Roots in reconstructed soils – how land reclamation practices affect the development of tree root systems

Simon Bockstette

Abstract

Tree root systems are incredibly complex organs that fulfill several vital functions, the main ones being anchorage and uptake of water and mineral elements. They perform these functions in a highly complex and challenging soil environment with heterogeneously distributed soil resources, physical barriers, and often intense competition with neighbouring plants. In adaptation to these challenges, roots systems do not have a genetically pre-determined shape. Instead, root system architecture is, to a large extent, the result of an integrated response to positive and negative environmental cues perceived by the growing root tips. Favorable conditions, such as high resource availability, good aeration and low penetration resistance promote root system development, whereas unfavorable conditions, such as low resource availability, oxygen deprivation and high penetration resistance can restrict it. Competing roots can also restrict root growth in one of two ways, either directly by acting as physical barriers, or indirectly, through local depletion of soil resources. This has some important implications for growing trees, because the resulting spatial arrangement, or architecture, of individual root systems directly determines the soil volume from which they can draw the required resources.

In my dissertation, I used a combination of established and novel techniques to study how changing abiotic conditions and belowground interactions with neighbouring plants act together to shape the root systems and thus determine the rooting space available to planted tree seedlings

during the initial stage of seedling establishment in a variety of reconstructed soils. The results revealed that in fertile reconstructed soils, belowground competition with grasses severely restricted root system development for planted aspen seedlings. Moreover, root competition had a much stronger impact on available rooting space than soil compaction, as the competing grass roots were able to rapidly colonize the available rooting space while simultaneously lowering the availability of water and nitrogen. At a second site, with different soils and climatic conditions I was able to show that planting mixtures of functionally diverse tree species resulted in increased belowground productivity or 'overyielding' due to niche complementarity, but only on one of two studied soil types, where abiotic conditions did not interfere with seedling phenology.

Overall, these findings highlight the need to consider both rooting space requirements associated with different species and site conditions and potential restraints on this shared resource a key factor in the design of reconstructed soils capable of supporting the successful re-establishment of self-sustaining forests after severe anthropogenic disturbances.