Extension Note
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An initial look at mycorrhizal fungi and inoculum potential in high elevation forests

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Abstract

Mycorrhizae are symbiotic associations that improve plant nutrition in the competitive biological communities that inhabit forest soils. The goal of this research was to determine if cutblock size and distance from the standing timber has any effect on the diversity of ectomycorrhizal fungi available for colonization of outplanted seedlings. During the winter of 1994–95, the Sicamous Creek Silvicultural Systems Study (Engelmann Spruce-Subalpine Fir Wet-Cold Biogeoclimatic Variant) was harvested. Four treatments were sampled in this study: no harvesting, 0.1-ha, 1-ha and 10-ha cutblocks. In the first summer following logging, there was no difference in the numbers or diversity of ectomycorrhizae in soil cores removed from the cutblocks and the forests. The number of ectomycorrhizae in the cutblocks decreased substantially by the second summer, and very few were present by the third summer. Moreover, the diversity of mycorrhizae was significantly reduced at a distance of 16 m or more from the forest edge. After 13 weeks of growth in the field, the number of types of mycorrhizae and the colonization levels of spruce seedlings planted several metres from the edge of the forest were significantly higher than those of seedlings planted further into the cutblocks. The management implications of this study are that there is still an active amount of mycorrhizal fungal inoculum available to seedlings shortly after harvest in the undisturbed organic horizons of the forest floor. This level remains quite high within the rooting zone of the standing timber, but decreases dramatically further into the cutblock.

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Introduction

Seedlings benefit from the symbiotic relationship that develops between themselves and mycorrhizal fungi that occur naturally in any soil environment. This symbiotic relationship improves seedling nutrition in the competitive biological communities that inhabit forest soils. Nurseries recognize the importance of this relationship and many have built it into their propagation strategies. It is common for the seedlings selected for outplanting to have been colonized by mycorrhizal fungi introduced in the nursery; these fungi may or may not be found in the environment in which the seedlings will be planted. It was once thought that just having a seedling with mycorrhizal fungi was sufficient to enable it to survive better in the wild. Research results to date seem to suggest that the quantity of mycorrhizal colonization should not be the only aspect of concern to the silviculturist; the diversity of fungal species involved in the colonization is important as well.

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Mycorrhizae are specialized organs formed as a result of the symbiotic association of specific fungi with the feeder roots of higher plants. They are often divided into several general groups, with ectomycorrhizae, vesicular-arbuscular mycorrhizae and ericoid mycorrhizae being examples of specific groups. Ectomycorrhizae are the types that form on most of the important conifers of BC (pine, spruce, Douglas-fir, larch, hemlock and true firs), as well as such hardwoods as birch and aspen. Besides benefiting the host by increasing nutrient and water absorption, the colonization of roots by ectomycorrhizal fungi also reduces the infection of fine roots by pathogens. Different fungal species prefer to inhabit different substrates. Some prefer mineral soil, while others prefer forest floor, or decaying wood. The fungi can also differ in their preference for different ages of trees or parts of the root system. Since forest soils are such heterogeneous environments, it makes sense that a tree can maximize its exploitation of soil resources if it is colonized by a diverse assemblage of these fungi. Ectomycorrhizal fungi also use different forms of inoculum to infect their host; mycorrhizal roots, spores, and vegetative resting structures are three such sources of infection.

The research study at Sicamous Creek and the results presented here focus on ectomycorrhizae and the impact of alternative silvicultural systems on their density and diversity over a three-year period immediately following the removal of the overstorey canopy.

Mycologists estimate that there are approximately 5000 species of ectomycorrhizal fungi, each likely differing in the benefits it provides to its host as well as the substrate which it prefers to inhabit. For a forester developing renewal strategies for a site that involves the use of planted seedlings, this observation leads to a number of questions:

1. What are the naturally occurring mycorrhizal fungi on the site?
2. Do they differ from the ones found on the seedlings grown at the nursery?
3. If they are different, what impact does that have on the seedlings' ability to exploit the site in terms of increased survival and growth?
4. Does the size of clearcut or the distance from the forest edge impact mycorrhizal levels that would normally be available to outplanted seedlings?
5. Does this impact change over time?

In order to shed some light on these complex questions, this study focused on providing a basic understanding of what types of ectomycorrhizal fungi are found on tree roots in the forests at Sicamous Creek. Cutblock size and distance from the standing timber were then measured to see if harvesting patterns had any short-term effect on the fungi colonizing spruce seedlings. The impact that these specific ectomycorrhizal fungi have on the ability of outplanted seedlings to better exploit their environment is the topic of another study, the results of which will be released at a later date.

Site

The Sicamous Creek Silvicultural Systems Study is situated on the Cariboo Plateau in the Southern Interior of British Columbia. The study area ranges in elevation from 1500–1850 m and is located in the Engelmann Spruce-Subalpine Fir (ESSF) Wet-Cold (wc2) Biogeoclimatic Variant. During the winter of 1994–95, the site was harvested in 30-ha units. There were three replicates of five treatments: no harvesting, single tree selection (not sampled in this study), 0.1-ha, 1-ha and 10-ha cutblocks.

Figure 1. An overview of the research site.

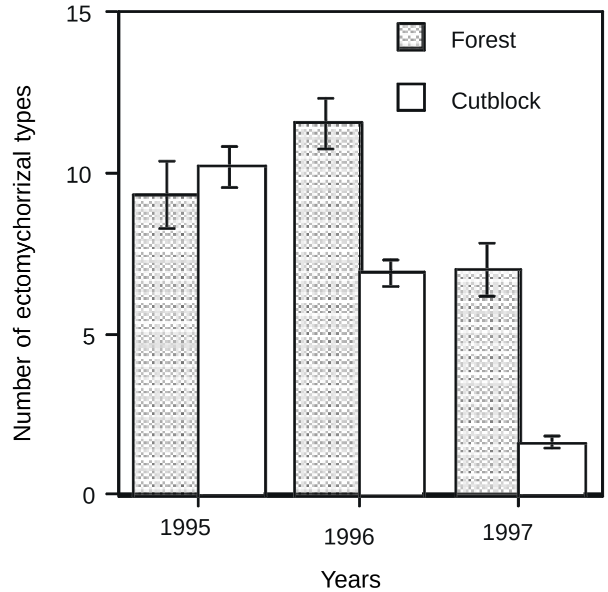

Figure 2. The total number of types of ectomycorrhizae found in soil cores for the first three years after winter logging at Sicamous Creek. Error bars represent one standard error of the mean.

Approximately 33% of the total timber volume was removed from each 30-ha treatment unit for each of the four removal treatments. An overview of the research site is provided in Figure 1.

Objectives

1. To determine how long the ectomycorrhizae from the harvested stand persisted in the soil of the cutblock;
2. To determine how the level and diversity of ectomycorrhizal colonization of young, outplanted seedlings varied across cutblocks; and;
3. To determine if either of the above were influenced by the size of the cutblock.

Sampling Design

For the first three summers following winter harvesting (1995–97), soil cores were collected in the centres of each size of cutblock and at locations across the larger two cutblock types, as well as in the uncut forest. In the second and third growing seasons, eight-week-old non-mycorrhizal spruce seedlings were outplanted into these same locations and grown for 13 weeks before being harvested. All core samples and seedling roots were examined for ectomycorrhizae. The ectomycorrhizae were then separated into different fungal types based on their morphology. DNA of the major types was studied to aid in the identification of the fungi involved.

Results

Core Samples

In the first summer following winter logging, there was no difference between the cutblocks and the forests in the proportion of active roots or in the numbers and diversity of ectomycorrhizae. Live conifer roots were more difficult to find by the second summer and fewer fungi species were encountered. Very few were present by the third summer (Figure 2).

DNA testing of ectomycorrhizal fungi on roots in both cutblock and forest samples helped to identify the different fungal species found in the soil (Figure 3). Although no difference in mycorrhizal diversity was observed along the transect line from the forest to the centre of the cutblock the first year, differences were evident in years two and three. The variety of mycorrhizae per plot was significantly reduced at a distance of 16 m or more from the forest edge (Figure 4).

This relationship between ectomycorrhizal diversity and distance into the cutblock occurred regardless of cutblock size. Therefore, the major effect of cutblock size on the diversity of ectomycorrhizae is due to the higher edge-to-area ratio of smaller cutblocks.

Seedling Roots

Similar trends to those of the soil cores were observed in the eight-week-old non-mycorrhizal seedlings when they were planted in plots across the cutblocks in 1996 and 1997 (Figure 5). The number of types of mycorrhizae associated with seedlings planted several metres from the edge of the forest was significantly higher than the number found on seedlings planted further into the

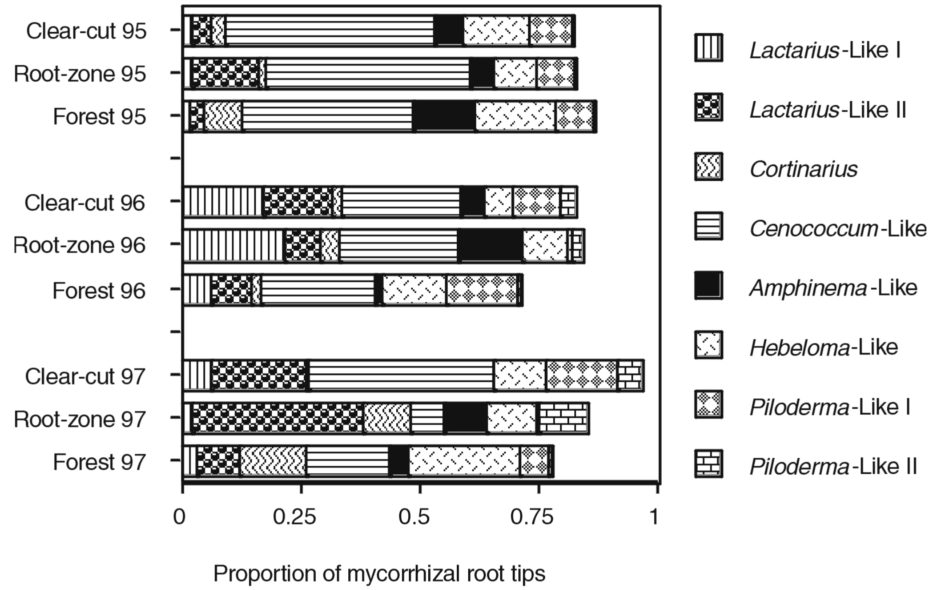

Figure 3. The proportion of the dominant ectomycorrhizal types encountered in soil cores one, two and three growing seasons after winter logging at Sicamous Creek.

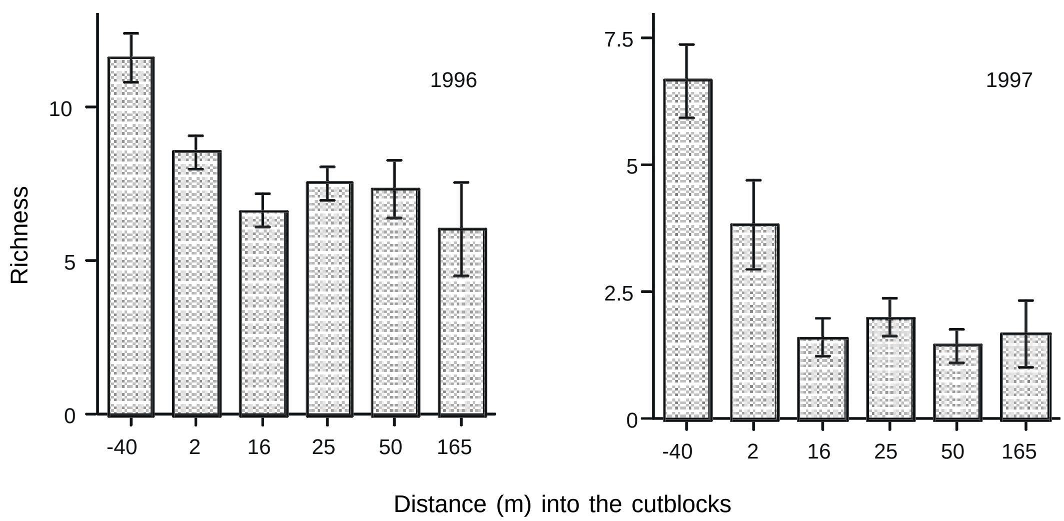

Figure 4. Richness of ectomycorrhizae encountered in soil cores sampled from Sicamous Creek two and three growing seasons after logging with increasing distance from the block edge. The -40 m samples were collected at least 40 m into the forest adjacent to the cutblocks and in the uncut controls. Error bars represent one standard error of the mean. A one factor ANOVA detected significant distance effects at alpha = 0.05 in both years.

cutblocks. Moreover, colonization levels were higher for seedlings planted within the rooting zone of the standing timber (50% of root tips in both 1996 and 1997) than for other cutblock seedlings (33% in 1996 and 19% in 1997). The reduction in colonization between 1996 and 1997 for seedlings planted 16 m or greater into the cutblock may have been a result of the extreme reduction in active ectomycorrhizae present in the soils by the third summer following harvest. The results are consistent regardless of cutblock size (Figure 6).

What have we learned?

In this study:

1. The major ectomycorrhizal fungi have been described both in the soil and on the roots of planted seedlings (Figures 3 and 6) on the Sicamous Creek research site. Although most fungi observed on roots of young seedlings were also found in the soil, some were not. Therefore, sources of inoculum other than ectomycorrhizal root tips from the previous stand, possibly including spores, may also be important to the seedlings.
2. Seedlings planted close to the forest edge have

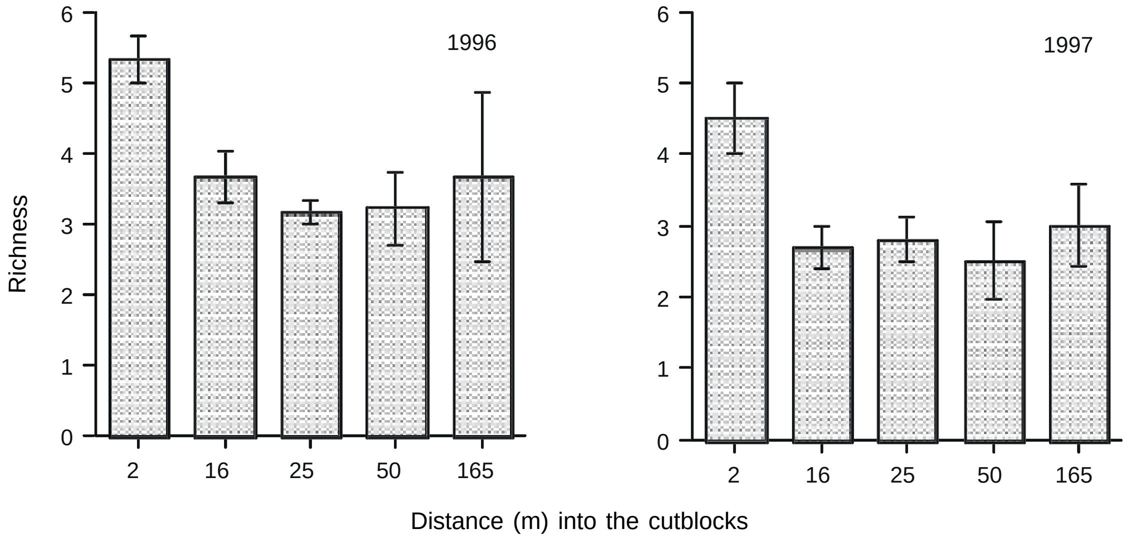

Figure 5. Number of types of (richness) of ectomycorrhizae encountered on seedling roots grown at Sicamous Creek for 13 weeks, two and three growing seasons after logging with increasing distance from the block edge. Error bars represent one standard error of the mean. A one factor ANOVA detected significant distance effects at alpha = 0.05 in both years.

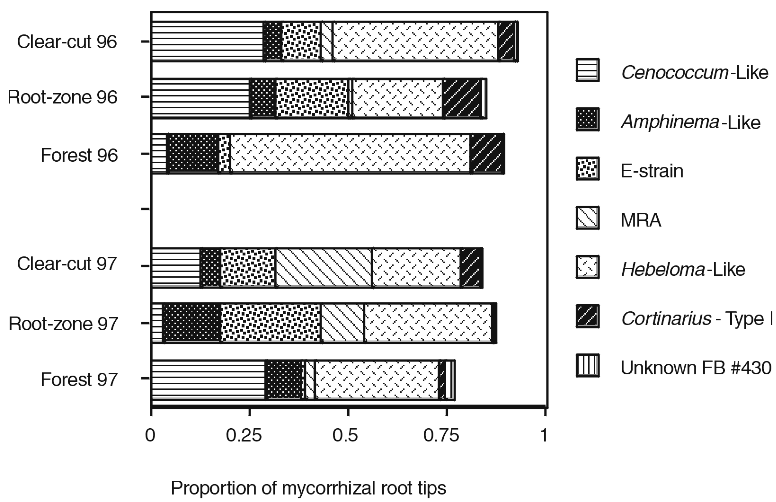

Figure 6. The proportion of the dominant ectomycorrhizal types encountered on seedling roots two and three growing seasons after winter logging at Sicamous Creek.

the advantage of being exposed to a greater diversity of ectomycorrhizal fungi, including fungi that are already in association with the roots of the standing trees. This diversity is reduced the further into the cutblock the seedling is planted (16 m or greater) and the longer the time period between harvesting and establishment. This study investigated short-term (three years) effects only. Studies on older cutblocks would determine how long the reduction in diver sity remains and whether this reduction has any effect on a seedling's long-term growth potential.

What Next?

This study indicates that there is still an active amount of mycorrhizal fungal inoculum available to seedlings shortly after harvest in the undisturbed organic horizons of the forest floor. It also points to the fact that the closer to the original stand the seedling is planted, the more inoculum is available. This information lends more support to the practice of trying to establish the new forest as quickly as possible following harvest. Part two of this study is underway, documenting the colonization of nursery seedlings at Sicamous Creek, providing direct evidence that different fungi affect nitrogen uptake differently, and that this diversity of fungi has a positive impact on seedlings planted at higher elevations.

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