

# Potential of woody understorey plants to provide refuge for ectomycorrhizal inoculum at an Interior Douglas-fir forest after clearcut logging

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## INTRODUCTION

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Ectomycorrhizal fungi take up and transport essential nutrients to their host plants (Harley and Smith 1983). The ectomycorrhizal association may, therefore, be important for the adequate growth and survival of many tree species at both early and late stages of development (Christy et al. 1982; Perry et al. 1987). However, silvicultural systems such as clearcut logging can result in a reduction in quantity and diversity of ectomycorrhizal fungal inoculum (Harvey et al. 1980; Parsons et al. 1994; Hagerman et al. 1999). Thus, seedlings grown in areas of clearcut logging often form less ectomycorrhizae than seedlings grown in undisturbed soils (Perry et al. 1982; Parke et al. 1984). Furthermore, the dispersal of spores into disturbed areas may be insufficient to provide inoculum at levels comparable to the uncut forest (Perry et al. 1987). After clearcut logging, some plant species previously present underneath the canopy persist and proliferate throughout an opening. Many of these plant species form mycorrhizal associations with ectomycorrhizal fungi and have the potential to act as reservoirs for ectomycorrhizal fungal inoculum, which would otherwise die because of the lack of a plant associate. These plant species are referred to as “refuge plants.”

The alternative silvicultural systems trials at Opax Mountain aimed to gain a better understanding of the effects of various harvesting methods on the ecology and management of Interior-Dry Douglas-fir forests in British Columbia. The objectives of this part of the Opax study were:

- to identify understorey plants that could support ectomycorrhizal fungal inoculum for Douglas-fir seedlings outplanted in the clearcuts; and
- to quantify the diversity (expressed as richness) of ectomycorrhizae associated with refuge plants amongst each other and at clearcut and forest locations.

## MATERIALS AND METHODS

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The Opax Mountain Silvicultural Systems Trial is located in the southern Interior of British Columbia and ranges in elevation from 950–1370 m (Bealle-Statland 1998). The site was harvested in the winter of 1993–1994. The alternative silvicultural systems implemented included single-tree selection, as well as patch cuts ranging in size from 0.1, 0.4, and 1.6 ha in a randomized block design. This study was

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conducted in the three upper-elevation, 1.6-ha patch-cut treatment units (and adjacent uncut forest) and at the three lower-elevation patch-cut treatment units (and adjacent uncut forest).

Roots from 16 species of common woody understory plants (Table 1) were sampled from the uncut controls in July 1995 to assess their ectomycorrhizal status. Ectomycorrhizal and arbutoid mycorrhizal roots were described and identified according to specific morphological features and molecular characteristics (PCR/RFLP analysis). Based on the preliminary screening of the 16 potential refuge plants sampled in 1995, a subset of the most extensively colonized species was selected for further analysis in 1996, 1997, and 1998.

Diversity is expressed as richness, where richness is the number of morphotypes encountered (at the scale of the individual plant;  $n = 200$  mycorrhizae). The effect of treatment (clearcut vs. forest) on the richness of the mycorrhizal community was tested by one-way ANOVA.

## RESULTS AND DISCUSSION

Colonization by ectomycorrhizal fungi was observed for 11 of 16 plant species surveyed (Table 1). Although many of the plants assessed were extensively associated with ectomycorrhizal fungi, *Arctostaphylos uva-ursi* and advanced regeneration seedlings of Douglas-fir had a high proportion of fine roots colonized by ectomycorrhizal fungi. These species were also abundantly distributed throughout the study site. Therefore, we considered these two plant species particularly good candidates to provide refuge for ectomycorrhizal fungi after logging. Additionally, *A. uva-ursi* forms extensive mats throughout the openings, but does not shade out young conifer seedlings.

TABLE 1 Ectomycorrhizal status of 16 understory plant species sampled from the Opax mountain site in July of 1995

Plant species	% colonization	No. of morphotypes observed	No. of morphotypes shared with Douglas-fir
<i>Acer glabrum</i>	0.00 ± 0.00	—	—
<i>Alnus viridis</i>	48.12 ± 7.60	8	8
<i>Amelanchier alnifolia</i>	17.11 ± 9.53	5	4
<i>Arctostaphylos uva-ursi</i>	34.99 ± 6.33	17	10
<i>Betula papyrifera</i>	56.01 ± 10.04	13	8
<i>Chimaphila umbellata</i>	0.00 ± 0.00	—	—
<i>Juniperus communis</i>	0.00 ± 0.00	—	—
<i>Mahonia aquifolium</i>	0.00 ± 0.00	—	—
<i>Paxistima myrsinites</i>	1.03 ± 1.03	1	1
<i>Populus tremuloides</i>	44.52 ± 6.80	16	11
<i>Pseudotsuga menziesii</i>	46.78 ± 9.24	15	
<i>Salix commutata</i>	25.38 ± 5.99	14	7
<i>Shepherdia canadensis</i>	15.16 ± 7.79	8	4
<i>Spiraea betulifolia</i>	0.99 ± 0.99	2	2
<i>Vaccinium caespitosum</i>	0.97 ± 0.97	1	1
<i>Vaccinium membranaceum</i>	0.00 ± 0.00	—	—

Over all years of the study, 29 and 33 morphotypes were described for Douglas-fir and *A. uva-ursi*, respectively. Twenty-seven types were shared by both species. A shared community of ectomycorrhizal fungi may contribute to the regeneration success of Douglas-fir. This was the conclusion of Horton et al. (1999), who investigated Douglas-fir regeneration in proximity to *Arctostaphylos* in a chaparral community on the central coast of California.

Other plant species, such as *Betula papyrifera*, *Populus tremuloides*, *Alnus viridis*, and *Salix commutata*, were patchily distributed throughout the site, yet hosted a diverse community of ectomycorrhizal fungi. Therefore, we also considered these plants as important for providing refugia.

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## DIVERSITY OF THE MYCORRHIZAL COMMUNITY

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Refuge plants may be important for maintaining a diverse ectomycorrhizal community. Because the quantity and diversity of some types of ectomycorrhizal inoculum can decrease after clearcut logging, this community will be available to outplanted seedlings. In the latter two years of the study, *A. uva-ursi* exhibited similar levels of mycorrhizal diversity in both forest and clearcut plot locations (Figure 1). This observation is important because many researchers suggest that seedlings associated with a diverse array of ectomycorrhizal fungi may be better able to adapt to changes in the environment (Perry et al. 1987; Simard et al. 1997A). In contrast, advanced regeneration Douglas-fir seedlings sampled from the openings were associated with a significantly less diverse assemblage of ectomycorrhizal fungi than were the Douglas-fir seedlings sampled from the forest (Figure 1). Advanced regeneration Douglas-fir seedlings growing in openings may be unable to support some species of ectomycorrhizal fungi in the absence of fungal connections with mature trees (Simard et al. 1997B).

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## MANAGEMENT IMPLICATIONS

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Clearcut logging can reduce the quantity and diversity of ectomycorrhizal fungal inoculum. For this reason, refuge species (e.g., *Arctostaphylos uva-ursi*, *Betula* spp., and *Populus* spp.) on clearcut sites are considered important for the maintenance of ectomycorrhizal inoculum and for successful stand regeneration in these Interior Dry Douglas-fir forests.

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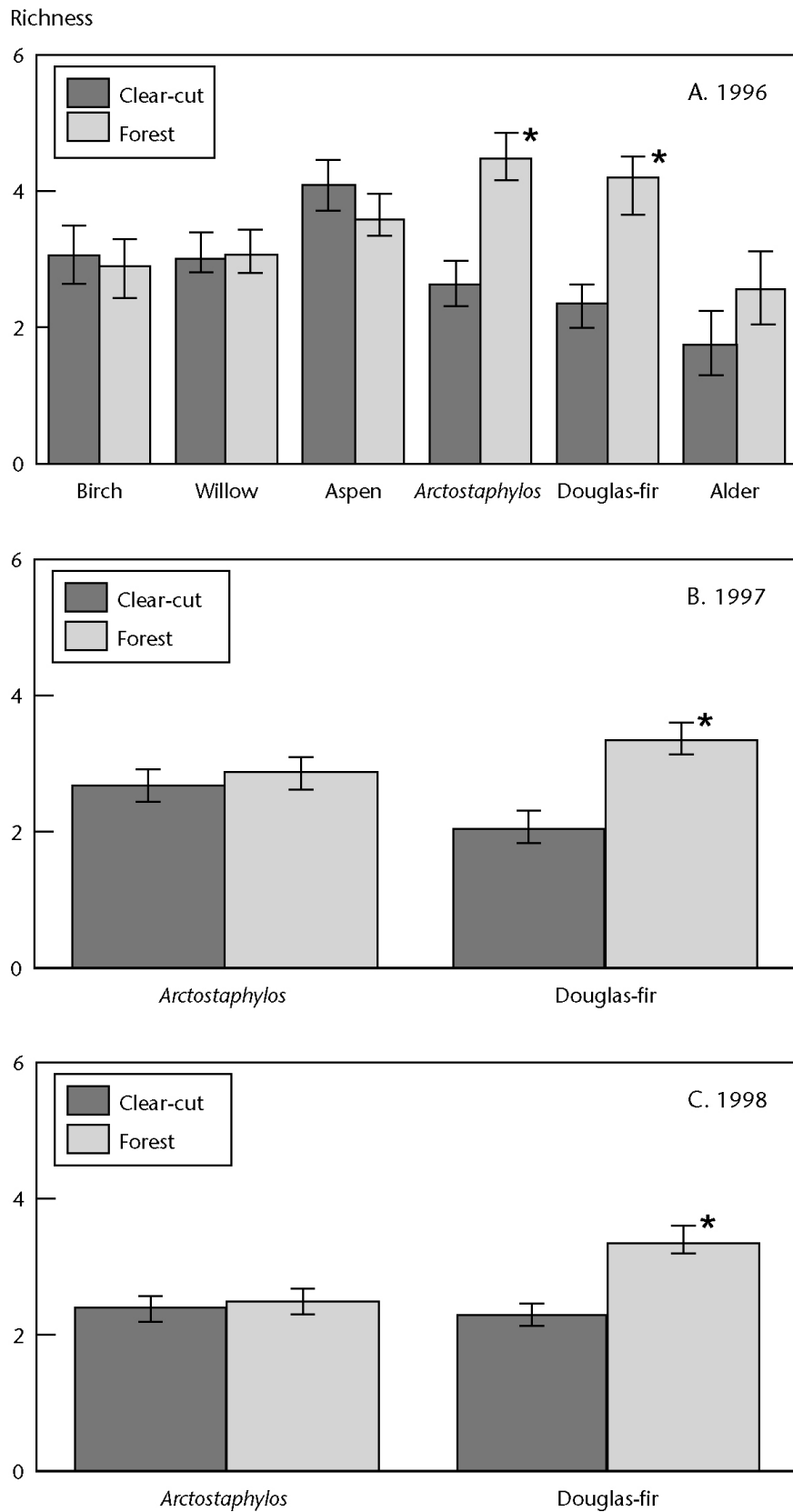


FIGURE 1 Richness of mycorrhizae (per plant) associated with selected refuge species in clearcut and forest locations in 1996, 1997, and 1999. Bars marked with an asterisk differ significantly ( $p < 0.05$ ).

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