. The main decay has been successfully detected using minimum operational and computational resources. The axes are in cm.

## Typical Radar Systems

- Designed for civil engineering and geophysical applications.
- Unpractical configurations that result to time consuming surveys.
- Non-optimal signal penetration and resolution.



## New Generation of Sensors



- Novel antenna array designed by our lab, The Faringdon Centre.
- Practical configuration that allows multiple measurements in any arbitrary shaped tree.
- Optimal penetration depth and resolution.