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THE ECOLOGY AND BIOLOGY OF SOME HIGH ELEVATION NATIVE LEGUME SPECIES

by Clint Smyth

Introduction

Revegetation of alpine and subalpine mine disturbances presents a unique and difficult challenge for mine reclamation personnel (Tomm and Takyi, 1981). These areas are characterized by short growing seasons, high isolation levels, cool temperatures, and generally dry soil conditions (Sellings and Mooney, 1968; Billings I974a, I974b, Brown et al, 1976; and Ogilvie, 1976). The low heat budget under which plant species must complete their life cycles in these enivronments does not favor agronomic species which are bred for lower altitudes and more temperate climates (Brown and Johnston, 1979). Errington (1978), in his reclamation species trials in alpine areas of the Northeast Coal Block in British Columbia, found that several agronomic grass species performed adequately, but the agronomic legume species did not establish with any consistency. The legumes did not overwinter very well, and legume growth decreased during the second year (Errrington, 1978). Low moisture content on very coast textured sites seemed to limit legume growth (Errington, 1978).

The importance of including nitrogen-fixing legumes in the seed mixes used to revegtate mine disturbances is the result of the fact that mine spoil as *a* growing medium is low in "plant available" nitrogen (Tomm and Takyi, 1981). In fact, nitrogen appears to be the limiting nutrient in undisturbed areas at these altitudes (Nishimura, 1974; Luttmerding, 1976; and May, 1976).

It would appear that the long term establishment of nitrogen-fixing species and grasses in these areas may require the use of native legume species which are adapted to the harsh conditions. Unfortunately, seed for native legume species is not available in large quantities from seed companies. Therefore, a study of the biology and ecology of some native legumes would provide valuable information for mine reclamation personnel and commercial seed producers.

Project Objectives

There are two general objectives for the study: (I) to evaluate each species and determine their suitability for mine reclamation programs, and (2) to provide technical information on seed collection, processing, storage and planting requirements for each of the species considered to be suitable.

Report Objectives

For the purposes of this preliminary report, this discussion has been divided into the following sections: (I) species selection, (2) study area physiography, (3) site selection, (4) species biology and ecology and (5) a summary of research/management considerations.

1. Species Selection: Seven species have been selected for investigation. All of the species are members of the Pea Family (Leguminosae). Please refer to Table I for the list of species. The criteria used for species selection was: (I) their presence in disturbed or exposed habitats, (2) their ob served potential as early successional species in mine reclamation projects and (3) their palatability to wildlife.

2. Study Area Physiography; The study area lies within the Front Ranges of the Rocky Mountains in southeastern British Columbia. The main areas of concern are the major ridges of the Elk River, Fording River and Corbin Creek valleys (map). The southern boundary of the study area is the Flathead Pass, and the northern boundary is the northern boundary of Fording Coal Ltd.'s coal lease. The area is characterized by a strong north-south alignment of major ridges parallel to the strike of westward-slipping thrust

Table I

Species List and Distributions

1. Astragalus alpinum (alpine milkvetch)
   Locations: Ewin Ridge/Bald Mt. (CNRL) and North Greenhills (FCL)

2. Astragalus bourgovii (bourgeau's milkvetch)
   Locations: Micehl Ridge (BCCL), Ewin Ridge/Bald Mt. and Mt. Michel (CNRL), North Greenhills (FCL).

3. Astragalus robbinsii (robin's milkvetch)
   Locations: Ewin Ridge/Bald Mt. (CNRL) and North Greenhills (FCL).

4. Astragalus vexilliflexus var. nubilis (bent flowered milkvetch)
   Locations: Ewin Ridge/Bald Mt. (CNRL), Michel Ridge (BCCL), and North Greenhills (FCL).

5. Hedysarum sulfurescens (sulfur hedysarum)
   Locations: Ewin Ridge/Bald Mt. and Todhunter Basin (CNRL), Michel Ridge (BCCL), and North Greenhills (FCL).

6. Oxytropis podocarpa (stalked pod locoweed)
   Locations: Ewin Ridge/Bald Mt. and Todhunter Basin (CNRL).

7. Oxytropis sericeq (silky locoweed)
   Locations: Ewin Ridge/Bald Mt. and Todhunter Basin (CNRL), Michel Ridge (BCCL), North Greenhills (FCL), and South Greenhills (WML).

faults and sedimentary strata (Holland, 1964). The study sites are found within the Alpine Tundra (AT) and the Englemann Spruce-Subalpine Fir Biogeoclimatic Zones at elevations ranging from 1,900 to 2,500 metres. These areas are underlain by sandstone, siltstone, conglomerate and coal of the Kootenay Formation and shale of the Fernie Group. Some of the areas, particularly the eastern area, are underlain by relatively resistant limestones and dolomites of the Rundle Group (Ryder, 1981). The surficial geology of these areas is primarily composed of glacial veneers and colluvium (Ryder, 1981).

3. Site Selection; The majority of the work to date has been carried out on Bald Mt. and Ewin Ridge (Crowsnest Resources Ltd. — Line Creek Operations). Sampling has also been carried out on Michel Ridge near Byron Creek Collieries, on South Greenhills (Westar Mining Ltd. — Greenhills Operations), and on North Greenhills (Fording Coal Ltd.). The work on Ewin Ridge and Bald Mt. and of areas adjacent to the other cooperating mines. A tenative list of the areas to be sampled in 1984 has been created: (I) Byron Creek Collieries area — Andy Good Peak, Tent Mt., Mount Ptolemy, Mount McGladrey, Mount Pengelly and Michel Ridge; (2) CNRL-Line Creek area — Mount Michel, Tornado Mt., Beehive Mt., Line Ridge, Long Ridge, Wilson Ridge, Imperial Ridge, Todhunter Ridge and the Witsukitsak Range; (3) Fording Coal area— Castle Mt., Turnbull Mt., Mount Gass, Mount Lyall, Mount Farquhar, Mount Tux ford and the North Greenhills Range; and (4) Westar Mining area — Erickson Ridge, Burnt Ridge and South Greenhills.

4. Biology and Ecology: The purpose of this section of the project is to use biological and ecological data to evaluate the

suitability of some native nitrogen-fixing legumes as mine reclamation species. In order to carry out this evaluation, seven areas of investigation were undertaken: (4a) environment/plant relationships; (4b) bio-meteorology; (4c) phenology and growth; (4d) rooting patterns; (4e) bacterial isolation, culturing, identification and nodulotion; (4f) nitrogen fixation; and (4g) seed dispersal and establishment of seedlings.

(4a) Plant/Environment Relationships; The objective of this section was to provide information on the environmental factors that influence the growth and distribution of the selected species. The most important function of this section is to determine the favorable and/or unfavorable environmental conditions for each species. This information will then be compared with information on the properties of mine spoils in the area to determine their suitability.

1983 Field Season: Forty-two of a total of 100 ten square metre sampling units were established, using a stratified random sampling procedure. The areas were stratified on the basis of vegetation, soils and surficial geology. The vegetative cover of the seven species, along with accompanying species, soils and environmental data, has been collected for each sample unit. The following is a summary of the data collected during the summer:

(a) The majority of the species occurred on coarse textured soils. In some cases, plants grew in cracks in the rocks.

(b) A. alpinum, A. vexilliflexus var. nubilis, and O. sericea were generally found on wind exposed ridges.

(c) There appears to be an inverse relationship between the presense of these species and the density of other species, particularly grasses.

(d) H. sulfurescens, A. bourgovii, and to a lesser extent, A. robbinsii were restricted to less exposed areas and appeared to tolerate greater densities of grasses.

(e) O. podocarpa was absent from all of the east aspects sampled. Only a few individuals of O. sericea were found on east aspects.

(f) Most of the species had vigorous growth throughout their range. H. sulfurescens was the only species that did not have consistently vigorous growth throughout its range.

1984 Field Season: A further 58 sampling units will be established in 1984. An intensive soil sampling program will also be initiated.

(4b) Biometerology; The objective of this section was to collect data that will be used to interpret the phenology, growth and plant/environment data that is being collected in other sections of the project.

1983 Field Season: Three complete meteorological stations were established above treeline on the south-west, west and east aspects of Bald Mt. In addition, two stations were established below treeline on the north and south-west aspects of Ewin Ridge. Precipitation, max./min. atmospheric temperature, solar radiation, wind exposure, atmospheric humidity and soil temperature were measured at the complete meterological stations and all but max./min. atmospheric temperature and wind exposure were measured at the partially complete stations. Meterological data was collected from June 10th to September 13th. There was a lot of variation in meterological data. General patterns in the data indicate that the west aspect was the coldest and windiest, while the east aspect was the warmest. There was a considerable amount of variation in soil moisture content within sites and between sites.

1984 Field Season: Meterological sampling in 1984 will be increased to 4 complete meteorological stations. Wind speed and wind direction measurements will also be recorded. Soil temperature measures will also be increased from I pair per aspect to 3 pairs per aspect.

(4c) Rooting Patterns: The objective of this section was to examine the rooting patterns and nodu lotion of each species under different substrate conditions.

1983 Field Season: A number of

individuals of each species were dug up and their rooting patterns photographed. The data for this section showed that the most extensive root structure was developed by Hedysarum sulphurescens and second by Oxytropis sericea. The roots of these species could penetrate as far as 30 cm., but this was, of course, restricted by bedrock. Astragalus alpinum has a rhizoidal root structure that is fibrous in nature. This plant has the ability to spread and form extensive mats. Astragalus vexilliflexus var. nubilus favoured the rockiest substrates and was found rooted in cracks in the bedrock. The remainder of the species were intermediate in their rooting patterns. However, all species favored rocky substrates. Please refer to the Diagrams I -3 for more information.

1984 Field Season: The field work for 1984 will be a continuation of the 1983 sampling program.

(4d) Phenology and Growth; The objective of this section was to observe the growth and development of the species through the growing season. This information will provide an understanding of the developmental biology of the species along with practical information such as seed collection times.

1983 Field Season: A total of 40 sampling units (IO individuals/species) were established on Bald Mt. and Ewin Ridge. Measurements of plant height and width, and recodings of the stages of vegetative and reproductive development were made every 5 days from May 24th to September 14th. The field data can be summarized as follows:

(a) Initiation of growth began in late May and continued until late July-early August

(b) Flowering begin in late June-early July and continued until the first week in August

(c) Seed dispersal by O. podocarpa began the first week in August and continued until the 15th of September. The other species began to disperse their seed in the second week in August and peaked around the end of August. However, seed dispersal by O. sericea had not peaked by the middle of September.

(d) Most of the species showed signs of senescence during the 3rd and 4th weeks of August.

(e) Agronomic legumes sown on re claimed exploration roads in the area did not initiate growth until the middle of June, and only one plant was ob served to flower during the third week of August. This attempt was thwarted the next day with the season's first snowfall. Please refer to Table 2 for more information.

1984 Field Season: The field work for 1984 will simply be a continuation of the 1983 sampling program.

(4e) Bacterial Isolation, Culturing, Identification and Modulation: The objective of this section was to isolate the bacterial strains associated with the species being studied and to provide a source of inoculum for the seeds.

1983 Field Season Summary: Several plants of each species were dug up, and a number of nodules were excised and brought back to the laboratory for culturing. There have been some problems in culturing the bacteria. The bacterial strain that nodulates O. podocarpa is the only one that is presently viable. It would appear as though the nodules were allowed to dry out too much during transport and storage. This problem has necessitated my return to the study area on January 6, 1984.

1984 Field Season: Work will continue on the culturing and nodulotion of the bacterial strains.

(4f) Nitrogen Fixation; The objective of this section was to evaluate the viability of the bacteria in the nodulated plants and to determine the amount of nitrogen fixed per individual plant.

1983 Field Season: Work on this section was not initiated during 1983.

1984 Field Season: A number of seed lings per species that result from the germi nation tests will be used in greenhouse trials to determine the amount of nitrogen fixed

Diagram I

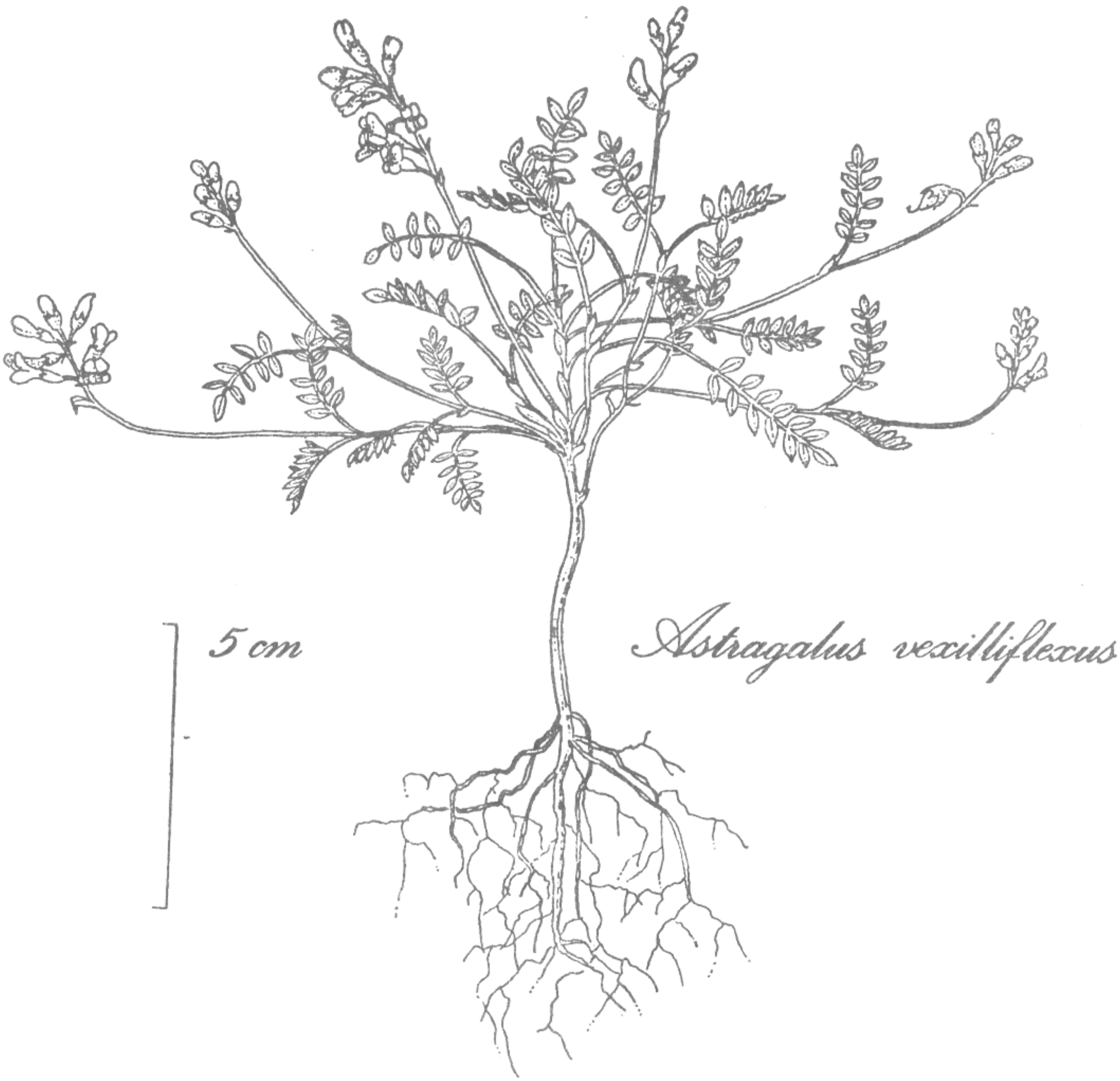


Diagram 2

Oxytropis podocarpha

Diagram 3

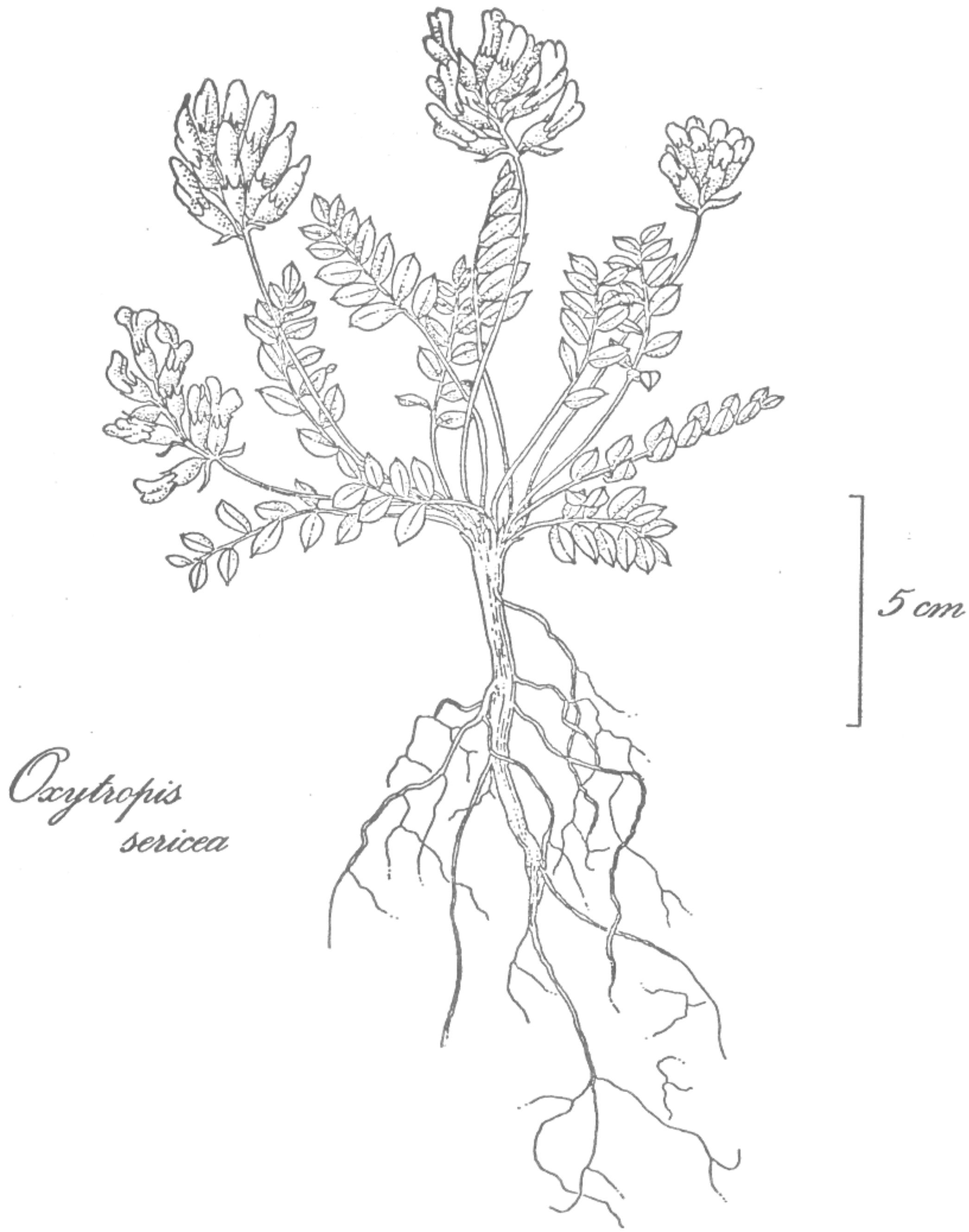
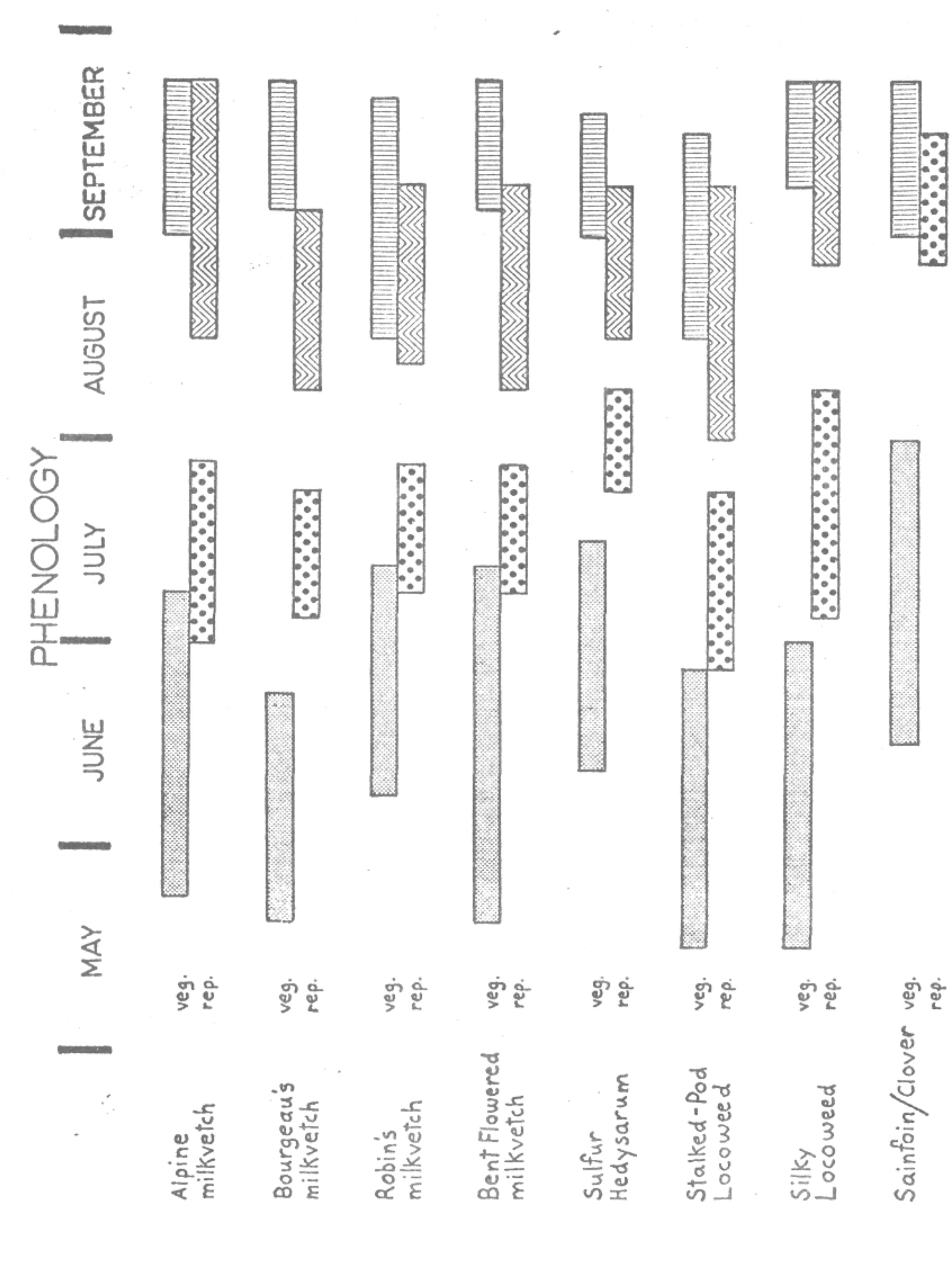


Table 2


PHENOLOGY
MAY
JUNE
JULY
AUGUST
SEPTEMBER
Alpine milkvetch
Bourgeau's milkvetch
Robin's milkvetch
Bent Flowered milkvetch
Sulfur Hedysarum
Stalked-Pod Locoweed
Silky Locoweed
Sainfoin/Clover
veg.
rep.

per plant.

(4g) Seed Dispersal and Establishment of Seedlings: The objective of this section is to provide information on seed dispersal, seed germination and seedling establishment for each species.

1983 Field Season: The data can be summarized as follows:

(a) Wind appears to be the major dispersing agent for most species, although preciptation in the form of rain drops may be a factor in O. sericea. However, seed dispersal and seed morphology vary between species. A variety of seed shapes and sizes, and seed dispersal mechanisms were observed:

(i) A. Alpinum, A. bourgovii, and A. vexilliflexus var. nubilys — the pods of these species are membranous and green or yellow when mature. Some pods remain attached to the plan during seed dispersal, while other pods of the same plant drop to the ground before dispersing their seed. The seeds of three species are reniform in shape and 1.5-2.0 mm. in length. However, the seeds of A. alpinum and A. bourgovii are a yellow or light green color, while the seeds of A. vexilliflexus var. nubilis are black. The seeds of these three species fit together and are tightly packed in their pods, while the seeds of all the other species being studied are held loosely inside their pods, (ii) A. robbinsii— the pods of this species are a tan color, and the valves are fully distended when mature. The pods always remain attached to the plant. The seeds of this species are cordate shaped, 1-2 mm. in diameter and tan colored.

(iii) H. su lf u re seen s — the loments of this species are a dull yellow or tan colour when mature and generally break into individual segments during dispersal. The seeds remain encased in the segments of the loment, are cordate shaped, 2-3 rnm. in diameter and tan colored.

(iv) O. podocarpa — the pods of this species are ovoid and the largest of the species being studied. The pods begin to open at the distal end of the dorsal suture, and seeds in this position are dispersed first. An abscission layer forms in the stalk of the pods at the same time as the pods are opening, and eventually the pods and the proximally positioned seeds are dispersed by the wind. The seeds are held in the pods by a cobweb-like substance. The seeds are cordate shaped, black, and 1.5-2.0 mm. in diameter.

(y) O. sericea — the pods of this species are smaller and woodier than O. podocarpa, and remain attached when mature. The pods open by forming a small distal pore, and the seeds are then dispersed by either wind or rain droplets. The seeds are cordate shaped, 0.5-1.0 mm. in diameter and a reddish brown color.

(b) Seeds were collected from the different populations of each species. The seeds were then processed and stored at 2-5 degrees C. Seed germination tests are due to begin in March 1984.

(c) Processing the seeds at this point in time is very labor-intensive. The ease of seed processing varies between species. H. sulfurescens and O. sericea are very easy to process, A. robbinsn and O. podocarpa are moderately easy, and A. alpinum, A. bourgovii, and A_1 vexilliflexu var. nubilis are difficult to process.

1984 Field Season: the 1984 field work will be a continuation of last year's work.

5. Summary of Research/Management Considerations: Seven native legume species

have been selected for research. There are many factors to consider when selecting species. For various reasons, some of these species appear to be more suitable for mine reclamation programs than others. While discussion of many of these factors cannot be concluded at this point in time, there are some very important technical considerations that can be discussed. The first factor to consider is that of wildlife utilization. Two of the species selected, A. robbmsii and O. podocarpa showed signs of having been browsed by elk and/or sheep. The seeds of CX godocarpa are also eaten by ptarmigans. It would appear that neither of these species are toxic to wildlife. However, a survey of the literature indicates that a number of species of the genus Astragalus sequester selenium, an element that is toxic to wildlife and also contains miserotoxins. This is a segment of the research that must be investigated in the 1984 field season. The second factor to consider is whether the growth medium and environmental conditions in which these species are found are similar enough to the conditions of the mine spoil to warrant further research. With the exception of H. sulfurescens, all of the species were found growing in very coarse textured materials (not really soils) and in very exposed environments. These conditions are, of course, very similar to those of mine spoil. A_1. alpinum, A. vexilliflexus var nubilis, O. podocarpa and O. sericea are found growing in extremely adverse conditions. O. sericea appears to tolerate the widest range of habitats. The third and final factor to consider is that of seed processing, seed handling and seedling establishment. Seed processing for many of these species was very time consuming. H. sulfurescens, O. podocarpa and O. sericea were easy to process, but the remainder of the species were difficult. The utilization of these other species will be very dependent upon the development of a rapid method of seed processing. Seed handling and storage does not appear to be a problem. Seedling establishment information cannot be provided until the seed germination and seedling trials on mine spoil are concluded this summer. In conclusion, it would appear, at this point in time, that O. sericea, O. podocarpa, and A. robbinsii show potential as mine reclamation species. A. alpinum and /v. vexilliflexus var. nubilus also have potential if the seed processing difficulties can be overcome.

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