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PROTECTION WITH VEXAR CYLINDERS FROM DAMAGE BY MEADOW VOLES OF TREE AND SHRUB SEEDLINGS IN NORTHEASTERN ALBERTA

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ABSTRACT: Vast areas of land will require reclamation and reforestation following oil sands development in northeastern Alberta. Greenhouse-grown tree and shrub seedlings used in reforestation may be clipped or girdled by meadow voles, especially during periods of high population density. The impact of partial girdling, the most common form of damage, varies among species. Reduced survival rates in seedlings girdled over as little as 50% of their circumference and reduced growth rates in seedlings girdled over as little as 25% of their circumference, have been noted. Plastic mesh cylinders (tradename Vexar) have proven effective in preventing seedling damage and durable in the climatic extremes occurring in northern Alberta. Growth and survival rates of all species of protected seedlings have been at least equal to unprotected seedlings and substantially greater in some. The purchase and installation cost of Vexar cylinders is approximately 25% of the cost of growing and planting a seedling.

INTRODUCTION

The Athabasca oil sands of northeastern Alberta cover an area of 30,000 km^2 and represent the world's largest single oil sands deposit. Twenty-five billion barrels of oil are recoverable from the 3,200 km^2 that are surface mineable. Two commercial scale plants, Syncrude Canada Ltd. and Suncor Ltd., have been engaged in open pit mining of oil sands for 8 and 19 years, respectively, and together currently produce 180,000 barrels of synthetic crude oil per day. Open pit mines, plant sites, and water impoundments associated with these plants presently cover approximately 75 km^2. Since areas disturbed by the present plants will continue to expand, and further oil sands development is inevitable as reserves of conventional crude oil decline, land reclamation on a vast scale will be needed.

Strategies and techniques for land reclamation are still under development. However, present plans call for soil reconstruction, seeding with grasses and legumes to create an erosion-controlling ground cover, and planting of greenhouse-grown, native, coniferous, and deciduous tree and shrub species to initiate reforestation. Low seedling survival and slow growth rates have occurred in many of the experimental and relatively small-scale reforestation projects conducted to date. The causes of poor seedling performance are not clear but may involve poor soil and stock quality, competition from grasses and legumes for moisture and nutrients, and rodent damage.

Deer mice (*Peromyscus maniculatus*) and meadow voles (*Microtus pennsylvanicus*) occur on reclamation areas. Population dynamics of meadow voles are consistent with a 3-to-5-year cycle of abundance, as noted elsewhere in microtine species (Krebs and Myers 1974). During years when meadow voles are abundant, up to 95% of some seedling species have been damaged. The damage consists of clipping of stems or removal of the bark near the ground from all or part of the circumference of the stem (girdling). Girdling disrupts the channels for nutrient flow from the leaves to the roots and by starving them, either kills the seedlings directly, or weakens them, reducing growth and making them more susceptible to other agents of stress, such as drought or disease.

Initial attempts to control rodent damage on oil sands reclamation sites included the use of sheet-metal seedling protectors and placement of brush piles on reclamation sites to encourage weasels, efficient vole predators, to take up residence. Experimental projects have been conducted to assess the feasibility of: a) reducing meadow vole abundance with rodenticides (Radvanyi 1980); b) providing preferred alternate foods during the winter (Green 1982); c) reducing vegetation cover to create an unfavourable vole habitat (Green 1982); and d) applying repellents to seedlings (Green 1982). Most of these have proven either ineffective, impractical, or undesirable. Methods of habitat manipulation to create unfavourable vole habitat are still under investigation. This report will present studies conducted to assess both the adverse impact of rodent damage on seedlings and the feasibility of seedling protection with plastic mesh cylinders.

SURVIVAL AND GROWTH OF TREE AND SHRUB SEEDLINGS WITH SIMULATED RODENT DAMAGE

The extent of rodent damage has varied greatly, both in the proportion of the seedling crop damaged, and the severity of damage to individual seedlings. Partially girdled seedlings usually survive, at least in the short term. Even completely girdled seedlings may survive, dying back to the point of injury and sending out new shoots from below that point. We have been conducting studies to assess the impact of rodent damage on seedling performance in order to facilitate the identification of a cost-effective level of expenditure on damage reduction.

Methods

Saskatoon (*Amelanchier alnifolia*), white spruce (*Picea glauca*), jack pine (*Pinus banksia*), and aspen (*Populus tremuloides*) seedlings were planted in a vole-proof exclosure in spring 1982. Simulated rodent damage was inflicted on seedlings in fall of the year they were planted. Only seedlings in apparently good condition were used. Damage consisted of removal of the bark with a sharp knife from the stem

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approximately 2 cm above the ground over a vertical distance of 1 to 2 cm. Four degrees of girdling were simulated: 0% (control), 25%, 50%, 75% of the circumference of the stem. Buffaloberry (*Shepherida canadensis*), alder (*Alnus crispa*), and dogwood (*Cornus stolonifera*) were added to the study during 1983.

Results and Discussion

Dieback of the stem to the point of injury, and new growth from below that point was common in saskaton, dogwood, and alder with 25% or more girdling, in aspen with 50% or more girdling, in white spruce with 75% or more girdling, and in all alder seedlings, whether injured or not. Dieback resulted in apparent negative growth in some species/treatment categories.

The effect of damage on seedling performance varies greatly among species, with reduced survival up to fall 1985 noted in damaged saskatoon, jack pine, and white spruce (Table 1) and reduced total growth to fall 1985 among white spruce, dogwood, and buffaloberry (Table 2). No significant effect of damage was observed on either growth or survival of aspen and alder, possibly due to the small sample size used in this study. The minimum amount of girdling at which significantly reduced growth or survival occurs is 25% in dogwood, 50% in jack pine, and 75% in saskatoon, white spruce, and buffaloberry. In several species/treatment categories, significant differences in growth noted at the end of the first growing season following damage disappeared after the second growing season. In most, but not all, species/treatment categories, most mortality of seedlings occurred during the first growing season following damage.

Table 1. Percent survival rate of damaged tree and shrub seedlings.

Species	n	No. growing seasons	Treatment: Control	0.25	0.50	0.75
Saskatoon	19	3	100	84	95	53*
Aspen	21	3	95	81	90	90
Jack pine	21	3	100	100	75*	76*
White spruce	21	3	100	95	95	71*
Dogwood	27	2	100	96	100	93
Alder	26	2	96	88	88	88
Buffaloberry	25	2	96	88	96	80

*denotes significant (P<0.05) difference from control.

Table 2. Growth (cm) of damaged tree and shrub seedlings.

Species	n	No. growing seasons	Treatment: Control	0.25	0.50	0.75
Saskatoon	10-19	3	15.9	12.0	13.3	11.7
Aspen	17-20	3	21.1	22.8	18.3	9.9
Jack pine	15-21	3	41.0	44.4	44.6	44.5
White spruce	15-21	3	12.5	12.1	11.0	3.2*
Dogwood	25-27	2	6.3	-0.5*	-2.8*	-7.0*
Alder	23-25	2	-5.6	-11.1*	-11.2	-11.1
Buffaloberry	25	2	12.4	8.4	7.2	2.7*

*denotes significant (P<0.05) difference from control.

The results of this study are, for the most part, consistent with the observations of Jokela and Lorenz (1959) that the effects of partial girdling varied greatly among the various hardwood and coniferous species examined. Mortality was limited to trees girdled over 75% or more of their circumference. Growth reduction in surviving trees varied with the extent of injury in some species, was greatest during the first year after injury, and was evident as long as 10 years after injury in some species.

SEEDLING PROTECTION WITH PLASTIC MESH CYLINDERS

During the early 1970s, Dupont developed a plastic mesh cylinder (tradename Vexar) to protect seedlings. These were effective in protecting conifer seedlings from ungulates, hares (Campbell 1969, Campbell and Evans 1979), and pocket gophers (Anthony et al. 1978). Their effectiveness in preventing damage by microtine rodents has not been previously demonstrated.

Given the site conditions and reforestation methods used on oil sands reclamation sites, inserting the seedling with root plug into the Vexar cylinder and then planting the Vexar/seedling package appears the preferred method of installing Vexar cylinders. Studies conducted at several locations in California, Washington, and Idaho, and using this method of installation have identified several potential weather-related problems, including breakage of the cylinders at low temperatures, accordion-like compression by snow, and frost heave which may dislodge cylinders and root plugs from the ground (Anthony et al. 1978, Ellis 1972). Since long winters with temperatures as low as -40°C are typical in northeastern Alberta, we had some concern regarding the durability of Vexar cylinders. Also of concern were possible adverse effects of Vexar cylinders on seedling performance from deformation of terminal shoots growing through the Vexar mesh (Anthony et al. 1978), constriction of roots encased in the Vexar cylinder (Ellis 1972), and shading.

We began studies in 1982 with Vexar cylinders to determine their durability and their effects on seedling performance, effectiveness in preventing meadow vole damage, and installation cost.

Methods

Vexar-protected and control seedlings of four species: white spruce, jack pine, saskatoon, and caragana (*Caragana arborescens*) were planted in spring 1982 on an east-facing slope which had been seeded with perennial grasses and forbs 4 years earlier. Approximately 200 control and 160 Vexar-protected seedlings of each species were planted.

Vexar cylinders consisted of photodegradable, semirigid, polypropylene mesh tubes (diamond pattern, 18 x 18-strand count, 1-mm strand diameter, 1.75 x 0.85 cm-mesh size). Sufficient ultraviolet inhibitor was incorporated in the polypropylene to provide an approximate lifetime of 10 years.

Eight Vexar cylinder configurations were used, involving two lengths (30 and 45 cm), two diameters (4.4 and 5.1 cm) and two depths of burial of the base (11 and 5.5 cm). The two depths correspond to the burial of the Vexar base to the entire length and one-half the length of the seedling root plug.

Prior to planting, seedlings were inserted into the cylinder so that the root plug was encased within the cylinder either to its entire length or one-half its length. A moistened peat moss/vermiculite mixture was worked through the cylinder mesh by hand to fill the space between the root plug and cylinder wall.

Seedlings were organized in five subplots, each measuring 4 x 72 m, with seedlings spaced 1 m apart. Plots were parallel to and at different elevations on the slope. Within each subplot species and treatments were randomly assigned to planting locations. Each seedling was planted on a scarified plot 8 to 12 inches in diameter.

The time required to prepare Vexar/seedling packages was assessed in a separate experiment. Three seedling species: saskatoon, jack pine, and dogwood (*Cornus stolonifera*) were used. Vexar cylinders, 46 cm in length, and of two diameters, 4.4 cm and 5.1 cm, were used. Seedlings were inserted into the Vexar cylinders root plug first. Root plugs fitted snugly into the smaller diameter cylinders. The ends of the Vexar cylinders were flared out slightly before insertion of seedlings by bending them outwards with the fingers so that roots projecting from the root plugs would not get entangled in the cut ends of the Vexar cylinders and complicate insertion. Dogwood and jack pine seedlings either dropped to the bottom of the Vexar cylinders or were pushed or tapped down. Saskatoon seedlings had twisted stems and were slightly more difficult to insert. A peat/vermiculite mixture was worked by hand through the Vexar mesh to fill the space between the root plug and cylinder wall.

Within each seedling species, 50 seedlings were packaged to practice the technique. The time required to package the next 50 of each species was recorded. Packaging time included flaring out of Vexar cylinders, insertion of seedlings, packing with peat, and placement into boxes for transport to the field.

Abundance of meadow voles was assessed using 60 livetraps, 2 at each of 30 locations 20 m apart in a grid pattern over the area of the Vexar study plot. The number of individual voles captured during 5 consecutive days in fall and midsummer was used as an index of over-winter and summer vole abundance, respectively.

Assessments of rodent damage were conducted during May and September of each year. Assessments of growth were conducted during September of each year.

Statistical analysis was conducted using software developed by SAS Institute, Inc. (Box 8000, Cary, North Carolina 27511). Differences in survival rate were tested for significance ($P<0.05$) using a form of chi-square test (PROC FUNCAT, SAS). Differences in growth were tested for significance ($P<0.05$) using a procedure for unbalanced analysis of variance (PROC GLM, SAS). A randomized block design and blocking according to plots was used. For tests among Vexar configurations a randomized block, factorial design was used with two levels in each of the three factors: length, diameter, and depth of burial. For tests involving growth, initial seedling height was introduced as a covariable.

Results

The number of meadow voles trapped on the 1.2-hectare area containing the Vexar study plots has varied from 1 to 43 or from 0.8 to 35.8 per hectare. From 0.6% to 40.1% of the unprotected saskatoon seedlings have been damaged during the period preceeding each biennial damage assessment. The extent of damage is loosely correlated ($P = 0.10$) with meadow vole abundance (Figure 1). Damage to individual unprotected seedlings has varied from girdling of 10% or less of the circumference of the stem or clipping of a single stem to clipping of the entire seedling. From 0.0 to 3.4% of the Vexar-protected seedlings have sustained some form of damage during the period preceeding each biennial damage assessment. Damage to Vexar-protected seedlings consisted either of clipping of lateral branches projecting through the Vexar mesh or clipping of stems projecting from the top of the Vexar cylinder. There were no instances of rodent damage to the Vexar cylinders. Among the remaining seedling species there was little or no rodent damage to either the Vexar-protected or control seedlings.

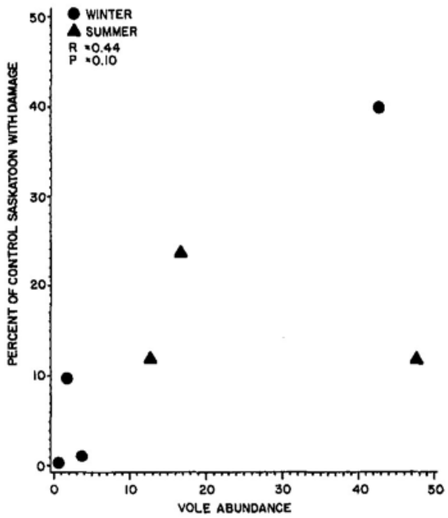


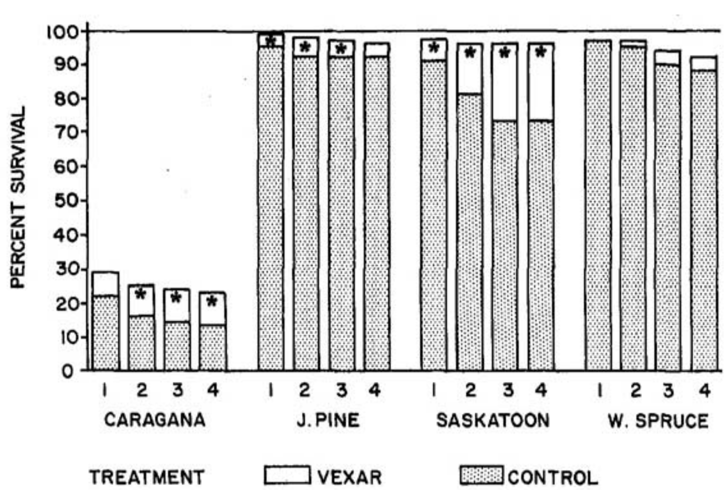
Figure 1. Seedling damage in relation to vole abundance.

Of the 636 Vexar cylinders installed in spring 1982, 1.3% were out of the ground, perhaps due to frost heave, and an additional 0.5% were disintegrating by fall 1985.

Survival rate of seedlings from spring 1982 to fall 1985 was not related to Vexar configuration (i.e., length, diameter, depth of burial). Only among saskatoon seedlings was an effect of Vexar configuration on growth noted. Seedlings in the longer Vexar cylinders had a slightly but significantly greater rate of growth. Seedlings with all Vexar configurations are pooled in one category for comparison with unprotected seedlings with respect to survival and growth.

The overall postplanting survival of caragana seedlings was poor with 29% survival among Vexar-protected and 22% survival among control seedlings for the first growing season (Figure 2). These seedlings were dormant when planted making assessment of seedling condition impossible. It appears likely that many of these seedlings were dead or in very poor condition when planted. The 23% survival rate to fall 1985 among Vexar-protected seedlings is significantly greater than the 13% survival rate among control seedlings. Growth did not differ significantly between Vexar-protected and control seedlings (Figure 3).

Figure 2. Seedling survival during the first 4 years after planting. Asterisks mark significant differences between control and Vexar-protected seedlings.



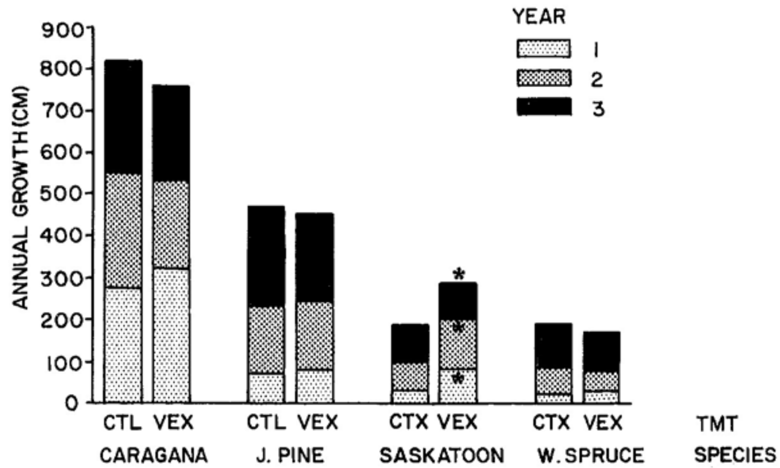


Figure 3. Annual and total growth of seedlings during the first 3 years. Asterisks mark significant differences between control and Vexar-protected seedlings.

Among unprotected saskatoon seedlings, there was an annual mortality rate during the first 3 years of 9 to 10% as compared to 0 to 3% among Vexar-protected seedlings (Figure 3). Both survival and growth from spring 1982 to fall 1985 were significantly greater among Vexar-protected (96%, 23.5 cm) than among control (73%, 18.5 cm) seedlings.

Among jack pine seedlings survival was slightly but significantly greater among Vexar-protected (97%) than among control (92%) seedlings (Figure 2). No significant difference was noted in growth (Figure 3).

Among white spruce seedlings, neither survival nor growth rate differed significantly between Vexar-protected and control seedlings (Figures 2 and 3).

Growth of terminal shoots through the Vexar mesh occurred in 31.9% of white spruce seedlings by fall 1985 and in a small percentage of seedlings of the other species. What, if any, impact this will have on future performance of the seedling, is not clear.

The time required to prepare Vexar/seedling packages was 0.64 and 0.76 minutes per seedling for saskatoon and dogwood, respectively, in 4.5-cm-diameter cylinders, and 1.17 minutes per seedling for jack pine in 5.1-cm-diameter cylinders. More time was required using the larger diameter cylinders in order to fill the greater space between root plug and seedling with the peat/vermiculite mixture. For all species, this was the most time-consuming component of the packaging process.

Discussion

Since over 98% of Vexar cylinders are intact and in place as installed approximately 3.5 years after installation there appears to be little reason to doubt their durability. However, tree growth in northern latitudes is slow and substantial vole damage to 2-inch-diameter hybrid poplar in the vicinity of the Vexar study plots has been noted. This suggests that it may be too early to draw conclusions regarding the durability of the Vexar cylinders relative to the span of time over which seedlings will benefit from protection.

Vexar cylinders have proven effective in preventing meadow vole damage to seedlings. In the few instances where Vexar protected-seedlings have been damaged, the damage has been minor relative to that of unprotected seedlings.

Vexar cylinders have not impaired seedling performance to date. Indeed, survival and growth has been greater in Vexar-protected than in control seedlings of some species. The improvement was most marked in saskatoon, the species most susceptible to rodent damage. Reduced rodent damage among protected saskatoon seedlings is likely to have been a factor in their increased growth and survival. The occurrence of improved performance in the remaining species, which did not sustain rodent damage, indicates that other factors were involved. Greater height growth of Vexar-protected seedlings has been noted elsewhere (Borrecco 1976, Anthony et al. 1978). It has been suggested that Vexar cylinders provide a beneficial shading effect and result in reduced stem movement from wind (Borrecco 1976) which inhibits height growth (Neel and Harris 1970).

The material and transportation costs of Vexar cylinders depend on volume purchased but are likely to total less than 10¢ per seedling. At a labour rate of $ll/per hour and a packaging time of 0.75 min/seedling, packaging cost is approximately 14¢ per seedling. Assuming the cost of planting Vexar/seedling packages is similar to the cost of planting unprotected seedlings, total estimated cost of seedling protection with Vexar cylinders is 24¢. This cost will be substantially reduced if filling the space between root plug and cylinder wall proves unnecessary. Since the cost of growing and planting a seedling in the Fort McMurray area has historically been approximately $1.00, Vexar cylinders appear to be a cost-effective way of protecting seedlings of tree and shrub species susceptible to damage by meadow voles.

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