“Smart Urban Trees” - monitoring and improving tree and root performance in city streets to enhance urban sustainability

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Knowledge gap and research objectives

Trees are a vital part of the urban landscape and are an essential factor for the well-being of people. Numerous services are provided by trees, such as shade, reduction of the urban heat island, absorption of pollutants, reduction of noise, provision of a natural ambience, and enhancement of biodiversity in the urban ecosystem, thus significantly contributing to the environmental, economic and social sustainability of cities. Trees, and mainly their root system, in urban environments are frequently subject to intense conflicts with infrastructure, such as buildings, roads and utility installations. Soil trenching and compaction, and a small soil volume can impair the root system by girdling and severing roots and by exposing them to hypoxia. Such damage to roots may considerably impair tree development and even increase tree mortality, thus reducing the benefits provided by urban trees. Because of the inaccessibility of the root system we have only a limited understanding of root activity and their interaction with the tree canopy in an urban setting. The goals of this project are to quantitatively assess growth and functionality of mature urban trees and their root system, and to test management options targeted at improving conditions of their root system.

Innovation and contribution to sustainability

Linking the biology of urban trees with the above- and below-ground street profiles constitutes a novel aspect of this study. Such an approach considers growth of urban trees as a process constrained both by biological properties and by the physical conditions given by urban planning (e.g., location of a tree relative to street width and building height). The study will also reveal the relationships between physical and chemical properties of the soil pit and the functioning of the root system, which often is the first to be damaged. We will test new tools to non-destructively study and monitor roots of city streets, and to link the status of roots to canopy performance. Furthermore, the study will provide insights into tree management using practices to improve root function and survival. The outcome of this project will enable the future development of an innovative digital application ("Smart Urban Tree") for mapping and monitoring urban trees and the conditions of their root systems. This application will contribute to the sustainability of cities by decreasing tree mortality and infrastructure replacement, thus ultimately reducing costs.

Methodology and way of collaboration between the partners

We will conduct this study on two platforms: 1) streets in the city of Modi'in planted with mature *Ulmus minor* trees (a species growing naturally in Israel), 2) a common garden experiment using large trees of the above species potted in 500-L container. Contacts have been established with officials in Modi'in, and potted trees will be provided by a commercial nursery. The experimental setup will be used to investigate the relationships between soil properties, root function and tree performance. In addition, the impact of the urban street profile on trees will be tested. In addition, two treatments to enhance root development and activity will be tested on each platform: oxygen addition (deep-soil aeration pipe) and soil modification (replacement of the compacted topsoil by an aerated substrate). Treatments will be applied to replicated trees on each of six streets in Modi'in and to replicated potted trees; untreated street and potted trees will serve as controls. Trees will be tested for their root and canopy performance before and after the treatment applications. Street and potted trees will be monitored for ecophysiological and morphological stress indicators regarding soil characteristics, root development, stem growth, leaf activity, and canopy size (LAI, NDVI). Root growth, turnover and functioning will be assessed using induced polarization (IP), a non-invasive geophysical method used for environmental and hydrological applications. Mapping the subsurface electrical properties is achieved by using multiple electrodes, and an inversion algorithm, to assess electrical conductivity and chargeability, both of which are influenced by the presence and function of plant roots. Using IP, the spatial distribution and activity of the roots will be assessed and linked to the different treatments and to the physiological state of the trees. This is a new, interdisciplinary collaboration between a hydrogeophysicist and a plant ecologist. NS will conduct the IP and soil analyses; JG will perform the ecophysiological measurements on tree roots and canopies; both PIs will jointly supervise a graduate student.