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Assisted Revegetation in a Subarctic Environment: Effects of Fertilization on the Performance of Three Indigenous Plant Species

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Abstract

Assisted revegetation is particularly difficult in subarctic and arctic ecosystems where the impact of anthropogenic activities can be extensive and natural plant regeneration is slow. The construction of a military base in the 1950s at Kuujjuarapik–Whapmagoostui in northern Quebec destroyed most of the vegetation cover. Afterwards, other anthropogenic disturbances linked to the village expansion (housing, ATV traffic, pedestrian trampling) have slowed down the recovery process. To provide residents with low-cost but efficient assisted revegetation techniques, we evaluated the performance (seedling emergence, survival, and biomass production) of three indigenous plant species (*Leymus mollis*, *Lathyrus japonicus*, *Trisetum spicatum*) submitted to different levels of mineral and organic fertilizer additions in both a greenhouse experiment and a field plantation in the village. In the greenhouse experiment, moderate mineral fertilization had positive impacts on seedling emergence and both aboveground and belowground biomass of *L. mollis.* The magnitude of this impact on biomass was greater when mineral fertilization was combined with organic fertilization. The effects of mineral fertilization were negative on the other two species, especially at higher fertilization levels. However, after two growing seasons, a moderate level of mineral fertilizer in the field plantation had positive effects on the cover and aboveground biomass of all three species. Overall, organic fertilization from the substrate of a nearby marsh did not enhance plant performance in either experiment. Planting seeds of *L. mollis* or *T. spicatum* in combination with a moderate level of mineral fertilization at the time of planting provides a low-cost assisted revegetation treatment for subarctic villages.

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Introduction

In arctic and subarctic regions of North America, anthropogenic pressure from the modern settlement of communities, exploitation of mineral and hydrological resources, and the development of ecotourism ventures led to the progressive degradation of pristine environments during the 20th century. Because of its negative impacts on the fragile ecosystems of the North, some northern communities are considering ways to mitigate this rapid development. Natural revegetation following such disturbance can be very slow in this region (Harper and Kershaw, 1996; Forbes et al., 2001) and restoration efforts have been minimal due to the lack of proper restoration guidelines. According to Forbes and McKendrick (2002), ecological restoration is still in its early stages in much of the subarctic and arctic zone due to a limited understanding of fundamental ecosystem processes, although some progress has been made recently. Experiments are then essential in order to determine what measures need to be taken to restore native species in such harsh disturbed environments.

Natural revegetation at sites disturbed by anthropogenic activities in subarctic ecosystems is subject to a harsh climate that reduces primary productivity. Sub-optimal temperatures and the short duration of the growing season slow down the pedogenic processes associated with soil development in arctic ecosystems (Kershaw, 1983; Harper and Kershaw, 1997), resulting in soil with low nutrient availability (Van Cleve and Viereck, 1981). Moreover, nutrients stocked in plant biomass or in the superficial layers of the soil are often exported from the ecosystem during or shortly after the disturbance. As a consequence, low nutrient availability negatively affects the rate of biomass accumulation. In this context, fertilizer addition during restoration can overcome the negative impacts of low nutrient availability. While the addition of mineral fertilizer only increases nutrient availability, the addition of organic fertilizer can also increase ion-exchange capacity (reducing nutrient leaching) and water retention capacity (Johnson, 1987; Elmarsdottir et al., 2003). Regeneration of indigenous plant cover can also be inhibited by factors common to all regions, including the absence of viable seeds (Ebersole, 1989; Forbes and Jefferies, 1999; Prach et al., 2001) or of mycorrhizal inoculum (Greipsson and El-Mayas, 1999; Blanke et al., 2007), herbivory (Arnalds, 1987; Bradshaw, 1987), substrate instability (Walker and Del Moral, 2003), compaction (Billings, 1987), desiccation (Arnalds, 1987; Cargill and Chapin, 1987; Chapin, 1993), and low nutrient availability (Arnalds, 1987; Bradshaw, 1987; Blanke et al., 2007).

The northern village of Whapmagoostui, in subarctic Québec is a typical example of a site that has undergone numerous anthropogenic disturbances in the last 50 years (Desormeaux, 2005). Originally an outpost for the fur trade in the earlier part of the 20th century, the vegetation prior to 1950 was almost continuous and covered 306 hectares. It was dominated mainly

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