CENTRE FOR BOREAL RESEARCH
TECHNICAL NOTE #41
FOREST RECLAMATION AND BOREAL REFORESTATION - SYNTHESIS OF TECHNIQUE – FEBRUARY 2021

Effectively Introducing Native Herbaceous Species Into Newly Reclaimed Upland Sites

CONTEXT

Planting tree seedlings is one of the most effective methods for rapid establishment of a closed tree canopy cover[1]. In addition to tree canopy cover, the reestablishment of understory vegetation during boreal forest restoration will positively impact the development of a forest floor and functional soil profile[1]. However, native herbaceous species are not typically intentionally established on such sites; introduction of these species is more often through natural regeneration via seed rain or redistribution of the surface soil, though natural regeneration is neither guaranteed, nor spatially consistent. Lack of commercially available seed sources coupled with a lack of understanding on effective seeding practices means that direct seeding of native herbaceous species is a rare practice[2,3]. Also, recent trial work in the mineable oil sands showed very low emergence rates after seeding for some herbaceous species[4]. Planting of nursery grown herbaceous stock is an alternative to reliance on natural regeneration or seeding. Just as with planting of trees, planting of herbaceous species should reduce risk of failure and enhance distribution (coverage) where desired. However, this approach is challenged by the lack of research into greenhouse propagation techniques of these species[1].

This technical note illustrates the principle of companion-production (i.e. growing two species in the same container or plug, also described as 'hitchhiker planting') of a native woody species with a native herbaceous species as container stock for field out-planting in land reclamation.

STUDY DESIGN

White spruce (*Picea glauca*) was chosen due to known tolerance of a wide range of light conditions which might be expected with the growth of companion herbaceous species. Two native herbaceous species – showy aster and fireweed – were chosen as both are known to develop rapidly following disturbance, however fireweed is typically considered to be a much more aggressive pioneering species, while showy aster tends to grow slower and tolerates shade more readily. White spruce was sown in nursery containers of contrasting cavity sizes (220 mL or 340 mL volumes), followed by sowing one of the forb species at different time intervals after the initial sowing of white spruce (6, 8, 10 or 12 weeks) to produce companion stock with a range of root and shoot characteristics. Seedlings were grown at the Centre for Boreal Research greenhouse in Peace River, Alberta from March to November 2014. Seedlings were lifted and overwintered until planting the following spring. For details on companion stock production, refer to *Technical Note #28 Hitchhiker Planting in Reclamation: Protocols for Developing Nursery Stock of Woody and Herbaceous Species*.

Four sites approximately 50-60 km NE of Peace River were selected for out-planting to represent a range of potential conditions experienced when reclaiming industrial sites in the region. Twenty-one seedlings of each stock type combination were planted at each site in late May 2015. Seedling and surrounding vegetation measurements were conducted annually in August for four years (2015-2018). At each established seedling, a 0.5 x 0.5 m quadrat with the white spruce positioned in the centre was used to measure percent cover of white spruce, fireweed or showy aster, in addition to three categories of 'other' herbaceous vegetation: native forbs, non-native forbs, and graminoids. The heights of white spruce, fireweed and showy aster (when present) were recorded to the nearest cm. Growth increment of the spruce was also recorded. Destructive sampling for aboveground biomass was conducted on a subset of seedlings within each of the study sites (n=7) at the end of the second and fourth growing season (2016, 2018). A detailed investigation of belowground root development and spread of a subset of seedlings was conducted in August 2016 at two of the study sites (AS1 and OSE2). The belowground biomass was meticulously extracted from the third replicate, in a minimum of five lines. This was accomplished by tracing the root systems out from the hitchhiker plant using hand exposure with the assistance of small trowels. Maximum root length and forb suckering data was collected before the roots were placed in large plastic bags and frozen at -4˚C until further processing. Root systems were manually washed and soil sieves (1 mm mesh screen) were used to capture loose root fragments.

KEY FINDINGS

Figure 1 (above). Images from different study sites and years of measurement illustrating examples of hitchhiker stock types where white spruce and fireweed in (a) year 1 and (b) year 4 and white spruce and showy aster in (c) year 1 and (d) year 4.

KEY FINDINGS AFTER FOUR GROWING SEASONS

- Cumulative survival of white spruce and the occurrence of showy aster or fireweed were not significantly affected by the size of cavity or sow date (timing of forb introduction) into the nursery cavity.
- Total height of white spruce was most strongly affected by sow date, despite this, even the earliest sow date still resulted in plants that were 66 cm on average after four years.
- Total shoot biomass of showy aster was similar across sow dates but approximately 45% higher when grown in larger cavities (340 mL rather than 220 mL).
- Total shoot biomass of fireweed was similar across 6, 8, and 10-week sow dates, but were 50% smaller in 12 week sow date; cavity size did not significantly affect shoot biomass in fireweed.

Figure 2 (below). **Total white spruce height after four growing seasons by sow date (Number of weeks forb was introduced after spruce sown)**. Grey lines overlapping trees indicates lack of significant difference between mean heights

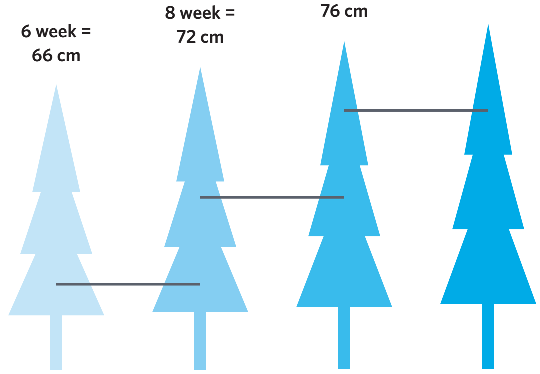

Figure 3 (below). Example of a length of excavated lateral root from fireweed hitchhiker stock.

KEY METRICS REGARDING EGRESS OF HITCHHIKED NATIVE FORBS FROM ORIGINAL PLUG AFTER TWO GROWING SEASONS

Longest lateral root observed per plant:

- Showy aster: 23-39 cm
- Fireweed: 55-144 cm

Number of new shoots arising from root plug (due to lateral root spread):

- Showy aster: 0.4-1.0 new shoots
- Fireweed: 0.3-3.7 new shoots

PRACTICAL RECOMMENDATIONS

Ultimately, the choice of stock type will depend on the restoration goal, whether it is speed of tree canopy cover or perhaps understory forb cover development. Where the goal includes faster tree cover establishment, but with the presence of native forbs, the following key recommendations apply:

1. Introduce the forb 8-10 weeks after sowing white spruce. Total height of white spruce was not significantly different amongst these sow dates, but shoot biomass of white spruce did substantially, though not significantly, benefit from the 10-week rather than 8-week sow date. The parameters of the forb trials were not substantively different between these sow dates.
2. The smaller cavity size, 220 mL, appeared to be a suitable minimum size to grow the white spruce and forb together with few limitations in survival or growth. However, larger cavities also resulted in positive outcomes and may be desirable for other reasons, particularly in situations where emphasis on maximizing initial growth rates are an important goal.

Alternatively, when the goal is to maximize native forb establishment with tree cover also developing, albeit at a reduced rate, the following recommendation is suggested:

3. Though the earliest sow dates resulted in white spruce seedlings that were very small at the time of initial planting (in some cases 10-15 cm), these small plants grew into seedlings averaging 65+ cm in height after four years. If maximizing the development of native forb cover is a key goal, then using the earliest sow date tested in this study (6 weeks) may be an alternative approach as the white spruce will persist, despite smaller overall stature, and the maximal spread and cover development of the forb will be achieved.

Lastly, site conditions play a large role in success of the out-planting of most species established from container stock. This study also illustrated this point well, as sites that exhibited limited herbaceous competition (even for just one growing season), coupled with loose surface soils through recent site decompaction, showed numerous benefits both in terms of survival, but also in growth of both hitchhiked plants.

COST IMPLICATIONS

The estimated costs of using hitchhiker seedlings was evaluated against single species planting (Table 1). Assuming that it is desired to establish 3,000 stems ha^{-1} of each species, the cost to do so with hitchhiking would be $4,120 if using 220 mL cavities, or $4,840 per ha if using 340 mL cavities. When singly establishing these species, the total cost rises to $5,400 per ha as twice as many physical plants must be grown and planted.

Table 1. Per seedling cost of producing different sizes of hitchhiker stock seedlings (white spruce + native forb) versus conventional production and planting of single species. The production cost of hitchhiker stock was determined by increasing the typical per seedling cost of these stock sizes (220 mL = $0.70 and 340 mL = $0.90) by an additional 20% to account for extra handling (sowing forb and thinning). The cost to plant used the following assumptions: planter day rate of $800 and 2,000 plants per day established with 125 mL stock versus 1,500 plants per day with 220 mL or 340 mL stock.

APPROACH	SPECIES / MIXTURE	CAVITY SIZE	COST TO GROW ($/PLANT)	COST TO PLANT ($/PLANT)
Use hitchhiker stock	white spruce + forb	220 mL	$0.84	$0.53
	white spruce + forb	340 mL	$1.08	$0.53
Establish plants singly	white spruce	125 mL	$0.50	$0.40
	forb	125 mL	$0.50	$0.40

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