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ROOT GROWTH RHYTHMS IN TEMPERATE CONIFERS

A review of the literature revealed a lack of current research on conifer root growth rhythms, and on lodgepole (*Pinus contorta*) and jack pine (*P. banksiana*) roots in general. The following is a summary of relevant information on root growth rhythms of various temperate zone conifers.

Seasonal root activity of temperate zone conifers has been shown to be controlled by endogenous rhythmic or cyclic processes, which in turn is modified by environmental conditions. For example, root growth is dependent to a large degree on a continuous supply of hormonal growth regulators flowing downwards from the shoot. However, the relationship between root elongation and shoot growth varies greatly among species. Root growth in species which recurrently reflush throughout the season closely parallels shoot growth. In temperate forest trees whose shoot is predetermined within a winter bud, seasonal root growth has often been reported to occur in two or more surges; one prior to shoot growth in the spring, and a smaller peak later in the summer after the cessation of shoot growth.

There are differences in root growth among species from different ecotypes. Roots of container-grown coastal (*Pseudotsuga menziesii* var. *menziesii*) and interior Douglas-fir (*P. menziesii* var. *glauca*) seedlings were observed to have two active periods, one in the early spring and one in the fall. However, root elongation of the coastal fir reached its' fall maximum two weeks later, and did not stop elongating during winter as did the roots of the interior fir. There are also differences in root growth among individuals of the same species and provenance, as observed in the varied rooting depth among individuals of lodgepole pine all growing on the same permeable soil. Even within individual seedlings, growth cycles of individual roots are cyclic and independent of one another, as observed in roots of one-year-old spring planted white spruce (*Picea glauca*) Although overall trends in root growth were observed, seasonal variation in the growth of different classes of roots (e.g. elongating or absorbing) were also reported.

Root growth differs from shoot growth in that it is far more opportunistic and exploitative, perhaps due to the less severe environment in which roots inhabit. Along with internal factors which influence seasonal root growth, there are external factors such as temperature and moisture which can modify root growth. It has been suggested that in species/ecotypes with less pronounced periodicity of shoot production or more pronounced seasonal changes in soil moisture or temperature (e.g. Alaskan taiga), root growth is more strongly modified by soil environment than by above-ground phenology. However, the authors still felt that fewer reserves are allocated to root growth during periods of active shoot growth.

Bud flush of black spruce (*Picea mariana*) and tamarack (*Larix laricina*) growing in a northern Albertan peat land occurred in May and early June, when soil temperatures at 10 cm depth were between 1 and 3°C. On these sites, root growth was not observed until early August, which continued until September for the tamarack, and into October for the spruce. The seasonal pattern of root growth was found to closely correlate with soil temperature in an Alaskan study. Root elongation in white and black spruce, and tamarack had begun May 6 when sampling was

initiated, reached a pronounced peak in July, declined in late summer, and ceased by mid-September. Comparing the fine root growth of jack pine, black spruce and aspen (*Populus tremuloides*) growing near Prince Albert Saskatchewan, and Thompson Manitoba, 83 to 93% of the observed variation within species was explained by soil temperature at 10 cm.

Root growth of Mugho pine (*Pinus mugo*) under southern Ontario climatic conditions began in early April and extended into late November. Low soil temperatures (i.e. 2 to 5°C) in the fall resulted in slow root growth, such that the root tips were completely suberized by the end of November. Root extension resumed in early April, when warmer air temperatures resulted in soil temperatures of around 7°C. It is interesting to note that soil texture also influenced root growth, as autumn root growth lasted longer in a peat soil compared to a sandy loam, which was thought to result from the insulative characteristics of the peat delaying the onset of cooler soil temperatures. Rooting depth also influences growth, as shown by the delay in growth of deeper hardwood roots compared to surface roots, due to the time lag in warming of the deeper soil layers in the spring.

Moisture stress applied prior to the peak of spring root growth in two-year-old potted red pine (*Pinus resinosa*) seedlings modified root growth by delaying the peak of root activity. Removal of imposed moisture deficits during other periods in the root growth period resulted in sudden, short-lived surges in root activity. Moisture excess can also modify the root system, as observed in the dieback of downward penetrating fine roots during the winter in lodgepole pine growing in waterlogged clay soils

From the preceding information it can be expected that lodgepole and jack pine root growth will be governed by internal rhythms in concert with shoot growth. However, in boreal ecosystems these rhythms will be strongly influenced by environmental conditions, namely soil temperature. Low soil temperatures are thought to decrease root growth by reducing metabolic activity and the turgor of root cells due to reduced water uptake. There exist critical temperatures below which root growth virtually stops. Methods for increasing root growth on sites with cold soils include mechanical site preparation, and microsite planting; both of which result in planting seedlings on warm, raised growing spots.