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SELECTION OF NATIVE LEGUME SPECIES FOR RECLAMATION IN THE ROCKY MOUNTAINS

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ABSTRACT

Natural habitat disturbances are increasing on the eastern slopes of the Rocky Mountains. At present, there is little choice of plant material to use for revegetating these disturbances because many available grasses and legumes are not adapted to survive or reproduce in the harsh environments at high elevations. The introduction of adapted agronomic plants is also a concern because these are often persistent and invasive; they restrict natural succession and replace indigenous species in previously undisturbed plant communities.

In 1990, Wild Rose Consulting, Inc. (Edmonton) and Alberta Environmental Centre, (Vegreville) began a four year project to collect, evaluate, and select native legume species for use in reclamation seed mixtures for the mountains and foothills. In 1990 and 1991, seeds of fourteen legume species were collected from 41 sites in the mountains and foothills of Alberta. Seeds were sown in the greenhouse, and transplanted to an evaluation field nursery. Plants were observed for three seasons. Data concerning survival, growth and development, and yield were analysed and combined with distribution data and legumes were ranked.

Astragalus alpinus had the best potential for use in reclamation on the eastern slopes of the Rocky Mountains up to an elevation of 2000 m. It will be useful for establishing a rapid cover on sites but should be used in mixtures with longer lived legumes, as it is short-lived.

Both *Oxytropis monticola* and *O. splendens* were also recommended for use in reclamation mixtures. *Astragalus vexilliflexus, Hedysarum boreale, Oxytropis sericeus* and *O. cusickii* display desirable qualities but require further study.

INTRODUCTION

Natural habitat disturbances are increasing at high elevation regions of Alberta due to extraction of natural resources and development of recreational facilities and transportation corridors. Commercially available agronomic, non-native grasses and legumes often cannot survive or reproduce in harsh environments at alpine and subalpine elevations. Where well-adapted agronomic plants have been used they have been persistent and invasive (Smreciu 1994); they restrict natural succession, decreasing diversity on reclaimed sites and invade natural areas replacing indigenous species. Native plants have several advantages over seeded exotic species in reclamation. They are often widely distributed and have wide genetic variability; they are adapted to local, natural conditions (such as low nutrient substrates and low moisture). Native

plants can be a part of, rather than restricting, natural succession. Most are non-aggressive and not highly persistent and therefore allow for increased diversity.

In 1990, Wild Rose Consulting, Inc. and Alberta Environmental Centre began a four year project to select native legume species for reclamation in the mountains and foothills of Alberta (Smreciu 1993).

The primary objective of this project was to evaluate and select native legumes for use in reclamation at high elevation sites in Alberta. Secondary objectives were to provide seeds to commercial growers such that legume seeds become readily available for reclamation projects, and to provide information regarding agronomic production and the use of these species in reclamation and restoration.

METHODS

In 1990 and 1991, legume seeds were collected from 41 sites at seven locations in the mountains and foothills of Alberta: from Grande Cache in the north, to Cadomin, Jasper, Banff, Kananaskis, Crowsnest Pass, and Waterton in the extreme south. Seeds of fourteen legume species were collected: *Astragalus alpinus* L., *A. americanus* (Hook.) M.E. Jones, *A. vexilliflexus* Sheldon, *Hedysarum alpinum* L., *H. boreale* Nutt., *H. sulphurescensRydb., Lupinus nootkatensis* Donn *ex* Sims, *L. sericeus*Pursh, *Oxytropis cusicTdi* Greenm., *O. deflexa* (Pall.) DC., *O. monticola* A. Gray, *O. sericeaNutt., O. splendens* Dougl. *ex* Hook., and *O. viscida* Nutt. Scientific names follow Moss (1983).

Seeds were cleaned and sown in the greenhouse the following winter. Twenty five transplants of each collection were hardened off and placed in a field nursery at Vegreville (Alberta) in late spring. Establishment and growth data (survival, vigour, spread, height, and seed yield) were collected from these plants for three growing seasons. Seeds harvested from the field nursery were tested for germination. Data were also collected concerning growth habit and phenology (as they relate to harvesting). Data were analysed using an analysis of variance and species compared by Duncan's Multiple Range Test. Legumes were ranked for each character and a final ranking was calculated.

RESULTS

Survival, vigour, cover, yield, and germination data were combined with data concerning the height of the seeds pods (important for mechanical harvest) (Smreciu 1994) and distribution within Alberta (Moss 1983) and each species was ranked for each of these characters (Table 1).

Table 1. The rank order of each species for each characteristic.

Species	Rank Order						
	Survival	Vigour	Cover	Seed Height	Yield	Germination	Distribution
Astragalus alpinus	1	1	1	12	5	2	3
Oxytropis monticola	6	3	8	3	2	1	4
Oxytropis splendens	3	5	7	6	4	1	3
Astragalus vexilliflexus	5	2	3	13	7	1	5
Hedysarum boreale	7	9	2	11	8	4	2
Oxytropis sericea	8	7	11	4	3	1	6
Oxytropis cusickii	2	4	13	8	9	1	7
Oxytropis deflexa	10	8	9	10	1	3	4
Oxytropis viscida	4	6	12	9	6	1	7
Hedysarum sulphurescens	9	11	6	5	11	1	6
Lupinus nootkatensis	13	10	4	1	12	1	8
Lupinus sericeus	11	12	5	2	13	6	6
Hedysarum alpinum	12	13	10	7	10	5	1
Astragalus americanus	14	14	--	--	--	--	2

-- *Astragalus americanus* was removed from testing due to very poor survival.

Survival varied with legume species, *Astragalus alplnm* had the best survival rate over three years (85 %). *Astragalus americanus, Lupinus nootkatensis, Hedysarum alpinum, Lupinus sericeus, Oxytropis deflexa,* and *Hedysarum sulphurescens* had the highest mortality, with less than 40% survival. Due to extremely poor survival, *Astragalus americanus* was removed from further trials.

Astragalus alpinus had the best average vigour over three growing seasons, followed by *Astragalus vexilliflexus, Oxytropis monticola,* and *O. cusickii.* Of the species that survived more than one season, *Hedysarum alpinum, Lupinus sericeus,* and *Hedysarum sulphurescens* were the least vigourous.

Vigour of individual species varied among years. *Astragalus alpinus* was very vigourous in the first and second growing seasons, however there was a noticeable reduction in the third year. Young transplants *of Lupinus nootkatensis* were also vigourous in the first season but there was a considerable loss of vigour in the second year. *Hedysarum boreale* demonstrated the opposite trend; vigour increased with age.

In the first season *Astragalus alpinus* produced significantly greater dry matter than all other species and provided the greatest average cover over three years. *Hedysarum boreale* plants increased in cover from year to year, and by the third year had surpassed the cover figures recorded for *Astragalus alpinus.*

Most legume species did not produce seeds in their first year in the nursery. Exceptions were *Oxytropis deflexa* (which produced significant quantities), *Astragalus alpinus, Oxytropis monticola, Astragalus vexilliflexus, Hedysarum boreale,* and *Lupinus sericeus. Oxytropis deflexa* and *O. monticola* were the most prodigious seed producers over three years, and *Oxytropis sericea, O. splendens,* and *Astragalus alpinus* all produced relatively well. Poor seed production was recorded for *Lupinus sericeus, L. nootkatensis, Hedysarum sulphurescens, H. alpinum, Oxytropis cusickii, Hedysarum boreale* and *Astragalus vexilliflexus.* Low yields by *Lupinus* species and *Astragalus vexilliflexus* were likely due to harvesting problems. *Lupinus* seeds ripened over a very long period of time and were dispersed immediately upon ripening. *Astragalus vexilliflexus* seeds were produced on the ground, under the prostrate branches. Low seed yield by *Hedysarum* plants was likely due to ineffective pollination.

Germination of seeds produced in the first two years indicate that most species germinated well. Seeds harvested in the second season germinated well (94-100%) within four days if they were scarified. Seeds of *Hedysarum boreale* and *Astragalus vexilliflexus* germinated more slowly, although excellent germination was recorded for these species in two weeks. Seeds *of Lupinus sericeus* germinated more slowly and after 30 days, germination was still significantly lower than for other species.

DISCUSSION

Based on measurable results obtained in the evaluation nursery, and on their distribution in Alberta (Moss 1983), legumes were given a final rank (Table 2). The following is a discussion of the potential of each legume for production and reclamation.

Astragalus alpinus was the highest ranked species. Several attributes make it a desirable species for use in reclamation. This legume is widely distributed in Alberta, establishes rapidly and grows quickly, is rhizomatous and spreads to form large mats that would be particularly effective for controlling erosion, produces large amounts of seeds that germinate well, and does not appear to be highly competitive.

Astragalus alpinus is indigenous to the mountains and foothills and some portions of northern Alberta. It was collected at elevations of 1700 m to 2000 m in the mountains and foothills.

Table 2. The rank order of legumes for their potential for reclamation in the mountains and foothills

Species	Rank Order
Astragalus alpinus	1
Oxytropis monticola	2
Oxytropis splendens	3
Astragalus vexilliflexus	4
Hedysarum boreale *Oxytropis sericea*	5
Oxytropis cusickii	6
Oxytropis deflexa *Oxytropis viscida*	7
Hedysarum sulphurescens *Lupinus nootkatensis*	8
Lupinus sericeus	9
Hedysarum alpinum	10
Astragalus americanus	11

Producing seeds of *Astragalus alpinus* in the nursery was relatively simple. Following mechanical or acidscarification it can be seeded at shallow depths, in spring, at a rate of 1.68 kg/ha with 40 to 60 cm row spacing. Nursery survival was high and a good yield of viable seeds was produced in each of three years. Seed production was best in the second year, as vigour and survival were somewhat reduced in the third season, suggesting that its primary function in reclamation mixes would be a rapid cover species and should be used with longer lived, more persistent native legumes.

The relatively low growing seed pods (approximately 5 cm) present some problems when harvesting by conventional methods. Some success in mechanical harvest was attained using a hand-held seed harvester. Because this species produced seeds over a long period of time two harvests maybe feasible.

Astragalus alpinus grown in the field nursery were found to have rhizobia associated with the roots. Two rhizobial strains, isolated from these plants and several rhizobial strains isolated from this and other species in the arctic, are being tested for their ability to improve establishment and growth of this legume.

Oxytropis monticola ranked second. Several characteristics make it an appropriate reclamation and revegetation species: it is native to a large area of Alberta, it grows in a wide variety of habitats including

on disturbed sites, and it produced large quantities of viable seeds.

This ubiquitous species, found in the mountains, foothills, prairie, parkland, and in restricted areas of the boreal region of Alberta, is suitable for use on disturbed sites in many areas of the province. It is recommended for use at elevations up to 1800 m.

Seed production was sufficient to expect successful perpetuation on reclaimed sites. Because it is non-rhizomatous, it will not produce a dense cover and should allow re-invasion by other native plants.

Although *Oxytropis monticola* did not survive as well as some other legumes, it survived reasonably well in the nursery. Seeds were formed on stiff stalks well above the plants and is well adapted for mechanical harvest methods. Seeds, produced in late June to late September, were maintained in upright pods unless plants were lodged by heavy rain or hail. This species also has a second flowering period that could results in double harvests in some years. Seed production was extremely good, and germination was rapid uniform following mechanical scarification.

Few nodules were found on the roots of *Oxytropis monticola* and *Oxytropis splendens* growing in the nursery at Vegreville. Preliminary tests indicate that some rhizobial strains will improve the growth of these species and a screening process of rhizobia should be carried out.

Oxytropis splendens, widely distributed in the mountains and foothills and in northern Alberta, ranked third in the evaluation. Plants survived well in the nursery and produced prodigious amounts of seed. Seeds were produced in capsules on upright stalks and were generally maintained in the capsules until harvest unless plants lodged in heavy rain or hail. Seeds were produced from late June until late September. Following mechanical scarification, germination was excellent. Field seeding this species were not as successful as seeding *Astragalus alpinus.* Further investigation into seeding methods, timing, seeding depth, etc. is required.

Astragalus vexilliflexus ranked fourth. It is native to much of the mountain and foothill regions of Alberta, and is often found growing on disturbed sites. It was vigourous and survived reasonably well in the nursery. As with *Astragalus alpinus,* this species provided better cover in the second year than in the first or third years, and may be an early successional species that is not very persistent. It has good potential for erosion control due to its prostrate growth habit, however this prostrate habit was also responsible for poor seed harvests because seeds were produced under the branches, on the ground.

Better harvest methods have to be found before this species can be recommended for commercial production.

Although *Hedysarwn boreale* plants were not very vigourous, had only average survival in the nursery, and had poor seed yield, it had several traits that make it desirable for reclamation and restoration. It is native to most areas of the mountains and foothills, plains, and into the boreal regions and was collected to elevations of 2100 m. This legume produced large amounts of above-ground biomass and provided good cover compared to many of the other species. Both vigour and cover increased in each of the three years, indicating that it is a longer lived species than some. Although seed yield increased in each successive year, yields were low. Mortality was high over the first winter however survival in the following years was good.

If initial survival and vigour could be improved, this species would provide some long term stability on reclaimed sites and provide good cover after the initial, fast growing, quick cover species started to die out. The benefits of rhizobial bacteria in establishment and growth would be worth investigating. The problem of poor seed yield, possibly due to the lack of pollination, also requires investigation.

Seed germination was good within 14 days; a little slower than several other species. Mechanical scarification of seeds was difficult since seeds tended to crack.

Oxytropis sericea ranked fifth overall. Vigour and survival were average but plants did not provide as much cover as many other legumes. Large numbers of seeds were produced on stiff stalks, 15 to 20 cm above the ground. Seeds were maintained within the capsules unless lodging occurred. Mechanically scarified seeds germinated very well.

This legume is native to the mountains and foothills but is primarily found at lower elevations (it was collected at sites up to 1150 m). It is also native to the plains and parklands, and may be of greater use for reclamation in these areas.

Oxytropis cusickii was vigourous and survived well in the nursery. It was a small species and did not provide extensive cover. *Oxytropis cusickii* however, did produced reasonable amounts of seed which germinated well. Seeds were produced on shorter stalks than some other legumes, but at sufficient height for mechanical harvest. Seed capsules were located on stiff stalks and seeds were maintained in the capsules. This species produced seed over a short period from late May through early July.

Although this legume is not widely distributed within Alberta, it is native to higher elevations than many other legumes (collected at 2100 m), and is recommended for use at very high elevation sites only.

The remaining species require further study to overcome the problems encountered in establishing, growing, and harvesting seed in the nursery before commercial supplies of seed will become available.

Oxytropis deflexa and *Oxytropis viscida* ranked seventh among the legumes studied. The former species was not very vigourous and survival in the nursery was poor. It did not provide as much ground cover as many other species. Seed capsules were borne on decumbent to ascending stalks that may cause problems for mechanical harvesting. This species however produced the largest amount of seed in each of the three years. Seeds germinated well. *Oxytropis deflexa* is widely distributed in Alberta (mountains, foothills, parkland and boreal regions), and could be particularly useful for all of these areas if vigour and survival could be improved. Preliminary test results suggest that certain rhizobia strains will improve establishment and/or growth of this species.

Oxytropis viscida plants had average vigour and good survival in the nursery but did not provide much cover. This species had only average seed yield but seeds germinated well. Seeds were produced in capsules on stalks that reached to about 15 cm.

This legume has a restricted range in Alberta and is found primarily in mountains, foothills and adjacent plains in southwest Alberta. It was collected at lower elevations; up to about 1600 m.

Hedysarum sulphurescens was collected primarily in the central and southern regions of the mountains and foothills but was found to elevations of 2100 m. However, its use in reclamation cannot be recommended at this time because vigour and survival were poor. Survival decreased in each of the three years. Plants did not provide as much cover as many of the other legumes. Seed yield was particularly poor but mechanically scarified seeds germinated well.

Although *Lupinus nootkatensis* is native to only a small area near Grande Cache, it has some potential for use in reclamation within that area and into British Columbia. This species was only tested for two years in the field nursery. Problems associated with this species included poor vigour and survival. It did however provide good ground cover, and seeds were produced in capsules, 25 to 30 cm above the ground. Seed yield was lower than most other species but seeds germinated well.

Hedysarwn alpinwn has a wide distribution range (not only in the mountains and foothills to elevation of 2100 m but throughout much of the province). This suggests that it would be particularly useful for reclamation in many parts of Alberta. However, *Hedysarum alpinwn* was not vigourous and had very poor survival in the nursery at Vegreville. This species produced few seeds in any of the three years; probably primarily due to ineffective pollination.

A small amount of seed was produced in the first season and germination of seeds produced in the initial season was lower than for most other species. Seeds produced in the second season however, germinated well. Because plants had an erect growth habit, seeds could be harvested using conventional methods.

Cover provided by this species increased in each of three years, and it may be useful in seed mixtures as a long term component. Further study is required to improve establishment, survival, and seed production before it can be recommended for use on a large scale.

Lupinus sericeus is native to the southern regions of Alberta, in the mountains and foothills (at elevations to 1550 m) and onto the adjacent plains. It was collected primarily at low elevation sites. Its use in reclamation projects will be restricted by its distribution but to a greater extent by its poor establishment, growth, and yield in cultivation.

CONCLUSIONS AND RECOMMENDATIONS

Astragalus alpinus has the best potential for use in reclamation in the mountains and foothills of Alberta and is recommended for elevations to 2000 m. It will be useful for establishing a rapid cover on sites but should be used in mixtures containing at least one longer lived, native legume because it appeared to be short-lived. Immediate release of this species for commercial production was recommended.

Notwithstanding the requirement for further work, this species was released for commercial production in the spring of 1994, and initial supplies may be available for retail as early as the fall of 1995.

Both *Oxytropis monticola* and *O. splendens* are also recommended for use in reclamation at high elevation in the near future. The former can be used up to 1800 m whereas the latter is recommended for up to 1600 m. Neither species will provide the abundant cover that *Astragalus alpinus* will provide but will be more persistent.

Other species with some potential for reclamation include: *Astragalus vexilliflexus* - if effective seed harvest techniques can be found, *Hedysarum boreale* - particularly as a longer lived component of seed mixtures, *Oxytropis sericea* - although this species may be best suited for lower elevations, and *Oxytropis cusickii* - particularly at high elevation sites within its restricted native range. More work is required for these before they can be released. The remaining species require further study to overcome the problems encountered in establishing, growing, and harvesting seed in the nursery before commercial supplies of seed will become available.

FURTHER WORK

Studies of individual species are continuing. Field trials with six legumes are now underway at sites in the mountains and northern Alberta. Laboratory tests to screen rhizobial strains with *Astragalus alpinus* are almost completed.

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