Interpreting Spatial GPR Classifications in Urban Trees Using Aggregation Strategies

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WHY THIS MATTERS

Background

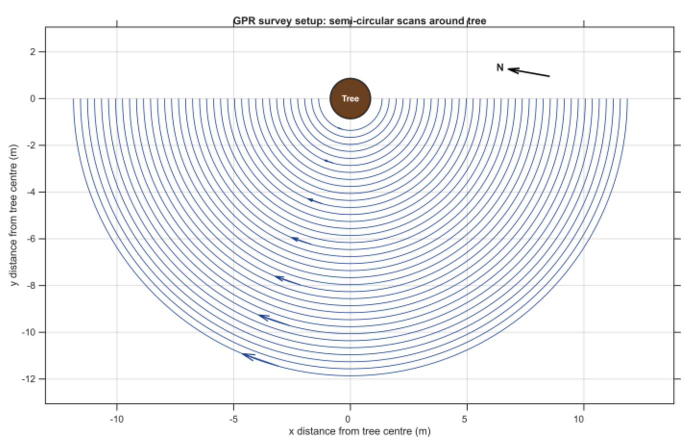
Urban trees provide essential ecosystem services, yet their interaction with buried infrastructure is difficult to assess without intrusive investigation.

Ground Penetrating Radar (GPR) offers detailed subsurface evidence, but interpretation often remains expert-dependent and difficult to translate into operational decisions.

Aim

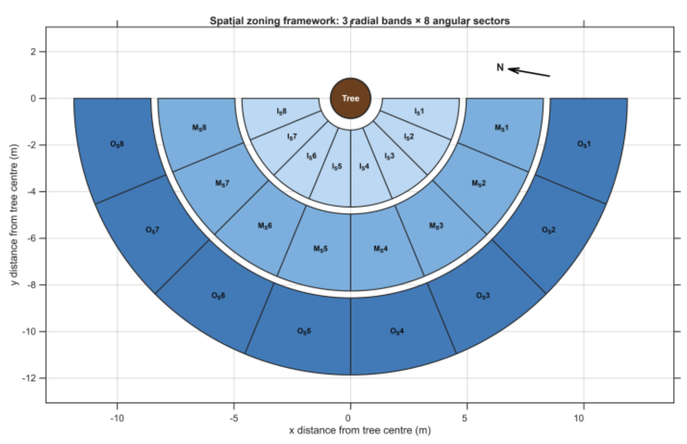
To develop a zone-based framework that translates GPR evidence into practitioner-relevant indicators for screening, monitoring, and prioritising tree–infrastructure interactions.

DATASET & METHODS



Case Study Survey

A mature urban tree was surveyed using 36 semi-circular GPR scans (700 MHz antenna) around the trunk.



Spatial Zoning Framework

The survey area was divided into 24 management zones: 3 radial bands × 8 angular sectors.

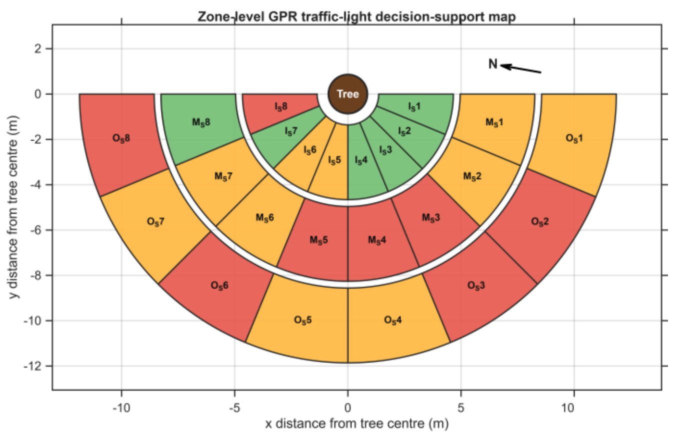
Zone-level Descriptors	
Energy	signal strength
Shallow Energy Ratio	near-surface dominance
Heterogeneity	spatial variability
High Amplitude Fraction	strong reflections
Local Variability	short-scale changes

Robust Relative Scoring

Descriptors were normalised using median + MAD to quantify deviation from the local survey background.

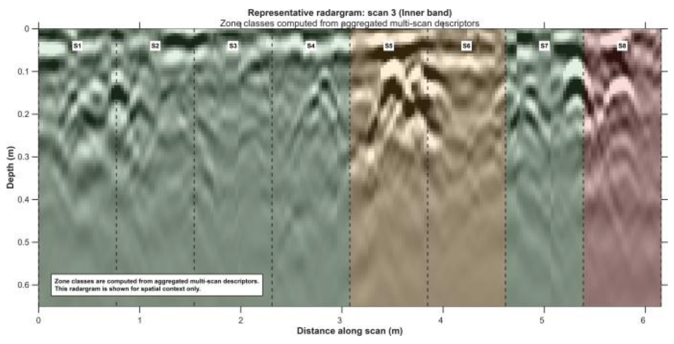
GREEN	AMBER	RED
$\lvert z \rvert \le 1.5$	$1.5 < \lvert z \rvert \le 2.5$	$\lvert z \rvert > 2.5$
Within expected range	Moderate deviation / review	Priority investigation

RESULTS



Zone-based Decision Map

Zone-level aggregation reveals structured variations in subsurface response. Anomalies are spatially concentrated in specific sectors, indicating localised features rather than uniform behaviour.



From Radar Data to Zone Indicators

Signal characteristics are quantified and aggregated within spatial zones, enabling translation of complex reflections into survey-relative indicators.

Key Concept

Zone classes are computed from aggregated multi-scan descriptors within each zone. Radargrams provide context, not direct decision criteria.

TREE-LEVEL INTERPRETATION

From Zone Classifications to Tree-Level Interpretation

Zone classifications summarise where subsurface response deviates from expected conditions.

Different aggregation strategies can lead to different tree-level interpretations from the same evidence.

Alternative Aggregation Strategies

MAJORITY

Tree class = most common class

MONITOR

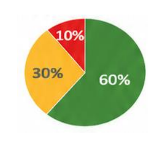
WORST CASE

Tree class = highest priority zone

INTERVENTION

PROPORTIONAL

Tree represented by proportion of green / amber / red zones



60% MONITOR
30% REVIEW
10% INTERVENTION

Next Steps

- Multi-site validation
- Compare aggregation strategies on multiple trees
- Integration with operational decision workflows

Conclusions

GPR-derived descriptors translate complex subsurface responses into spatially explicit indicators for targeted investigation and management.

References

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[2] F. Hou, X. Rui, X. Fan and H. Zhang, "Review of GPR Activities in Civil Infrastructures: Data Analysis and Applications," Remote Sensing (Basel, Switzerland), vol. 14, pp. 5972, Dec 1. 2022.

[3] L. Lantini, A. Ardakanian and F. Tosti, "From Detection to Interpretation: A Decision-Support Framework for GPR-Based Evidence in Urban Climate Adaptation," EGU General Assembly 2026, Vienna, Austria, 3–8 may 2026, EGU26-22982.