Jan Cermak et al., Expert Opin Environ Biol 2014, 3:2
http://dx.doi.org/10.4172/2325-9655.C1.005

OMICS International
conferenceseries.com SciTechnol

3rd International Conference on
Earth Science & Climate Change
July 28-30, 2014 DoubleTree by Hilton Hotel San Francisco Airport, USA

Field-applicable tools for mesurements of the whole tree absorptive root area and spatially distributed root water supply

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Following the new results of climatologists, water shortage and excess liked to variable rainfall may well be the most immediate consequence of global climate change affecting human livelihoods, while we get dangerously close to planetary boundaries of Anthropocene. We started to understand the problems of hydro-climatic perspective through learning the behavior of trees and forests, after getting experience about their macrostructure and water relations from over 60 experimental sites in Europe, USA and other countries in more than 50 tree species. Many excellent studies are going on at perfectly equipped stationary research sites at present. However some problems could appear, when the task would come, how to answer some practically important questions in many specific sites occurring in open forests dispersed under contrasting environmental conditions over the landscape. Together with several groups of physicists we developed and applied a series of mobile ("backpack transportable") methods allowing such studies in any parts of the World. These technologies are not yet covering all scientific fields as desirable and therefore their gradual development goes on. Here we want to present some of them characterizing macrostructure and water relations of aboveground as well as belowground parts of whole trees and stands, i.e., crowns, stems and root systems. Quantitative estimates of the functions and the effective parameters including their spatial distribution were difficult to obtain earlier, although badly needed for further calculations. E.g., tree foliage is usually characterized by leaf area index (LAI) estimated by optical methods. This works, but when more detail distribution analysis is needed, we can still use classical, but also other, such as fluviometric methods, which allow estimates of effective crown size and also its effective form (to address the stand optical roughness). This also allows better evaluation of e.g., tree transpiration and water consumption, magnitude of environmental (drought and hypoxia) stresses, tree water storage, and crown water holding capacity or absorbed amount of solar energy. Information about tree stems (especially large trunks) is needed from the viewpoint of tree heath state (e.g., detection of rotten tissues), wood quality or water storage, predisposition of trees to biotic attack, but also safety when considering e.g., trees growing in cities or along roads. We demonstrate practical examples of acoustic, thermodynamic or electric methods, which are of a great help here. Root systems represent very important part of trees, which can be fortunately studied in much more details now than in the past, due to further development of corresponding instrumentation. This includes similar but modified georadar, acoustic systems, sap flow vectors, modified earth impedance and supersonic air stream. Acoustic method provides horizontal distribution of large skeleton roots. Georadar gives similar results, but shows even smaller coarse roots down to the "finger size". Supersonic air stream can visualize many tiny 3D root details. However it is not easy to quantify the results in all these methods. In contrast, modified earth impedance method gives effective absorptive root area (m^2) in sections around stem and tree total. This includes absorptive Root Area Index (RAI_{abs}) comparable to leaf area index (LAI), or better sunlit leaf area index (LAI_{sun}) at the stand level. The radial pattern of sap flow in stems gives amount of water (kg or m) coming from superficial and sinker roots from different directions around stems. Studies of water redistribution between stems roots and soils, i.e., estimates of water amounts supplied by roots to crowns or from wetter to drier soil layers or water supplied by crowns, e.g. during rains after drought (important especially in mixed forests of different age) is also possible this way. Examples obtained in different species and contrasting environmental conditions indicate, that measured structural or effective parameters allows economically acceptable functional assessment of whole trees and stands, which makes it possible to apply such methods for practical purposes even up to the landscape level. Only on this objective quantitative background we can better understand tree and stand behavior and up to the level of landscape regions. This way we can contribute to more exact forecast of their development and eventually selection of the most appropriate control or technical measures.

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