

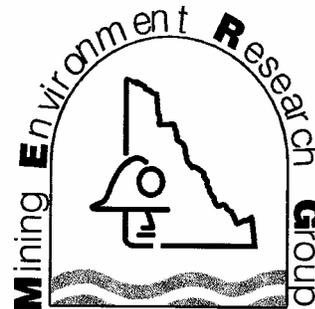
MERG Report 2002-1

**Experimental Reclamation Project**  
**Shrub Trial Plots - Brewery Creek Mine**

**By Stu Withers**

March 2002

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# **Experimental Reclamation Project**

## **Shrub Trial Plots – Brewery Creek Mine**

### ***Non-technical Summary***

In the September 2000, eleven shrub species were planted in experimental plots at three different areas of the Brewery Creek Gold Mine near the Klondike River. All of these shrub species naturally grow in the mine area. The purpose of this project is to find out which of these shrub species may be useful for revegetating the large open areas at the mine site, after the mine closes. It is anticipated that this information will also be useful when revegetating other mine sites in the Yukon.

The three sites chosen for these experiments are a steep north-facing slope, a steep south-facing slope, and a lower, nearly level area. The shrubs were planted in six plots at each of the three sites. All three areas had been graded and seeded in 1996-97, and there was a fairly thick growth of grasses and clovers at the time the shrubs were planted. To determine if this thick growth interfered with the survival of the newly planted shrubs, the grass and clover was first removed from one half of each plot.

The shrubs used in these experiments were transplanted from the nearby forest. Willow stem cuttings were also planted, and at one site, aspen root cuttings were tried. At all three sites, black spruce seeds were planted.

In July 2001, these test plots were checked to see which shrub species were still growing. At each plot, the number of surviving shrubs was counted. It was found that most of the shrub transplants were growing well, but many of the willow stem cuttings had not survived. The black spruce grown from seeds were not seen until another visit to the site in late August. The largest concentration of black spruce seedlings were found on the north-facing slope. Black spruce are well suited to north slopes and other cold areas.

It was also found that several shrub species were growing better on areas where the grass and clover had first been removed.

In order to get a better idea which of these shrub species are suitable for revegetating mine sites, these test plots should be checked again in future years.

# Acknowledgements

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Larry Connell, Mike Samuels, Steve Johnson, Strider Lacosse and John Waters of Viceroy Minerals Corporation provided logistical support and field assistance at the Brewery Creek Mine.

Don White of DIAND Forest Resources supplied the black spruce seeds.

Bonnie Burns of Laberge Environmental Services participated in the field surveys, the establishment of the trial plots, and the follow-up monitoring surveys.

Tony Hill, Catherine Kennedy and Chuck Hubert of the Yukon Department of Renewable Resources critically reviewed the draft report.

The project was administered by Karen Pelletier and Paula Sauve of Mining Land Use, DIAND, and by Lori Walton of the Yukon Department of Economic Development.

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## 1.0 Background

The reclamation of large open disturbed areas often requires assisted revegetation efforts for the expedient recovery of these surfaces to their natural state. Large open areas are usually too far from local seed sources for natural revegetation to quickly occur. An initial vegetative ground cover can readily be established through the seeding of agronomic and native varieties of grasses and legumes. Later successional stages can be encouraged through the establishment of shrub stands at strategic locations on these large disturbed surfaces.

Information on the reclamation capabilities of shrub species that are commonly found in the Yukon has largely been taken from the results of field trials in other northern regions (primarily Alaska and northern Alberta). In order to fully appreciate the potential of shrub species for revegetating mine sites in local environments, there is a requirement for field testing of these species at Yukon mine sites.

Viceroy Minerals Corporation has been implementing a multi-year reclamation program at the Brewery Creek Mine near the Klondike River (Figure 1) since the commencement of mine development in 1994. Waste rock dumps and backfilled pits have been recontoured and revegetated using a variety of seed and fertilizer mixes, including specially formulated northern native seed mixes. In addition, limited experimentation with the establishment of shrubs on the reclaimed surfaces has been carried out. In the spring of 1998, willow cuttings were collected from the Dawson City area and planted in trial plots in the reclaimed Canadian Zone waste rock storage area by students from the Robert Service School. Viceroy Minerals Corporation has monitored these plots on a regular basis.

In this project, funded jointly by the Mining Environment Research Group and Viceroy Minerals Corporation, shrub propagation experimental plots were established at the Brewery Creek Mine in the fall of 2000 with the objective of determining the reclamation potential of locally occurring species.

## **2.0 Methods**

The 2000 and 2001 field seasons included the completion of the following work at the Brewery Creek Mine:

### **2.1 Site Selection and Baseline Data Collection**

A preliminary survey of the Brewery Creek Mine in July 2000 resulted in the selection of three sites for shrub propagation trials (Figure 2). Sites were selected to represent a range of ecological variables (elevation, slope and aspect). All three sites had already been seeded with a cover of grasses and legumes.

At each site, baseline data was collected, including topographical information (elevation, slope and aspect), soil physical properties (texture, drainage and compaction), soil pH and existing vegetation (see photographs – Appendix A).

Soil samples were not collected for nutrient analysis during the current survey, although a 1996 analysis of plant-available nutrients in the Canadian Zone waste dump showed nitrate and sulfate levels to be low while phosphorous and potassium levels were moderate.

An inventory was also taken of the shrub species colonizing disturbed areas near each site. This information on voluntary revegetation was used for selecting species for propagation trials.

### **2.2 Establishment of Trial Plots**

Test plots were established at the three sites in mid-September 2000, at the onset of seasonal dormancy (leaves had turned colour but had not yet fallen). At each location, six two-metre X three-metre plots were situated abutting each other in a line perpendicular to the slope.

Existing vegetation was removed from one half of each plot but was retained on the other half. Shrubs (transplants, stem cuttings and root cuttings) were collected from nearby disturbed areas and planted in the test plots, with the number of specimens

placed in each half of each plot recorded (see photographs – Appendix A). Rooting hormone (beta-indolyl-butyric acid) was applied to the semi-hardwood (previous season's growth only) willow stem cuttings and aspen root cuttings. A small amount of soil was transported with each transplant to the test plots in order to transfer mycorrhizal fungi. Black spruce seeds, provided by Forest Resources (DIAND), were sown in one plot at each test site. Bone meal (2% total nitrogen, 14% phosphoric acid and 27% calcium) was applied to all plots at test site LP-1. No other fertilizer was used.

Comparison plots were also established in undisturbed, forested areas nearby each test site. Five-metre X five-metre plots were situated in areas representing natural, pre-disturbance conditions. At each comparison plot, the percent cover for each species in the tree, shrub and ground cover layers was estimated and recorded.

## **2.3 Follow-up Monitoring**

The shrub propagation trials plots were monitored in early July 2001. At each plot, the number of surviving plant species were recorded. The plots were revisited in late August 2001. Photographs of plots were taken during both 2001 site visits (see Appendix A).

## **3.0 2000 Shrub Propagation Trials**

Following is a summary of the site conditions, reclamation history and existing vegetation at each of the three test sites, along with a description of the test plots and the shrub species used for propagation trials:

### **Site C-1 (Canadian Zone)**

|                              |  |
|------------------------------|--|
| <b>UTM Coordinates:</b>      | 0634817 W 7105637 N  |
| <b>Elevation:</b>            | 828 m  |
| <b>Slope:</b>                | 30 <sup>0</sup>  |
| <b>Aspect:</b>               | northwest  |
| <b>Soil Characteristics:</b> | well-drained (moist at time of planting because of recent rains), angular bedrock fragments with clay (largest particle 40 cm), pH 7.0 |

#### **Reclamation History:**

This area was recontoured, seeded and fertilized on October 8, 1997 with 75 kg/ha Brewery Creek seed mix and 300 kg/ha fertilizer (28-28-0). Seed and fertilizer were dispersed by a bulk mixer truck.

Brewery Creek seed mix included: 17% Fowl Bluegrass  
16% Dalhurian Wild Rye  
16% Sheep Fescue  
16% Nugget Kentucky Bluegrass  
12% Creeping Red Fescue  
10% Climax Timothy  
8% Noducoat Alsike Clover  
5% Rangeland Alfalfa

**Current Vegetation: In area of trial plot (seeded area)**

|            |   |
|------------|---|
| shrubs     | <i>Populus tremuloides</i>  |
| forbs      | <i>Achillea millefolium</i><br><i>Chenopodium album</i><br><i>Medicago sativa</i><br><i>Plantago major</i><br><i>Trifolium hybridum</i> |
| graminoids | <i>Elymus trachycaulus</i> ssp. <i>subsecundus</i><br><i>Festuca ovina</i><br><i>Phleum pratense</i><br><i>Poa palustris</i>            |

Total vegetation cover: 30 %

**Colonizing lower slopes near edge of clearing**

|            |   |
|------------|---|
| shrubs     | <i>Betula neoalaskana</i><br><i>Ledum groenlandicum</i><br><i>Picea mariana</i><br><i>Populus tremuloides</i><br><i>Rosa acicularis</i><br><i>Rubus idaeus</i><br><i>Salix alaxensis</i><br><i>Salix bebbiana</i><br><i>Salix glauca</i><br><i>Shepherdia canadensis</i><br><i>Spiraea beauverdiana</i> |
| forbs      | <i>Cornus canadensis</i>  |
| graminoids | <i>Calamagrostis canadensis</i><br><i>Luzula parviflora</i>   |

**Shrub species used in reclamation trials:**

**Plot A** Alaska birch (*Betula neoalaskana*) transplants  
15 in cleared area and 18 in vegetated area

- Plot B**      Bebb's willow (*Salix bebbiana*) stem cuttings  
10 in cleared area and 10 in vegetated area
- Plot C**      prickly rose (*Rosa acicularis*) transplants  
13 in cleared area and 12 in vegetated area
- Plot D**      black spruce (*Picea mariana*) seedling transplants  
11 in cleared area and 11 in vegetated area
- Plot E**      Beauverd's spiraea (*Spiraea beauverdiana*) transplants  
8 in cleared area and 6 in vegetated area
- Plot F**      black spruce (*Picea mariana*) seeds  
approximately 4 grams spread on each half of plot

| Plot A       | Plot B        | Plot C       | Plot D               | Plot E             | Plot F       |
|--------------|---------------|--------------|----------------------|--------------------|--------------|
| Alaska birch | Bebb's willow | Prickly rose | Black spruce         | Beauverd's spiraea | Black spruce |
| Transplants  | Stem cuttings | Transplants  | Seedling transplants | Transplants        | Seeds        |

**Comparison plot in undisturbed, forested area:**

|              |                              |      |
|--------------|------------------------------|------|
| trees        | <i>Picea mariana</i>         | 40%  |
|              | <i>Betula neoalaskana</i>    | 2%   |
| shrubs       | <i>Vaccinium vitis-idaea</i> | 40%  |
|              | <i>Betula glandulosa</i>     | < 1% |
|              | <i>Rosa acicularis</i>       | < 1% |
|              | <i>Spiraea beauverdiana</i>  | < 1% |
|              | <i>Ledum groenlandicum</i>   | < 1% |
| ground cover | <i>Pleurozium shreberi</i>   | 70%  |
|              | <i>Nephroma arcticum</i>     | 7%   |
|              | <i>Cladonia</i> sp.          | 5%   |
|              | <i>Cladonia</i> sp.          | 5%   |

**Site C-2 (Canadian Zone)**

**UTM Coordinates:**      **0634918 W    7105576 N**  
**Elevation:**              805 m  
**Slope:**                    35<sup>o</sup>  
**Aspect:**                    south

**Soil Characteristics:** well drained (moist at time of planting because of recent rains), fractured bedrock with clay, pH 6.5 on upper part with sparse growth and 7.0 on lower part with more dense growth

**Reclamation History:**

This area was recontoured, seeded and fertilized on October 8, 1997 with 75 kg/ha Brewery Creek seed mix and 300 kg/ha fertilizer (28-28-0). Seed and fertilizer were dispersed by a bulk mixer truck.

Brewery Creek seed mix included:

- 17% Fowl Bluegrass
- 16% Dalhurian Wild Rye
- 16% Sheep Fescue
- 16% Nugget Kentucky Bluegrass
- 12% Creeping Red Fescue
- 10% Climax Timothy
- 8% Noducoat Alsike Clover
- 5% Rangeland Alfalfa

**Current Vegetation: In area of trial plot (seeded area)**

|            |   |
|------------|---|
| shrubs     | <i>Salix alaxensis</i>  |
| forbs      | <i>Crepis tectorum</i><br><i>Medicago sativa</i><br><i>Trifolium hybridum</i>   |
| graminoids | <i>Bromus inermis</i><br><i>Elymus trachycaulis</i> ssp. <i>subsecundus</i><br><i>Festuca rubra</i><br><i>Festuca ovina</i><br><i>Hordeum jubatum</i><br><i>Phleum pratense</i><br><i>Poa palustris</i><br><i>Poa pratensis</i> |

Total vegetation cover: 60 % in area of dense growth  
10 % in area of sparse growth

**Shrub species used in reclamation trials:**

|               |   |
|---------------|---|
| <b>Plot A</b> | black currant ( <i>Ribes hudsonianum</i> ) transplants<br>9 in cleared area and 6 in vegetated area |
| <b>Plot B</b> | black spruce ( <i>Picea mariana</i> ) seeds<br>approximately 4 grams spread on each half of plot    |
| <b>Plot C</b> | raspberry ( <i>Rubus idaeus</i> ) transplants<br>8 in cleared area and 7 in vegetated area          |

- Plot D** Alaska birch (*Betula neoalaskana*) transplants  
10 in cleared area and 7 in vegetated area
- Plot E** trembling aspen (*Populus tremuloides*) transplants  
10 in cleared area and 8 in vegetated area
- Plot F** little-tree willow (*Salix arbusculoides*) and blue-green willow (*Salix glauca*) stem cuttings  
10 in cleared area and 10 in vegetated area

| Plot A        | Plot B       | Plot C      | Plot D       | Plot E          | Plot F                                   |
|---------------|--------------|-------------|--------------|-----------------|--|
| Black currant | Black spruce | Raspberry   | Alaska birch | Trembling aspen | Little-tree willow and Blue-green willow |
| Transplants   | Seeds        | Transplants | Transplants  | Transplants     | Stem cuttings                            |

**Comparison plot in undisturbed, forested area:**

|              |                              |      |
|--------------|------------------------------|------|
| trees        | <i>Picea mariana</i>         | 25%  |
|              | <i>Betula neoalaskana</i>    | 7%   |
|              | <i>Populus tremuloides</i>   | < 1% |
| shrubs       | <i>Vaccinium vitis-idaea</i> | 40%  |
| ground cover | <i>Geocaulon lividum</i>     | 3%   |
|              | <i>Pleurozium schreberi</i>  | 10%  |
|              | <i>Polytrichum</i> sp.       | 3%   |
|              | <i>Cladina</i> sp.           | 1%   |
|              | <i>Peltigera</i> sp.         | 1%   |

**Site LP-1 (below Leach Pad)**

**UTM Coordinates:** 0632322 W 7104167 N  
**Elevation:** 769 m  
**Slope:** 8°  
**Aspect:** northwest  
**Soil Characteristics:** moderately drained (moist at time of planting because of recent rains), fractured bedrock with clay, pH 6.5

**Reclamation History:**

This area was recontoured, seeded and fertilized on October 7, 1996 with 80 kg/ha Klondike Valley seed mix and 300 kg/ha fertilizer (18-18-18). Seed and fertilizer were dispersed by an ATV-mounted broadcaster.

Klondike Valley seed mix included: 25% Creeping Red Fescue  
25% Common Bromegrass  
15% Common Kentucky Bluegrass  
10% Meadow Foxtail  
10% Engmo Timothy  
10% Alsike Clover  
5% Red Top Bent Grass

**Current Vegetation: In area of trial plot (seeded area)**

shrubs      *Populus tremuloides*  
                 *Salix arbusculoides*  
                 *Salix glauca*

forbs        *Epilobium angustifolium*  
                 *Equisetum arvense*  
                 *Trifolium hybridum*

graminoids   *Agrostis gigantea*  
                 *Bromis inermis*  
                 *Festuca rubra*  
                 *Phleum pratense*

Total vegetation cover: 60%

**Shrub species used in reclamation trials:**

**Plot A**        trembling aspen (*Populus tremuloides*) root cuttings  
11 in cleared area and 11 in vegetated area

**Plot B**        blue-green willow (*Salix glauca*) stem cuttings  
10 in cleared area and 10 in vegetated area

**Plot C**        prickly rose (*Rosa accularis*) transplants  
10 in cleared area and 11 in vegetated area

**Plot D**        Bebb's willow (*Salix bebbiana*) and little-tree willow (*Salix arbusculoides*) stem cuttings  
8 in cleared area and 9 in vegetated area

**Plot E**        dwarf birch (*Betula glandulosa*) transplants  
7 in cleared area and 8 in vegetated area

**Plot F**        black spruce (*Picea mariana*) seeds  
approximately 4 grams spread on each half of plot

|                 |                   |              |                                      |             |              |
|-----------------|-------------------|--------------|--------------------------------------|-------------|--------------|
| Plot A          | Plot B            | Plot C       | Plot D                               | Plot E      | Plot F       |
| Trembling aspen | Blue-green willow | Prickly rose | Bebb's willow and Little-tree willow | Dwarf birch | Black spruce |
| Root cuttings   | Stem cuttings     | Transplants  | Stem cuttings                        | Transplants | Seeds        |

**Comparison plot in undisturbed, forested area:**

|              |                                 |      |
|--------------|---------------------------------|------|
| trees        | <i>Picea mariana</i>            | 15%  |
| shrubs       | <i>Vaccinium vitis-idaea</i>    | 15%  |
|              | <i>Salix glauca</i>             | 4%   |
|              | <i>Ledum groenlandicum</i>      | 3%   |
|              | <i>Betula glandulosa</i>        | 2%   |
|              | <i>Vaccinium uliginosum</i>     | < 1% |
| ground cover | <i>Pleurozium schreberi</i>     | 30%  |
|              | <i>Carex</i> sp.                | 5%   |
|              | <i>Nephroma arcticum</i>        | 3%   |
|              | <i>Equisetum</i> sp.            | 2%   |
|              | <i>Calamagrostis canadensis</i> | < 1% |
|              | <i>Petasites</i> sp.            | < 1% |

## 4.0 2001 Results and Analysis

The preliminary assessment of the potential of these shrub species for mine reclamation is based on the findings of two follow-up site visits during the summer of 2001.

### 4.1 2001 Monitoring Results

The results of the monitoring survey on July 3, 2001 are as follows:

### **Site C-1 (Canadian Zone)**

| Plot     | Species                        | Cleared Area   |                  |            | Vegetated Area |                  |            |
|----------|--------------------------------|----------------|------------------|------------|----------------|------------------|------------|
|          |                                | Number Planted | Number Surviving | Survival % | Number Planted | Number Surviving | Survival % |
| <b>A</b> | Alaska birch Transplants       | 15             | 15               | 100        | 18             | 16               | 89         |
| <b>B</b> | Bebb's willow Stem cuttings    | 10             | 0                | 0          | 10             | 0                | 0          |
| <b>C</b> | Prickly rose Transplants       | 13             | 13               | 100        | 12             | 9                | 75         |
| <b>D</b> | Black spruce Transplants       | 11             | 11               | 100        | 11             | 11               | 100        |
| <b>E</b> | Beauverd's spiraea Transplants | 8              | 8                | 100        | 6              | 6                | 100        |
| <b>F</b> | Black spruce Seeds             | 4 grams        | —                | —          | 4 grams        | —                | —          |

### **Site C-2 (Canadian Zone)**

| Plot     | Species                                      | Cleared Area   |                  |            | Vegetated Area |                  |            |
|----------|--|----------------|------------------|------------|----------------|------------------|------------|
|          |  | Number Planted | Number Surviving | Survival % | Number Planted | Number Surviving | Survival % |
| <b>A</b> | Black currant Transplants                    | 9              | 8                | 89         | 6              | 5                | 83         |
| <b>B</b> | Black spruce Seeds                           | 4 grams        | —                | —          | 4 grams        | —                | —          |
| <b>C</b> | Raspberry Transplants                        | 8              | 8                | 100        | 7              | 7                | 100        |
| <b>D</b> | Alaska birch Transplants                     | 10             | 10               | 100        | 7              | 5                | 71         |
| <b>E</b> | Trembling aspen Transplants                  | 10             | 10               | 100        | 8              | 6                | 75         |
| <b>F</b> | Little-tree & Bluegreen willow Stem cuttings | 10             | 0                | 0          | 10             | 1                | 10         |

## Site LP-1 (below Leach Pad)

| Plot | Species                                      | Cleared Area   |                  |            | Vegetated Area |                  |            |
|------|--|----------------|------------------|------------|----------------|------------------|------------|
|      |  | Number Planted | Number Surviving | Survival % | Number Planted | Number Surviving | Survival % |
| A    | Trembling aspen<br>Root cuttings             | 11             | 5                | 45         | 11             | 1                | 9          |
| B    | Blue-green willow<br>Stem cuttings           | 10             | 0                | 0          | 10             | 0                | 0          |
| C    | Prickly rose<br>Transplants                  | 10             | 8                | 80         | 11             | 3                | 27         |
| D    | Bebb's & Little-tree willow<br>Stem cuttings | 8              | 0                | 0          | 9              | 0                | 0          |
| E    | Dwarf birch transplants                      | 7              | 5                | 71         | 8              | 3                | 38         |
| F    | Black spruce Seeds                           | 4 grams        | —                | —          | 4 grams        | —                | —          |

The most significant observation during the follow-up survey in August, 2001, was the propagation of black spruce seeds. While no seedlings had been evident during the early July survey, a large number had emerged by August 21 at Site C-1, the north-facing site in the Canadian Zone. Most of these were noted in the cleared portion of the plot, although some were also evident in the vegetated area (see photographs – Appendix A). A few black spruce seedlings were also noted in the cleared portion of Site C-2, the south-facing site in the Canadian Zone. No black spruce seedlings were observed at Site LP-1, the near level site below the leach pad.

## **4.2 Preliminary Analysis**

Most of the transplanted shrub species had a high survival rate, particularly on the two well-drained sites at the Canadian Zone. Alaska birch, rose, Beauverd's spiraea, raspberry, black spruce and trembling aspen all had 100% survival rates on well-drained sites where the existing vegetation was cleared.

The fairly dense cover of vegetation (mostly seeded grasses and legumes) that occurred at the three sites at the time that the trial plots were established appears to have impaired the survival of several shrub species. The survival of trembling aspen, rose, Alaska birch and dwarf birch was higher in the portion of the plots that were cleared of existing vegetation prior to shrub transplanting. This may mean that grass and legume species have been seeded too densely to allow the growth of these shrub species. Beauverd's spiraea, raspberry, black currant and black spruce, on the other hand, survived equally well on the vegetated and cleared portions of the plots.

Trembling aspen root cuttings did not do as well on the vegetated half of the plot (9% survival) as they did on the cleared half (45% survival) at Site LP-1. This may be the result of dense ground cover vegetation (seeded with grasses and legumes) restricting the survival of the root cuttings. It was noted, however, that trembling aspens have begun to voluntarily colonize this seeded area.

The willow stem cuttings did not appear to survive well on any of the three plots. Another year's monitoring is required to confirm this, however, as stem cuttings exhibit shock, and full recovery does not usually occur until after the first growing season. The first year's energy is expended on the production of new root systems, and above-ground growth may not be evident until the second growing season. It should be noted that, although the winter snowpack at the Brewery Creek Mine was approximately normal, precipitation in June 2001 (a critical time for the propagation of stem and root cuttings at this latitude) was only 17.7 mm, compared to the normal precipitation of 38.8 mm for this area. It is generally recognized that the establishment of willow cuttings is most successful when carried out in early spring. In this project, however, funding and approval constraints made a fall planting necessary.

Black spruce seedlings had begun to emerge in late August at the two Canadian Zone sites, most notably at C-1, the north-facing site. This would be expected as black spruce typically occur on north-facing slopes (as well as on poorly-drained sites and in areas with permafrost)

## 5.0 Recommendations

Conclusive evidence as to the success (or failure) of the propagation of these shrub species can only be gained through continued surveillance. It is anticipated that several years' monitoring would be required for an accurate assessment of the reclamation potential for each shrub species. Survival rate is only the first measure of the reclamation potential of these species; their ability to propagate, either by seed or vegetatively, and colonize the remaining disturbed surfaces is equally important. From the first year's observations, however, the following judgements can be made:

- Some of the grass and legume species used to establish the initial vegetative cover at these reclaimed surfaces, or their application rates, may not be conducive to encouraging the next seral stages of vegetative succession. It should be noted again, however, that willows and aspens have begun to voluntarily colonize some of these seeded areas, although not uniformly.
- The low shrubs (raspberry, rose, black currant, spiraea and dwarf birch) transplanted at the mine site are showing high survival rates, particularly where existing ground vegetation is not too dense.
- Alaskan birch and trembling aspen transplants are also surviving well. As these trees are very common in this area, they may be good candidate species for the assisted revegetation of the large open areas at this mine site.
- The propagation of black spruce from seeds may be an effective way of revegetating colder sites (north-facing slopes and sites with permafrost). Seed cones should be collected from nearby areas, where possible. Black spruce transplants are also showing a high rate of survival.

It should be emphasized that the establishment of woody species, by transplanting or by the planting of dormant cuttings, is very time-consuming. The entire planting of large areas using these methods would, therefore, be prohibitively expensive. The spacing of small patches or "islands" of shrubs throughout open areas so they can propagate and spread may, however, prove to be a feasible land reclamation technique.

## References

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