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Contrasting Phenology of Roots and Shoots in Arctic Tundra Plant Communities

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ABSTRACT

Phenology is an important component of models which predict the response of vegetation to global warming. However, despite the large contribution of fine roots to overall vegetation production (c. 50-80% of primary production in some vegetation types), phenology measurements are usually made only on shoots. Consequently, understanding of root phenology and of the extent to which root and shoot phenology are synchronous is limited. This is especially true of arctic ecosystems, which also have high ratios of below-ground to above-ground biomass and which are expected to experience the greatest climate change over the next century.

Recent research has shown a decoupling of fine root and shoot phenology in temperate deciduous forest, compared with adjacent grassland, which may be explained by the greater difference between atmospheric and soil warming in forests, and the competitive advantage of early leaf expansion in a forest canopy. We therefore hypothesised that in the low-stature, nutrient-limited tundra vegetation, root and shoot phenology are closely coupled.

We tested this hypothesis by measuring bud burst, shoot growth, leaf senescence and root growth of the dominant species in five arctic vegetation communities in northern Finland throughout the 2008 growing season. The communities comprised two wet sedge communities, dominated by *Eriophorum angustifolium* and *Carex rostrata* respectively, two dwarf shrub communities with a mixture of evergreen and deciduous shrubs (predominantly *Empetrum hermaphroditum*, *Vaccincium* spp. and *Betula nana*), and mountain birch (*Betula pubescens* subsp. *tortuosa*) forest with an understorey of evergreen shrubs. Mini-rhizotrons inserted at 45^{o} and a CID-600 root scanner were used to collect data on root growth, and both above and below-ground measurements were made weekly throughout the growing season.

Our results showed a close coupling of root and shoot phenology in the graminoid dominated communities but a decoupling in shrub and birch forest communities, where peak root production occurred a month after peak shoot production. In graminoid dominated communities the period of root production exceeded that of shoot production. Soil temperature throughout the season did not differ significantly between communities and therefore does not explain the observed differences in root phenology.

This study supports the finding that shoot phenology is not an adequate representation of overall vegetation phenology, and the results may have implications for the prediction of the response of arctic ecosystems to warming, especially in view of the expansion of shrubs in this region and the potential impacts on below-ground processes.

KEYWORDS: root, shoot, phenology, production, arctic, tundra