Proceedings: Workshop on Native Shrubs in Reclamation

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FOREWARD

The workshop recorded in these proceedings was organized by the Alberta Reclamation Research Technical Advisory Committee as the first step in developing a Native Shrub Research Program for reclamation. While the importance of a detailed literature survey was recognized and is presently underway; the Committee also understood that a great deal of valuable information was of a practical nature and was not recorded in the literature. The workshop provided a forum for the exchange of information and experiences on three major topics: propagation, outplanting and species section. The discussions were very productive in helping the Committee identify areas for future research and those areas where sufficient knowledge already exists.

We are, therefore, indebted to those who participated in the workshops and, particularly, to those who presented summaries of their own shrub research programs. I would also like to thank the other members of the workshop Steering Committee, Mr. C. A. Dermott of the Alberta Forest Service and Dr. H. P. Sims of Alberta Environment for their help in organizing the workshop and for preparing the transcripts of their respective working groups.

P.F.Z.

OPENING ADDRESS

P. F. Ziemkiewicz, Chairman
Reclamation Research Technical
Advisory Committee

On behalf of the Reclamation Research Technical Advisory Committee, I'd like to welcome you to our workshop on Native Shrubs in Reclamation.

Before going further, perhaps some background information would be helpful. First of all, the Reclamation Research Technical Advisory Committee, with membership representing five Provincial Departments began operating in March of this year. The Committee is an advisory body to the Land Conservation and Reclamation Council and is charged with reviewing and coordinating reclamation research funded by the Alberta Government. Reclamation of the Oil Sands Area in the past had fallen under the Federal-Provincial AOSERP Program. With termination of federal participation in the AOSERP Program, the Committee will now review proposals for reclamation research in the Oil Sands Area.

We are now in the process of developing a comprehensive reclamation research program for the province. Certainly shrub research will have a place in this program, for while shrubs represent a small part of the reclamation picture they can fulfill specialized and critical roles in wildlife browse and habitat, windbreaks and aesthetics. Also, shrubs can be used as stabilizing materials on unstable slopes.

One of the reasons for holding this workshop is that much of the information regarding shrub propagation, outplanting and selection has come about through years of experience and hasn't yet found its way into the literature. Several private and government organizations have investigated the use of shrubs and trees in reclamation. Also, a great deal of information on shrub propagation and selection has been acquired by government sponsored shelterbelt programs in Western Canada.

We hope that by bringing these diverse groups together we can generate some mutually productive discussions. Moreover, I hope we arrive at some conclusions regarding the state of the art in shrub propagation, outplanting techniques and species selection. These conclusions will serve as the framework of our shrub research program and will allow us to avoid "reinventing the wheel". In short, we would like to come away from this meeting with a clearer understanding of where we stand and where we have to go in shrub research for reclamation.

NATIVE SHRUB RESEARCH AT SYNCRUDE CANADA LTD.

A. W. Fedkenheuer, Environmental Affairs
Syncrude Canada Ltd.

ABSTRACT

The Syncrude project is an open pit oil sands mining operation located about 418 km north of Edmonton. In preparation for mining a large area has been disturbed and must be reclaimed. Also, in the extraction of oil there will be about 6,000 acres of tailings sand to be reclaimed to grasses, legumes, shrubs and/or trees.

The main objectives of Syncrude's native shrub research program are to evaluate the propagation, survival and growth of shrubs on reclamation sites as an integral part of the vegetation.

Propagation research on seed has included collection, extraction, treatment, container growing, outplanting and follow-up evaluation. Results have been highly variable dependent on the species involved.

Vegetative propagation has also been used and has included softwood, semi-hardwood and hardwood cuttings. Results have been highly variable dependent on species and type of cutting.

INTRODUCTION

The Athabasca, Cold Lake and Peace River oil sands deposits represent the major oil sands accumulations in Alberta. The only deposit with active extraction facilities at present is the Athabasca. The latter two are currently in the pilot plant stage.

Of the approximately 300 billion barrels considered recoverable from the Athabasca deposit, about 28 percent are suitable for recovery by surface mining techniques. The Cold Lake and Peace River deposits are suitable only for in-situ recovery.

Surface mining and in-situ recovery both involve reclamation. However, surface mining with its associated tailings sand has been the major reclamation concern in the oil sands. Initially tailings sand is high in sodium content and relatively sterile; not a highly desirable material for plant growth. Upon completion of mining the Syncrude Canada Ltd. project will have approximately 5,000 acres of tailings sand in the mine and 1,000 acres of it in the tailings pond dike.

The Land Surface Conservation and Reclamation Act was put into effect by the province of Alberta in 1973. Subsequently, the Land Conservation and Reclamation Council developed a set of proposed standards entitled "Guidelines for the reclamation of land affected by a surface disturbance" (Land Conservation and Reclamation Council, 1977).

This document specifies that for land uses other than agricultural production, mined land must be reclaimed to an accepted end land use with a productivity equal to that which existed prior to mining. The accepted end land uses for the Syncrude venture are forestry, wildlife and recreation.

It follows that the main objective of the Syncrude Canada Ltd. reclamation program is the establishment of a system at least equal to the pre-disturbed state in ecological productivity. This system should be consistent with the regional surface hydrology, the natural vegetation and the land use for forestry, wildlife and recreation. Additionally, the plant communities will be permanent, self-supporting and maintenance free.

In the company's reclamation program a serious attempt is made to establish a grass cover on a disturbed site within one year after cessation of the disturbance in order to control surface wind and water erosion. Subsequently, shrubs and trees are planted to eventually develop into a productive forest cover.

In determining which species to plant, there are several alternatives available for a reclamation program; native species, "exotic" species or a combination. Syncrude has taken the approach of first evaluating the capabilities of native trees and shrubs present on its leases before examining exotic species to any extent.

The lack of available information regarding propagation and performance of container grown shrubs for reclamation purposes prompted Syncrude to initiate an ongoing native shrub research program in 1977.

Thanks to Mr. George Grainger and his staff, especially John DenHeyer, Cecilia McIsaac and Alena Straka at the Oliver Provincial Tree Nursery, a small amount of greenhouse space and a lot of technical information was made available to assist in getting Syncrude's shrub research underway. Appreciation is also extended to Mr. Con Dermott of the Alberta Forest Service for the co-operation received from his staff, especially Dr. Sam Takyi, Glen Dunsworth and Jim Sherstabetoff.

METHODS

The most appropriate combinations of plant species have not yet been developed for Syncrude (Fedkenheuer and Langevin, 1978). Therefore, the approach of examining a relatively large number of native shrubs has been taken (Table 1). Using propagation and performance data the number of species being dealt with can then be narrowed down. Some species may require very little work, while others may require very intensive work and still others may be eliminated from further consideration for oil sands reclamation.

Research into the propagation of the species in Table 1 has involved both the vegetative and seed aspects except for *Alnus crispa*, *Eleagnus commutata*, *Prunus virginiana* and *Salix* spp. For these first three

TABLE 1

NATIVE SHRUBS CURRENTLY BEING EVALUATED
IN SYNCRUDE'S RESEARCH PROGRAM

(Nomenclature follows that of Moss, 1959)

Alnus crispa (Ait.) Pursh	Green alder
Amelanchier alnifolia Nutt.	Saskatoonberry
Arctostaphylos uva-ursi L. Spreng.	Bearberry
Betula pumila L. var. *glandulifera* Regel	Bog birch
Cornus stolonifera Michx.	Red-osier dogwood
Eleagnus commutata Bernh.	Silverberry
Potentilla fruticosa L.	Shrubby cinquefoil
Prunus pennsylvanica L.f.	Pin cherry
Prunus virginiana L.	Choke cherry
Rosa acicularis Lindl.	Prickly rose
Salix spp.	Willow
Shepherdia canadensis (L.) Nutt.	Canadian buffaloberry
Symphoricarpos albus (L.) Blake	Snowberry
Vaccinium vitis-idaea L. var. *minus* Lodd.	Bog cranberry
Viburnum edule (Michx.) Raf.	Lowbush cranberry

species only the seed aspects are being evaluated and for Salix spp. only cuttings are being used. The basic references used for procedures were the "Seeds of woody plants in the United States" (U.S. Department of Agriculture, 1974) and "Plant propagation principles and practices" (Hartmann and Kester, 1975).

In the seed portion of the program an attempt has been made to look at effects of collection time, seed cleaning, storage and stratification on seed germination and seedling growth. Stratification measures to date have included only temperature and moisture variations. Chemical treatment for some species such as Arctostaphylos uva-ursi and P. virginiana are being planned.

Vegetative propagation has included softwood, semi-hardwood and hardwood cuttings, but not all of these have been tried for all species. Rooting has been attempted in covered rooting boxes. In 1977 no bottom heat was used in the rooting boxes while in 1978 bottom heat was applied. Rooting was also attempted in Spencer-LeMaire containers without any special humidity control. No mist system has been utilized for any of the cuttings.

In cases where seedlings were obtained, they have been evaluated for container size suitability and then planted in the field plots. The majority of the species have been planted on tailings sand plots which have been amended with clay, reject tar sand or "native" sand plus peat for a long term evaluation of performance. Some shrubs have also been planted on other plots to assess their response to surface scarification treatments and small mammals.

RESULT AND DISCUSSION

Before getting into a discussion of results it should be recognized that for Syncrude's program a container system is being used. It is not a bare root operation. Additionally, it is relatively small operation and the numbers of some species required is limited. Thus, for some species, vegetative propagation may be more economical than propagation from seed. However, a larger operation may find vegetative propagation of these same species highly impractical.

Results to date are incomplete as the data is in the process of being organized and analyzed. However, some preliminary information from the seed program is shown in Table 2. All the fleshy seed used had the fruit pulp removed, but the seeds were not separated on the basis of specific gravity. Therefore, some germination percentages are lower than should be the case if the seeds had been separated by weight. This is especially true for a species such as Amelanchier alnifolia which can have a high proportion of immature seeds. P. virginiana is another species which should have given better results if separated by weight as there were a number of wormy seeds. The germination percentage column in Table 2 is the percentage of seed planted which actually germinated in cavities in the greenhouse. With most of the germination percentages at less than 20 percent, there should be room for improvement of germination by better seed treatment or germination conditions.

TABLE 2

PRELIMINARY RESULTS OF SEVERAL GREENHOUSE SHRUB SEED GERMINATION TRAILS

Species	% Germination (range)
Alnus crispa	17 - 18
Amelanchier alnifolia	8 - 15
Betula pumila	12
Potentilla fruticosa	82
Prunus pennsylvanica	0
Prunus virginiana	1
Shepherdia canadensis	14 - 19

In Table 3 some results of the vegetative propagation program are presented. These are the summation of results from all treatments per species. This increases the range of variability in results. For example, the number of Rosa acicularis cuttings producing roots ranged from zero to 100 percent. The low results were obtained using upper stem cuttings. The high values resulted from using cuttings taken from the base of the stem. The results from A. alnifolia and Shepherdia canadensis cuttings have been consistently low regardless of type of cutting. Harris (1972) suggests softwood cuttings taken early in the growing season will root readily, however, softwood cuttings to date from Fort McMurray have not done well.

Data on species performance on the field plots with a tailings sand base have not been synthesized for 1978.

As a result of findings to date, no further vegetative propagation work is being planned for A. alnifolia and S. canadensis. Other propagation research will be continued. Potentilla fruticosa requires only some refinements in cleaning the seed while for others such as A. alnifolia, a more consistent technique for a higher germination rate needs to be developed. There undoubtedly may be techniques available already to do these things and perhaps they will be outlined at this workshop.

FUTURE RESEARCH

The shrub research program at Syncrude has provided some answers, but it has given rise to a number of additional questions as well. The effects of seed extraction and storage, seed treatments, appropriate container size, appropriate seedling size, effects of rodents on shrub survival and growth, planting methods, survival and growth on amended tailings sand, etc. will continue to be researched until satisfactory results are obtained for each species or until the species is taken out of the reclamation program. There are many facets of shrub research which still must be investigated. The key is in knowing what shrub research is going on at any one time so that duplication of effort is minimized.

The Reclamation Research Technical Advisory Committee (RRTAC) is to be commended for initiating this workshop in an effort to determine the "state of the art" of shrub research. I recommend that this become an annual meeting and that it be expanded so other parties funding reclamation research on shrubs can become more aware of what research the government is funding as well. If groups outside of the Alberta Government are to accept and utilize the research results, they want to know more about the research. Being handed a final report and told, "here are the results" is not going to get the results applied. There has always been a fundamental problem of applying research results when no one has taken the responsibility of demonstrating their usefulness on a practical basis. This workshop could provide that vital function.

Shrub research for reclamation purposes will be furthered if the RRTAC publishes the results of this workshop and makes it generally available. Another project the RRTAC could undertake is the putting to-

TABLE 3

EARLY RESULTS OF GREENHOUSE
SHRUB CUTTING PROPAGATION TRIALS

Species	% Producing Roots (range)
Amelanchier alnifolia	0 - 8
Arctostaphylos uva-ursi	1 - 36
Betula pumila	0 - 46
Cornus stolonifera	33
Potentilla fruticosa	0 - 54
Prunus pennsylvanica	0 - 31
Rosa acicularis	0 - 100
Salix spp.	42 - 83
Shepherdia canadensis	0 - 1
Symphoricarpos albus	12 - 82
Viburnum edule	0 - 70

gether and publishing of a report outlining, in "cookbook" fashion, shrub seed collection times, seed extraction and storage procedures. This report should also include information on seed stratification and treatments used with an accompanying germination percentage. This could be accomplished by having the Oliver Provincial Tree Nursery write a chapter on their procedures, Kaiser Resources Ltd. a chapter on their procedures and so forth for anyone wanting to and having something to contribute. The users could make their own selection of a procedure based on their situation.

There are a number of other shrub research possibilities listed for discussion by the three workshop working groups. Fitting these together with the current work will provide numerous shrub research possibilities.

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PERFORMANCE AND MAINTENANCE OF NATIVE TREES AND SHRUBS ON DISTURBED LANDS

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BACKGROUND

Planting of native trees and shrubs on disturbed areas in Saskatchewan has been of an experimental nature only. The Forestry Branch of the Department was asked in 1963 to conduct some experiments in establishing tree cover on the disturbed land resulting from coal extraction near Estevan in the south-east corner of the Province.

A study was conducted and an experimental program was devised involving different trees and shrubs.

WORK PROGRAM

The spoil piles at Estevan rise above the surrounding Prairie landscape and remain bald for many years before vegetation becomes established. The area was determined to be a difficult situation for the establishment of tree growth because:

1. Presence of salinity and its influence on tree species.
2. The nutrient problem in general.
3. The influence of soil pH on different tree species.
4. The influence of the absence of organic matter.

PLANTING

A small planting was done in 1964 and initially, considering the dry valleys to be almost impossible for survival, planting was done adjacent to small lakes that had been created in the spoil areas. Indications from preliminary investigations of soil moisture, length of exposure to the sun, air and ground temperatures and evaporation, pointed the way to using north and east facing slopes for test planting.

Vegetation showed that the distance up the slopes from the water was also an important consideration in plant survival.

Four species were used (being all that were available): Siberian Elm, Hybrid Poplar 44 - 52 cuttings, Green Ash and Scots Pine. The trees were planted in rows 1, 2, and 3 feet above the level of the lake, and organic matter was added to half the trees planted. With the exception of the Poplar cuttings, survival was exceptionally high in both the untreated

and treated plants. However, survival in the rows 2 and 3 feet above the lake was better, probably showing the effect of the salinity in the soil near the water. The addition of organic matter seemed to have some effect, but the test was too small to have any real significance.

In 1965, a further planting was conducted, adding to the previously mentioned species--Eastern cottonwood (Populus detoides), (Local cuttings), Russian olive (Eleagnus angustifolia), hawthorn (Crataegus rivularis) and a willow species. Keeping in mind the two main factors of moisture and salinity, all the planting material was put at one-foot vertical intervals on slopes of eastern exposure, starting one foot above the water, and ranging as high as six feet.

Green ash and Siberian elm survived well at all levels. Hybrid poplar and the local cottonwood survived well up to the four-foot level. Scots pine survival was very poor at the lower levels, but increased up to the five-foot level, and remained the same at the six-foot level. The Russian olive survived well at all wells, as did the hawthorn. The local willow showed requirement for a very moist soil.

Survival of 1964 plantings remained good, with the exception of Scots pine. All species, however, showed signs of chlorosis.

In 1966 and 1967 further plantings were done, using the same species. Survivals were directly related to precipitation. In 1966, there were three periods when the plants were in a drought condition, and in 1967, a very low rainfall caused a drought lasting from May until mid-September. Survivals of newly established plantations in these years were very low. In earlier plantations survival was also reduced, however, the addition of the organic matter enhanced survival of all species in the 1965 plantation. Presumably, there was more moisture retention around the root zone.

In 1970, measurements on the 1965 planting revealed that average heights of species and average survival were:

Species	Height	Survival
Siberian elm	28 inches	57%
Green ash	14 inches	70%
Scots pine	14 inches	23%
Poplar 44-52	20 inches	15%
Cottonwood	24 inches	5%
Russian olive	11 inches	51%
Hawthorn	11 inches	53%

Not a spectacular growth rate but reasonable for the situation and the weather conditions that prevailed during 1966 and 1967.

LEVELLING AND PLANTING

I mentioned earlier that the piles remain bald for many years. The piles do not stabilize as continued erosion takes place. Our experiments had determined that some tree species could grow in specific environments within the spoil banks, but planting was of little use before the soil was stabilized. A good cover crop would also have been an asset.

In 1968, funds were appropriated, a D8-H crawler tractor was hired, and approximately 11 acres were levelled ($60/acre). By levelled, I mean the tops of the ridges were flattened to a width of about 15 to 20 feet. An attempt was made to have two profiles in the levelled tops: 1) flat with ridges along the edges: and 2) slightly dished to hopefully retain moisture.

In 1969, planting commenced on the levelled spoil piles, using the same species as had been used previously, but adding a few more Poplar Hybrids. Survival ranged from 56% for the poplars, to 80 to 90% for the rest of the species. The survival on the flat was slightly higher than the dished. This may have resulted from too much moisture, as precipitation in 1969 was excessive.

The high precipitation caused washing and flooding, which played havoc with the earlier plantings along lakes and up the slopes. (Most of the trees at the one-foot level in 1965 and 1966 plantations were lost).

In 1970 and 1971 larger plantings were undertaken on the levelled tops. A larger number of poplar clones (14) were used, some trees and six shrub species. Several willow clones (18) were planted in a moist east-west valley.

The trees used were green ash, American elm, Scots pine, Manchuriam elm, and Russian olive; the shrubs used were lilac, buffaloberry, chokecherry, sandcherry, nanking cherry, and rose.

The 1972 assessment of these plantations (8 replications) showed no Scots pine surviving, 50% survival for Manchurian elm, 58% for American elm, 85% for Russian olive and 100% for green ash. Average heights were 12.5 inches for green ash, 6.3 inches for Manchurian elm, 6.9 inches for American elm, 15.0 inches for Russian olive and 12.5 inches for green ash.

The survival for shrubs was, lilacs 96%, buffaloberry 68%, chokecherry 60%, sandcherry 64%, nanking cherry 60%, and roses 96%.

Average heights were 3.2 inches for lilacs, 11.9 inches for buffaloberry, 11.9 inches for chokecherry, 15.6 inches for sandcherry, 8.0 inches for nanking cherry, and 10.7 inches for rose.

The willows survived well in the moist valleys, the lowest survival being 52%. Growth was not exceptional, however, heights after two years ranged from 11.7 inches to 20.2 inches. The mean being 17.3 inches.

The mean survival of the poplar clones used was 37% and the mean heights was 16.8 inches.

Survival and growth of these plantations were checked annually up to 1975 and found to be very favourable. Excellent moisture conditions in 1973 through 1975 contributed greatly to the good survival on the flattened areas. The excellent moisture, however, drowned many of the Willows that were planted in the moist valleys.

The statistics given above are for plantations planted in the raw spoils of the area, where organic matter (forest peat moss) was added --- survival and growth were somewhat better.

General findings with regard to tree species show the following to be most successful for planting in the Estevan area in terms of survival, total height and vigor:

1) Russian Olive: Good survival and growth.

2) Manchurian Elm: Fair--limited to better sites, organic matter added--desirable.

3) Hedge Rose: Good survival, fair to poor growth.

4) Scots Pine: Fair on higher levels, on better sites and with organic matter added.

5) Willow: Use rooted stock in moist to wet valleys. The following clones are recommended:

1. Salix elegantisima (Pentandra)
2. Salix sp. (White)
3. Salix sp. (Acute)
4. Salix sp. (Black)
5. Salix alba (Vittelina) Purp.

6) Poplar: Use rooted stock--clones recommended:

1. Populus canadensis (Grandifolia)
2. Populus petrowskiana
3. Populus sp. (Griffin)
4. Populus sp. (Northwest)
5. Populus sp. (Wheeler #4)

7)

- Hedge Rose
- Common Chokecherry
- Buffalo Berry

At Estevan the disturbed land, as I mentioned at the outset, is in a Prairie area where few trees grow naturally. We felt that, although, tree and shrub cover is nice, would it not be adviseable to just have much of the area covered with grass? We experimented with several grasses on levelled areas and found that after four years of growth--sweet clover grew very well; crested wheat grass, Russian wild rye, and brome grass also performed well.

The Saskatchewan Power Corporation in the early 1970's commenced an annual reclamation project involving levelling, at a cost of $200 per acre, plowing furrows and adding topsoil prior to tree planting. The weed growth from the topsoil was excellent, but tree survival was limited. The area between the tree rows was seeded to grass. I am not aware of the overall results of their work, but expect weather conditions and planting locations determined the degree of success.

In conclusion, some trees and shrubs can be grown in selected sites at Estevan, but levelling to stabilize the soil is a must for quick rehabilitation. Reclamation can be expensive and the extent of work done is directly proportional to the purpose of the reclamation and the intended end use.

BIOENGINEERING IN RECLAMATION

Nick Horstmann
Western Canada Erosion Control Ltd.

The use of plants as construction materials is called bioengineering. Usually a mixture of grasses, legumes, shrubs is used in bioengineering project. But, the shrubs are of particular importance, especially those which have strong stems and roots, and which root easily from cuttings.

Today, I will discuss bioengineering as a reclamation technique and the kinds of situations where shrubs can be used. I will also discuss the sort of information we need so that we can make fuller use of our shrubs for reclamation in Canada.

Perhaps the simplest way to describe the subject would be to recount examples where bioengineering was tried. In general, bioengineering is used in areas where erosion is a problem and something must be done right away to stop erosion while laying the framework for permanent reclamation.

Steep slopes often present great reclamation problems. The common approach might be to hydroseed the slope with a grass-legume mixture or to plant a single species of trees in rows. The bioengineering approach would be to first establish a grass-legume cover, then plant a variety of shrubs and trees. This way, the different types of plant roots penetrate to different depths and thus hold the slope together much more effectively than if the roots all penetrated to the same depth. Also, the top of the slope must be rounded off. Otherwise, erosion will continue from the top of the slope burying the plants below.

Bioengineering was also used on sand dunes near Slave Lake. Very heavy cuttings were used. After one year the relationship between root and top growth was very good. Many shrub varieties were used as well as some exotic grasses. Some people suggest that we should not use exotic plants in reclamation, that we should only use native material. I quite agree but in many areas imported plant varieties are the only ones available.

Along a pipeline route where there was a break, we started by using spruce boughs to stop erosion. Four years after seeding there was a very heavy cover of grass and cicer milkvetch. I think this would be an excellent test site to see how well shrubs will grow in a grass-cicer milkvetch cover. Many people say that such a heavy cover could keep the shrubs from establishing. I am not sure, I feel that for most areas of Alberta that the grass-cicer milkvetch mix is the best for reclamation. Cicer milkvetch is very slow to establish. A helicopter was used to seed an area in the Swan Hills. It wasn't until five years that cicer milkvetch became established. I now have a good cover and a good grass-legume mix. This was accomplished without any innoculation of the cicer milkvetch seed.

At another site in Ram River we seeded cicer milkvetch beside a wellsite which had been seeded to grasses. The grasses were dying out.

Now there is a thick growth of cicer milkvetch and the grasses among the cicer milkvetch are vigorous. This would be another good test site for shrub research. We could look at the growth of shrubs planted among cicer milkvetch versus those planted in the improverished grassy area.

Procurement of shrub material for bioengineering can be a problem. We solved this problem at Luscar Coal Mines by simply putting down a sheet of plastic then a layer of peat moss with the willow cuttings. We did this in both fall and spring and had good rooting success.

Care must be taken in selecting plant species for bioengineering. Plants should be selected on the volume and strength of their root systems. In Japan, Indonesia and Europe institutes have been established which test the root strengths of plants. Presently, we have not examined in any detail the bioengineering characteristics of Alberta species.

Eroding river banks are also stabilized using bioengineering techniques. Willow wands are laid up the bank, perpendicular to the flow of water. The wands are kept in place by wire strung along the bank. The willows grow into the bank stabilizing it while providing a natural-looking aspect. If bank erosion is severe then rocks can be used along with gabions to stabilize the bank. The important thing to remember is by using bioengineering less rock is needed to secure the bank against erosion. Therefore, equipment costs are lower, in fact, with bioengineering the cost of the project goes down while creating a more stable bank.

A few words on reclamation in general: when topsoil is placed on slopes it must be mixed with the underlying soil, particularly if the subsoil is heavy clay. If this is not done the topsoil will wash away. Also, in order to do a good reclamation job and save money reclamation should be done as the project progresses.

CONCLUSION

Bioengineering means using plants as building materials. This is often done in conjunction with standard building materials. Properly employed, bioengineering speeds up the healing process and gives longer-lasting results.

We still need to know the varieties of plants in Alberta which would be suitable for bioengineering. We also need to know the optimal planting times for these varieties. These varieties should be examined in terms of root strength, survival and site preference. We also need more work regarding protection of shores and banks from erosion.

INTERIM REPORT ON SELECTED LANDSCAPE REHABILITATION PROJECTS IN THE WESTERN NATIONAL PARKS

J. Peepre
Western Region, Parks Canada

INTRODUCTION

Parks Canada's mandate includes the two-fold responsibility of protecting and preserving the natural environment, while providing opportunities for wilderness and facility-oriented recreation. Although this task may often seem to be contradictory, the intention is to achieve a balance between the two factors by utilizing effective management techniques. The interaction of people and the physical landscape creates a dynamic medium where both elements may be manipulated to achieve a desired result. Landscape rehabilitation is, therefore, a management decision, and as such may be pursued for a variety of different reasons.

Current capital projects and maintenance operations require a high degree of landscape development and rehabilitation within the following areas:

1. Site development projects (campsites, day use areas)
2. Highway landscaping (selective clearing and revegetation)
3. Disturbed site revegetation (gravel pits, fire roads, etc.)
4. Revegetation of over-used sites (trails, campsites)

The goal of the rehabilitation program is to re-establish a native vegetation cover in a species mix closely resembling the parent forest type. Rehabilitation projects are designed to blend in with the natural environs aesthetically as well as ecologically. Other sub-goals are to accelerate natural successional processes by introducing a given proportion of native climax species, as well as designing the site to avoid future damage through over-use.

Traditional landscape architectural approaches have not been satisfactory in meeting these goals, and thus new methods are being tried and tested. The Plant Materials Program is a major step in this direction. The first task of the program has been to develop an inventory of western native plants suitable for rehabilitation projects. The second phase will assess the capability of Western Canada's commercial nurseries to collect and grow containerized native plant material, with the final objective to provide a ready source of native plants for use throughout the western parks.

While the Native Plant Materials Program evolves the general framework of plant material requirements, a number of pilot projects have been implemented to test collection methods, growing of native plants, costing, and rehabilitation techniques. A summary of these pilot projects

comprises the remainder of this paper. It is important to note that the information included is by no means complete. The projects described are either in the planning phase or at the 50-60% completion stage. The intent of the report is to provide an initial insight into the types of ongoing projects, as well as some description of techniques and preliminary results.

LONG BEACH NORTH

Pacific Rim National Park.

The Site

Long Beach North is part of the Western Coastal Plain located along the western coast of Vancouver Island. Geological deposits in the immediate area are characterized by glaciomarine stony clays and silt with sand lenses, while the beach itself consists of sand beach deposits. The area is imperfectly drained.

Maritime climatic conditions are predominant, with 2500 - 3800 mm of precipitation, prolonged cloudiness, and a narrow temperature range from 5°C to 14°C. Due to this moderate climate, vegetation is lush, and growth rates are rapid. (Provisional Master Plan, Long Beach Unit, 1973).

Vegetation zones are distinctive with the following types identified as linear patterns graded from the beach to climax forest (after Bell, 1972).

Zone		Vegetation Association
Fore-Log	Sea Rocket	(Cakile edentula)
	Sea Purslane	(Honkenya peploides)
Drift Log	Beach Rye	(Elymus mollis)
	Beach Pea	(Lathyrus japonicus)
	Giant Vetch	(Vicia gigantea)
Post-Log	Salal	(Gaulthena shallon)
	Willow	(Salix)
	Wild Rose	(Rosa nutkana)
Sitka Spruce Fringe	Sitka spruce	(Picea sitchensis)
	Salal	(Gautheria shallon)
	Salmonberry	(Rubus spectabilis)
Beach Terraces	Red Alder	(Alnus rubra)
	Salmonberry	(Rubus spectabilis)
	Salal	(Gaultheria shallon)
Cedar-Hemlock Forest	Western Red Cedar	(Thuja plicata)
	Western Hemlock	(Tsuga heterophylla)
	Salal	(Gaultheria shallon)

A further important factor is the effect of constant cool breezes and salt spray resulting in a distinct krummholz effect, and an occurance of salt tolerant plants. Periodic flooding, nutrient leaching, and trampling by visitors must also be considered.

Scope of Project

Conditions prior to the project implementation included a parking lot in the post-log zone, and a highway located directly east of the Sitka Spruce fringe. Landscape development plans cover a 3.36 hectare site and included removal and rehabilitation of the beach parking lot, re-location of the old highway and revegetation of the old alignment, as well as addition of parking and walkways behind the Sitka Spruce fringe.

Rehabilitation Techniques

1. Biophysical data was consulted during the inventory stage to identify plant species, associations, linear zoning characteristics, soil types, and other factors.

2. Landscape development site plans and proposed rehabilitation areas were super-imposed on a map displaying biophysical data to identify the native vegetation type corresponding to proposed treatment areas.

3. Each site development and rehabilitation area was then designated a list of plant species, including information on dominance patterns, species frequency, soil and other factors.

4. Commercial availability of species was investigated and discussions were held with a horticulturalist to determine the feasibility of collecting and growing certain native plants. The following plants were considered essential to the rehabilitation program:

Plant Material Sources

Plant	Proposed Source	Quantity
Thuja plicata (Western Red Cedar)	commercial	500
Picea sitchensis (Sitka Spruce)	commercial	1500
Tsuga heterophylla (Western Hemlock)	commercial	150
Pinus contorta (Shore Pine)	commercial	12
Gaultheria shallon (Salal)	commercial	22,000
Polystichum munitum (Sword Fern)	commercial	870
Vaccinium ovatum (Evergreen Huckleberry)	collected	340
Picea sitchensis (Sitka Spruce)	collected	200
Rosa nutkana (Wild Rose)	contract grown	1310
Lonicera involucrata (Black Twinberry)	contract grown	735
Ribes divaricatum (Gooseberry)	contract grown	870
Rubus spectabilis (Salmonberry)	contract grown	4700

5. During the investigation of plant material availability and contract growing possibilities, the development of a rehabilitation plan proceeded with the classification of the site into four treatment zones. This classification was intended to reduce costs by separating high priority from low priority areas, but was also designed to demarcate rehabilitation types by biophysical unit. The four classes were arranged vertically on a chart with sub-titles listed horizontally to indicate type of zone, biophysical unit, phasing, site preparation techniques, plant associations, short and long-term maintenance.

6. Following the development of a rehabilitation plan a small service contract was let to Corbett's Nursery, Aldergrove, B.C. to collect cuttings from the wild and grow them under controlled conditions for one growing season as a pilot project. Results are indicated on the following page. Cuttings of roses, black twinberries, and gooseberries were collected from May 30 to June 15, 1978, and stuck in a media of three parts sand to one part perlite, with a treatment of Seradix I rooting hormone. Rooted cuttings were transplanted approximately six weeks later into 4 inch pots, with a growing medium of 70% sawdust, 20% peat, and 10% sand. Salmonberries were collected as root cuttings or by crown division, and were planted immediately into 4 inch pots. (Plants were collected and grown by Corbett's Nurseries, Aldergrove, B.C.).

PRELIMINARY RESULTS FROM CONTRACT TO COLLECT AND GROW NATIVE PLANTS FOR LONG BEACH NORTH*

Plant	Type of Cutting	Number Collected	Survival Prior to Planting	Per Cent Success
Rubus spectabilis (Salmonberry)	root cuttings crown division	4700	3150	67
Rosa nutkana (Wild Rose)	hardwood cuttings	1310	800	61
Ribes divaricatum (Gooseberry)	softwood cuttings	870	750	86.2
Lonicera involucrata (Black Twinberry)	softwood cuttings	610	610	100

* Plots have been established to monitor long term success of contract grown plants.

Data on top-growth to root-growth ratios have yet to be tabulated.

7. A contract was let to install plant materials according to the rehabilitation plan. The plan indicates classification areas, species, and quantities, while the final plant grouping and distribution will be directly supervised by a landscape architect. Close supervision has been deemed necessary to ensure site factors such as micro-climate, topography, and desired plant mixes are considered.

   The rehabilitation procedure included seeding of a nurse-crop during the late spring of 1978 to prevent excessive erosion prior to final rehabilitation. During the fall of 1978 further site preparation included scarification where required, rototilling, application of bonemeal and addition of topsoil mixed with decomposed sawdust in Class I (High priority) areas. Certain moderately erosion prone areas as well as Class I areas are to receive a bark and wood chip mulch. Fertilization of planting areas will be completed during the spring of 1979. Seeding of native grasses as well as wildflowers will commence in the spring of 1979. Grass communities are only to be established along road edges and potential erosion slopes.

8. Phase Two will include collecting Beach Pea and Giant Vetch seed (to be planted directly in the beach area, or grown under nursery conditions), and direct application of willow cuttings.

Assessment

Although it is too early to assess the overall success of the rehabilitation program, the methodology appears to be useful for the type of project under consideration. As the final goal is a self-sustaining duplication of the forest type it is felt that the detailed attention to site biophysical units as well as strict adherence to native plants are justified.

The initial phase of the project, including the contract growing of plant material appears to have been successful. The unit price of the contract grown plants is 73 cents, (60 cents for collection and growing, and 13 cents to install), a saving of at least 40% over comparable commercial stock, and considerably cheaper than transplanting directly from the wild. While the survival of rooted cuttings is encouraging, there is room for improvement both in handling and plant collection techniques.

Plots have been established at several locations to monitor the long term success of the rehabilitated areas. Factors such as survival, invasion by other species, competition, and growth rates are to be monitored.

MALIGNE LAKE HIGHWAY, Jasper National Park

The Site

The Maligne Highway environs are situated at an elevation of 1000 - 1500 m in the montane and sub-alpine vegetation zone of the

Northern Rocky Mountains. The continental climate is characterized by cool summers and cold winters with a mean annual temperature of approximately 2 degrees Celsius. Total precipitation is 400 mm with 70% in the form of snow, while average cloudiness through the summer is 58% (Kuchar, 1972).

The surficial geology of the area has a large variety of depositional features due to glaciation and erosive forces. Forest soils generally show a shallow profile with an eluviated Ae horizon (Kuchar, 1972).

Dominant vegetation types in the area are lodgepole pine and spruce-fir forest.

Rehabilitation Projects

There are several rehabilitation projects currently underway in the Maligne Lake area. These include:-

1. Preliminary collection and growing trials of native plants.
2. Maligne Lake Highway Landscape Planting.
3. Maligne Lake Highway Forest Recovery Program.

Preliminary Tests

The preliminary tests were carried out by Reid-Collins and Associates in 1976 to determine the feasibility of collection, propagation, and nursery cultivation of plant species native to Jasper National Park. Root cuttings and stem cuttings were collected from the Park for a variety of species and transported to the nursery where they were stuck in a rooting media of 75% course sand and 25% horticultural grade perlite. Four different strengths of IBA (Indole 3 butyric acid) powder were used. The flats were placed on a heated bench with a media temperature of 21 Celsius. When rooted cuttings were established they were transplanted into pots with a standard nursery mix of 75 parts sawdust, 25 parts peat, and 15 parts sand.

According to the nursery report, indications are that Arctostaphylos uva-ursi, Cornus stolonifera, Juniperus communis, J. horizontalis, Salix sp., and possibly Lonicera sp., and Sambucus sp., could be propagated commercially for Park rehabilitation purposes. The report indicated that Ribes sp., and Rosa sp., would best be propagated by using softwood cuttings taken in summer from nursery grown plants. Additional trials for Shepherdia canadensis, Symphoricarpos alba, and Elaeagnus sp. are required to determine suitability.

Maligne Lake Highway Landscaping

The Maligne Lake Highway was constructed in 1978, and allowance has been made for rehabilitation of the highway edges. A rehabilitation plan was adopted in 1976 and involved the collection and growing of plants from seeds and cuttings. Planting work will proceed in the spring and early summer of 1979.

The following plants have been grown:-

Plant	Method	Size at Outplanting in 1979
Pinus contorta	seed	15 cm
Picea glauca	seed	15 cm
Alnus sp.	seed	70 cm
Rosa sp.	cuttings	25 cm
Cornus sp.	cuttings	35 cm
Salix sp.	cuttings	70 cm
Juniperus communis	cuttings	15 cm
Arctostaphylos uva-ursi	cuttings	15 cm runner

Planting will be done on a random basis within specified zones although species numbers per acre have been identified. Plots will be established to assess the success of revegetation efforts, both in terms of survival of contract grown material, hydro-seeding, and the colonization of other pioneer species.

Jasper Forest Recovery Program

This program was designed to make use of existing plant material in Jasper in areas designated for future development. The old highway right-of-way situated between the newly constructed Maligne Lake Highway section and Medicine Lake supports a variety of trees and shrubs suitable for transplanting into selected rehabilitation and landscape development sites.

The project should supply useful data on plant species available for most transplanting purposes as well as information on techniques, size limitations, fertilizer requirements and other factors.

An inventory of selected trees and shrubs of a size deemed suitable for transplanting was conducted in the fall of 1978. This pool of available material will be alloted to projects in similar vegetation zone and elevation.

A pilot transplanting program was carried out in Mid-September of 1978 where 225 trees and 150 shrubs were moved to the Lake Edith-Annette area. Plants were dug and re-planted within several hours under cool wet conditions. Most planting areas consisted of sandy and gravelly till, with no addition of imported topsoil.

The following species were transplanted:

Plant	Size
Pinus contorta	30-60 cm
Picea glauca	30-60 cm
Pseudotsuga menziesii	25-60 cm
Populus tremuloides	25-90 cm
Abies lasiocarpa	30-50 cm
Shepherdia canadensis	30-60 cm
Ledum groenlandicum	30-60 cm
Rosa sp.	15-30 cm
Salix sp.	30-60 cm
Juniperus communis	10-25 cm
Betula glandulosa	15-25 cm
Ribes sp.	20-30 cm
Lonicera involucrata	30-50 cm

The preliminary success of the pilot program will be assessed during the early growing season of 1979 and recommendations as to species and techniques will be made at that time. Follow-up monitoring plots will also be established.

Heather Lake, Mt. Revelstoke

Heather Lake is situated at an elevation of 1950 m in Mt. Revelstoke National Park. The area has been disturbed and heavily over-used by Park visitors. In 1976, 25,000 plugs of native transplanted material were introduced to the area, with a follow-up in 1977 of 13,000 plugs. Sphagnum peatmoss, organic fertilizer, and lime were applied to the planting areas. Plugs of matt forming herbaceous species were spaced at 40-45 cm. These were collected from similar elevations.

Preliminary tabulations indicate a 95-100% survival, but with little initial growth. Larger plugs, water, fertilizer, and topsoil improved survival. (Hammer, 1977).

Snowshoe Fireroad, Waterton Nation Park

This fire road is only one of several to be rehabitated in the western parks. Techniques will include limited regrading, scarification, grass and legume seeding followed by transplanting of shrubs, trees and grass plugs to form "mini-communities'. Mulching will also be applied where deemed necessary.

No other data is available at this time, as the project is in the preliminary planning and design stages.

FUTURE RESEARCH NEEDS

This paper has attempted to provide some insight into the progress of rehabilitation programs in the Western Region of Parks Canada. At this time information is incomplete, but preliminary data indicate success in collecting and growing native plants, rehabilitation and cost reduction.

Success of the various projects will be monitored over time to assess a variety of factors such as long-term cost effectiveness, success of planted material, species competition, invasion by colonizing species, aesthetic impact, and resistance to visitor damage.

Information on plant species suitable for collection and growing, transplanting, and outplanting techniques, is incomplete. However, Parks Canada's experience within a variety of vegetation zones should provide some useful data in the near future.

Resistance of herbaceaous and woody plant species to human impact and wildlife browsing are other areas of concern. Furthermore, it is felt that proper application of design principles in rehabilitation projects will greatly increase planting success and decrease the possibility of future damage through over-use. These principles would include a thorough examination of the proposed use patterns and their control through properly designed circulation systems, planting areas and signage. The rehabilitation plan must accurately reflect the dynamic quality of the biophysical environment as well as incorporate the various forms of human impact.

REFERENCES

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Hammer, O; "Subalpine Revegetation", Parks Canada, 1978.

Kuchar, P., "Ecological Impact Study of the Maligne Lake Area, Jasper National Park", 1972.

Provincial Master Plan, Long Beach Unit, Pacific Rim National Park, Parks Canada, 1973.

The following firms have contributed to the program by supplying data, and assisting in the formation of rehabilitation plans.

Eikos Environmental Design Group, Vancouver, Canada.

Reid, Collins and Associates, Vancouver, Canada. (Corbett's Nurseries).

The following Parks Canada staff are directly involved in the rehabilitation programs outlined in the report, as well as several not mentioned.

Landscape Architecture Section -

Peter Coe
Erik Mustonen
Otto Hammer

Natural History Research -

Gail Fitzmartyn
Bruce Leeson

NATIVE TREE AND SHRUB PRODUCTION

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Provincial Tree Nursery
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We at the Provincial Tree Nursery have a responsibility to propagate native trees and shrubs for two clients. The principal production is for Provincial Parks replanting. The other area is propagation for reclamation requirements. The propagation of native stocks has been going on in increasing volume for over six years.

Our investigations are following two main avenues in the production of native stocks. First, we require the basic seed/cutting information. Of secondary necessity is information in the containerized growing of that material. In the realm of basic seed work, we are endeavouring to ascertain proper picking and cutting times, especially of the fleshy fruit varieties, as well as the improvement of the stratification and callousing procedures of difficult species such as Bearberry (Arctostaphylos uva-ursi).

The Provincial Parks production (up to 50,000 annual requirements) is being grown entirely in Spencer LeMaire containers and nursery pots up to an average height of 1.5 meters. In most of our native stock production, we had to start from zero base in all areas of propagation and total container requirements. There was not that much information available. We have used information from the"USDA Woody Plants Seed Manual" and personal contact with other researchers such as Ted Laidlaw and others to improve and expand our own information base. We are now able to propagate and grow with some success 38 different native tree and shrub species ranging from the White (Paper) Birch (Betula papyrifera) to Blueberry (Vaccinium myrtilloides). The attached appendix gives some idea of the types we are concerned with.

There a number of types that still give us trouble in germination and/or rooting. Some of the problem appears to be associated with picking times and years of collection as the germination varies more on a yearly basis within the same variety rather than on a individual type basis. We have improved the stratification techniques of a number of species such as Chokecherry (Prunus virginiana). Instead of requiring 5 months, we now can achieve germination in 2½ to 3 months. Balsam Poplar (Populus balsamifera) is easier to propagate by seed than by cuttings. We can now readily root many native willows and poplars in the field but the percentage is low. Our new misted propagation beds should allow us flexibility in solving this problem.

The improvements we have made in seed work and cutting procedure are for the most part still preliminary and require further evaluation. As we feel confident in our efforts, the results are publicized in publications, in particular, "Tree Planters Notes".

Equally as important and demanding is the growing of the propagated material. Our investigations are also concerned with growing

medium, container size, and the adaptability of the stock to containers. Native stock appears to do somewhat better in containers than bare root or field grown. In particular, we found birch (B. papyrifera) does very poorly under field conditions, but exceedingly well in container greenhouse conditions, particularly when out planted.

It is difficult for a nurseryman to start many native trees and shrubs when he is at the end of a natural process. If late spring frosts don't kill the flower, if disease doesn't destroy the embryo, if worms or insects don't eat the seed; the nurseryman just may be able to propagate native stocks from the seeds left after the squirrels and birds have taken their share!

APPENDIX

Trembling Aspen
Populus tremuloides

Balsam Poplar
Populus balsamifera

Chokecherry
Prunus virginiana

Wolf Willow
Elaeagnus commutata

Dogwood
Cornus stolonifera

Cinquefoil
Potentilla fruticosa

Wild Rose
Rosa woodsii

Jack Pine
Pinus banksiana

Lowbush Cranberry
Viburnum edule

American Elder
Sambucus canadensis

Bog Cranberry
Vaccinium vitis-idaeus

Blueberry
Vaccinium myrtilloides

Gray Alder
Alnus incana

Scarlet Elder
Sambucus pubens

Snowberry
Symphoricarpos albus

Silver Buffaloberry
Shepherdia argentea

Prickly Rose
Rosa sp.

Highbush Cranberry
Viburnum trilobum

Paper Birch
Betula papyrifera

Thinleaf Alder
Alnus tenuifolia

Pincherry
Prunus pennsylvanica

Caragana
Caragana arborescens

Russet Buffaloberry
Shepherdia canadensis

Bracted Honeysuckle
Lonicera involucrata

White Spruce
Picea glauca

Ground Juniper
Juniperus communis

Saskatoon
Amelanchier alnifolia

Bearberry
Arctostaphylos uva-ursi

Black Alder
Alnus glutinosa

Crowberry
Empetrum nigrum

Raspberry
Rubus idaeus

Sitka Mountain Ash
Sorbus sitchensis

Western Mountain Ash
Sorbus scopulina

Beaked Hazelnut
Corylus cornuta

Lodgepole Pine
Pinus contorta v. latifolia

Northern Gooseberry
Ribes oxyacanthoides

AOSERP WORK IN SHRUB RESEARCH

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ABSTRACT

Slides were shown to demonstrate the type of problem analysis conducted on the projects when the author assumed responsibility, the types of problems recognized as high priority, and the research projects initiated to solve the problems. It was demonstrated that there were a variety of vegetation associations in nature and explained that projects to determine productivity had been initiated. These studies developed directly from the problem analysis because the legal reclamation requirement makes mandatory the knowledge of productivity prior to disturbance.

Recognizing that successful reclamation must allow the government and the operator to cease all maintenance before an area can be considered reclaimed, the AOSERP problem analysis determined that native trees and shrubs would be required because those were the only species where life history data could assure climatic adaptation allowing survival and reproduction without propagules from local populations of native species.

Testing of seedlings in the tailings and spoil areas has been severely handicapped because of extensive seedling damage by small mammals. From the problem analysis it was evident that the small mammal population had to be characterized in the area under reclamation to determine if unique situations existed. This is still underway, while at the same time a study of the available methods for control of damage to shrub and tree seedlings is being conducted. These methods include exclosures so that seedling response to other environmental factors of micro-climate and air pollution can be conducted.

Resulting from a general problem analysis AOSERP has developed a program of research on reclamation with trees and shrubs which is moving forward on several problems at the same time. Results will start coming available in quantity in another year.

NURSERY ACTIVITIES AND PRODUCTION OF NATIVE TREES AND SHRUBS

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The PFRA Tree Nursery was established in 1902 by the Department of the Interior, to provide tree and shrub material to settlers on the prairies. Through various political changes it has come under other departments and is now under PFRA. At the present time the Tree Nursery distributes tree material free of charge to farmers, municipal, provincial and federal government agencies, charitable organizations and rural small holdings. Our tree distribution to non-farm applicants has increased from less than 3% of total production in 1960 to 20% of total production in 1977. The increase was due to a greater demand for plant material from government agencies for wildlife and reclamation plantings. Over the years the Tree Nursery has introduced various tree and shrub species for shelterbelt use. Many of these have proven to be highly satisfactory (i.e. caragana). In the last 15 years we have tested various native tree and shrub species for use in prairie plantings. On the basis of extensive regional testing both chokecherry and buffaloberry were deemed suitable for shelterbelt plantings, with over 20 other species rejected for various reasons.

Initiation of Species Production

Before initiating production of a species, one must have a demand for it. This demand could be initiated by various government agencies, for specialty planting or by the Tree Nursery itself to replace problem species, for example, the American elm, which is susceptible to Dutch elm disease, is being replaced by the Japanese elm.

One of the first things that must be done is a very thorough literature review. The USDA Woody Plants Seed Manual is a good place to start. Tree Planter's Notes is another good source of information.

When the literature review is complete, seed is acquired either from the people requesting the stock or from our own seed orchards. A test sowing is then made following any recommendations for stratification. If there are no recommendations then one must proceed by trial and error, (i.e. plant in the fall and wait to see how things turn out). With the seedlings thus acquired, nursery plantings are established which are evaluated after five years. Parameters involved are hardiness, growth and suitability. If the species performs satisfactorily over a fairly wide geographical area and the decision is made to go into production, a standard series of steps are followed to cover such aspects as seed work and planting survival.

METHODS

1) Seed maturity is looked at as there is no point in planting seed and getting germination in the range of 10-20%. For example, with Siberian

elm if you pick the seed to soon, you will be lucky to get 40% germination, whereas if you pick seed when dry, around 10-15% moisture, germination can be as high as 70%.

2) Seed sources and harvesting methods are then looked at. Hand picking is tedious. For this reason we have evaluated mechanical and chemical harvesting. Using the test chemical UBI, buffaloberry fruit started to drop within a week. The fruit dropped into tarpaulins and the total time for spraying and collecting the 40 pounds of fruit was a little less than one hour.

3) Once the seed is collected it must be either dewinged or cleaned.

4) One problem with many shrub species is that they need a stratification and sometimes other treatments to break dormancy. For example, germination of rose seed can be increased from 5 to about 80% by treatment with acid. To avoid time-consuming and costly stratification procedures seed is sown in the fall whenever possible. With some species like chokecherry it was determined that the seed needs a warm treatment first then a cold treatment. Therefore, chokecherry is sown around August 5 so that it lies in warm soil before winter, which results in stands of 80 to 90%.

5) Viability of seed is tested to help plan sowing rate.

6) Studies are then undertaken to determine the best seed storage temperature. It is necessary to have several years seed supply in stock in case of a seed crop failure.

7) Extensive testing of herbicides is conducted which ultimately results in the reduction of manpower required for production. Without herbicides production of bare root stock would be extremely expensive.

8) For each species replicated sowing trails are run in the field on the rate, depth and sowing date. To get accurate sowing depths a specialized shrub seeder had to be developed. Both poplar and willow planting has been mechanized and is very efficient with over 1.5 million cuttings planted in less than four weeks.

9) In the fall of the second year we lift most of the plant material and heel it in. In spring, material is brought in from the heeling-in plots and is packed, with about 3,000 bundles per day being distributed. To put out 7,000,000 trees takes about two weeks. (construction of a cold storage building has been started which will hold about 5,000,000 seedlings, and will enable us to increase production considerably).

SPECIAL PROJECTS

a) In 1974, the Tree Nursery received a request from Saskatchewan Power Corporation to initiate a series of studies on the coal mine site at Estevan. Test plantings were established using contour plantings around slopes and herbicides to control weeds. Some work with container

stock was started in 1976. The results of these plantings are somewhat questionable due to wet springs since 1975, however, the results indicate that survival of bare root stock equalled that of container plantings. A 32 cubic inch container made of decomposible tar paper was used for this study. Some 'dishing' studies were initiated, where a backhoe dug small holes into which trees were planted. The results were variable; in dry years it worked well but in wet years shrubs which do not like wet feet, like buffaloberry, died out. We also tried using polymulches, and these were more successful. Some plants established in 1975 are now five - six feet tall and results look promising.

b) A large number of test plantings have been established on the prairies. Some of these are used as wildlife projects, however, the majority of test planting sites are connected with the shelterbelt program.

c) Species selection and improvement are also carried out. Considerable work with hybrid poplars has been conducted, with one clone found to be vigorous on adverse sites, whereas others do poorly. It is important to be familiar with the various poplar clones available as many are quite susceptible to disease and insect pests.

SPECIES	SEED COLLECTION DATE	SEED CLEANING	SEED STORAGE	RATE	SOWING DATE	DEPTH	HERBICIDES	YRS TO	WINTER STORAGE	FUTURE REQUIREMENTS . ETC.
Acer ginnala	Sept - Oct.	de-wing	-18°C	75/ft.	Sept. - Oct.	1"	Linuron for 1-0	2	heeled-in outdoors	Excellent survival herbicides for sowings
Amelanchier canadensis	July	debvig	-18°C	75/ft	Oct.	½"	Linuron for 1-0	2	32°F	Fair survival herbicides for sowings
Caragana arborescens	August	NA	room temp	60/ft	June	3/4"	Pre-emergence Chloroxuron Post-emergence 1-0 linuron	2	32°F heeled-in	Excellent survival
Celtis occidentalis	Oct.	debvig	-	-	Oct.	3/4"	-	2	-	Poor survival and slow growth
Cornus stolonifera	August	debvig	-18°C	70/ft	Oct.	1"	Linuron 1-0	1 or 2	32°F or heeled-in	Good survival
Cotoneaster acutifolia	Sept. - Oct.	debvig	-18°C	-	Oct.	-	Linuron 1-0	2	heeled-in or 32°F	Excellent survival
Cratageus sp.	Sept.	debvig	-	-	August	3/4"	-	2	-	Good survival
Eleaagnus angustifolia	Oct. - Nov.	debvig	-18°C	50/ft.	Oct.	3/4"	Linuron 1-0	2	heeled-in or 32°F	Good survival
Eleaagnus commutata	Oct.	debvig	-	-	Sept.	3/4"	-	2	-	Good survival

Propagation Unit - PFRA Tree Nursery

SPECIES	SEED COLLECTION DATE	SEED CLEANING	SEED STORAGE	RATE	SOWING DATE	DEPTH	HERBICIDES	YRS TO	WINTER STORAGE	FUTURE REQUIREMENTS
Hippophae rhamnoides	Oct. - Dec.	debvig	-18°C	50/ft	Oct.	3/4"	-	2	heeled-in or 32°F	Good survival
Lonicera tatarica	August	debvig	-18°C	60/ft	Oct.	½"	-	2	heeled-in or 32°F	Excellent survival
Malus baccatta	Sept. - Oct.	debvig	-18°C	50/ft	Oct.	½"	Linuron 1-0	2	heeled-in or 32°F	Good survival
Physocarpus glabratus	Oct.	shaking & wind	-	-	Oct.	¼"	-	2	-	Poor survival
Prinsepia sinensis	Sept.	debvig	-	-	August	1"	-	2	-	Poor survival
Prunus besseyi	Sept.	debvig	-	-	Sept.		-	2	-	
Prunus fruticosa	Sept.	debvig	-	-	Sept.		-	2	-	Poor survival
Prunus maaki	August	debvig	-	-	Sept.		-	2	heeled-in	Good survival
Prunus nigra	Sept.	debvig	-	-	Oct.	1½"	-	2	heeled-in or 32°F	Good survival
Prunus padus	Aug.	debvig	-	50/ft	Oct.	1"	-	2	heeled-in or 32°F	Good survival

SPECIES	SEED COLLECTION DATE	SEED CLEANING	SEED STORAGE	RATE	SOWING DATE	DEPTH	HERBICIDES	YRS TO	WINTER STORAGE	FUTURE REQUIREMENTS
Prunus triloba	Aug. - Sept.	hand	-	-	Sept.	1½"	-	2	heeled-in	Fair survival
Prunus tomentosa	July - August	debvig	-	-	Sept.	1"	-	2	heeled-in	Good survival
Prunus virginiana melanocarpa	July - August	debvig	-18°C	50/ft	Oct.	1½"	Linuron 1-0	2	heeled-in or 32°F	Excellent survival
Ribes sp.	Aug.	debvig	-	-	Oct.	-	Linuron 1-0	2	heeled-in	Fair survival
Rosa sp.	Sept.	debvig	-18°C	40/ft	Sept.	3/4"	Linuron 1-0	2	heeled-in or 32°F	Excellent survival
Sambucus racamosa	Aug.	debvig	-18°C	100/ft	Oct.	½"	Linuron 1-0	1	heeled-in or 32°F	Good survival
Shepherdia argentia	Oct.	debvig	-18°C	50/ft	Sept.	½"	Linuron 1-0	2	heeled-in or 32°F	Excellent survival
Sorbus sp.	Oct.	debvig	-	-	Oct.	½"	-	2	heeled-in	Good survival
Syringa villosa	-	shaking screening	-18°C	75/ft	Oct.	3/4"	Linuron 1-0		heeled-in or 32°F	Excellent survival
Vibernum trilobum	Sept.	debvig	-	-	August	3/4"	-	2	Heeled-in	Poor survival Double dormancy

WORKING GROUP I - Propagation

Participants

Mr. Paul Ziemkiewicz, Moderator - Alberta Energy & Natural Resources
Mr. Doug Culbert - Alberta Fish & Wildlife
Mr. Tom Shopik - Great Canadian Oil Sands
Dr. Gordon Howe - Indian Head Nursery
Dr. Herman Vaartnou - Vaartnou & Sons
Mr. George Grainger - Oliver Nursery, Alberta Agriculture
Mr. Dick Hillson - Forest Science, University of Alberta
Mr. Peter Etheridge - Pineridge Forest Nursery, Alberta Forest Service
Mr. Ted Laidlaw - Alberta Environment
Ms. Sharon Guenette, Secretary - Alberta Energy & Natural Resources

Discussion Topics

Collection of Fruit
Seed Extraction
Seed Storage
Pregermination Treatment
Germination Tests
Raising From Seed
Cutting Collection
Cutting Storage
Preplanting Treatment
Raising From Cuttings
Nursery Handling and Treatment
Literature Review

DISCUSSION

ZIEMKIEWICZ: The idea behind this working group was to get all of the experts in one room to try to catalogue all of what is known in the way of Native Shrub propagation. Do we know as much as we have to know? Particularly we want to find out what areas require further research.

I was interested to hear that in Gordon's work in Saskatchewan, he was using abscisic to aid in seed harvesting.

HOWE: Yes, we have used abscisic compounds experimentally, but they are not registered for commercial use yet. Others such as endothal and ethryl are on the market though not necessarily for this use. For other hard-to-pick species such as chokecherry and caragana, the nurserymen have their own way of procuring seed. For prickly species such as buffaloberry and buckthorn, clipped off short seed-producing branches are collected, then the fruit are picked off one by one; you can imagine the costs. That is why we are interested in chemical fruit harvesting. There are several mechanical harvesters also available on the market.

GRAINGER: We've tried the small fruit harvestor which is a vibrator attached to the branch so that the fruit falls into a canvas bag. As long as the fruit is mature it works well.

HOWE: Does it work for chokecherry?

GRAINGER: We've only tried it on saskatoon, buffaloberry and Russian olive. But I think the collection of the fruit, be it mechanically or chemically aided, is not as important as the timing. Because it may be hardest to collect at the time when it is most viable for germination.

ETHERIDGE: Do you look at moisture content of the seed prior to harvesting?

GRAINGER: No, just maturity of the fruit, this ties in with moisture content but the premise here is that if we harvest the seed when it is most easily harvested, then it may not have met is stratification requirements.

VAARTNOU: We collected seed at three different times. When collected very early germination was about 10%, when seed was ready we got approximately 40% and when collected two days after first killing frost, germination was 90% without stratification. So sometimes I wonder how much we know about sub-zero stratification on Native Shrubs. We think this may be very important in Native Shrub germination.

ZIEMKIEWICZ: Pincherry, I've heard, needs a warm period than a cold period in order to germinate.

GRAINGER: This is true of shrub seed in general.

VAARTNOU: We collected willow seed in early September. We got about 100% germination. But when the seed was stored at low temperature for a week germination went down to about 30%. And after stratification germination went back up again. So if seeds are not stored at the right temperature a secondary dormancy may be imposed.

ZIEMKIEWICZ: Regarding seed extraction, pulpy fruit or those with large wings cause handling problems. Do you have any experience with seed extraction devices?

HOWE: With Manitoba maple, commercially available de-wingers work well without damaging the seed. So this is no problem. Regarding extraction of pulpy fruit, I haven't had much experience with that though I have heard that the Dybvig extractor works well.

GRAINGER: A new extractor from the Northeastern United States is used for large fruit operations, it has a capacity of 2 bushels vs. 1/2 bushel for the Dybvig.

HOWE: A lot of commercial nurseries are now taking pails of apples, they let them rot until very soft then mash up the pulp and sow the entire contents.

ZIEMKIEWICZ: This is sometimes done with tomatoes, the acidity generated in fermentation kills wilt fungi on the seed coat.

Back to seed storage. What effects might storage temperatures have on germination.

GRAINGER: As Herman mentioned cold storage may put some seeds into secondary dormancy. Which is not in keeping with the native environment.

VAARTNOU: This year I collected Dryas in the middle of August and germination was 100%, but after cold storage germination went down to 53%.

LAIDLAW: With some species of prunus and hazel, if seed is kept too dry then after long-term storage low viability problems may arise because of dessication. This perhaps needs more research, particularly with hazel.

HOWE: We tried hazel but it did not survive the droughts in Saskatchewan. We have problems storing oak seed. It sets seed sporadically, so it must be stored for long

periods. However, if it is kept dry enough that seed moisture drops below 40%, then you are wasting your time planting it. We have been unable to store it for one year, then it sprouts in storage regardless of temperature. This, then, requires special handling in planting, as the sprouted seeds cannot be used in a normal seeder. Also, storage below freezing kills the seed.

LAIDLAW: Doesn't burr oak naturally germinate in late summer and early fall right after falling from the tree?

HOWE: Oak requires at least thirty days if stratification after harvesting.

GRAINGER: We've had them germinate in the collecting baskets.

LAIDLAW: I understand that many of these "difficult" seed can be kept for a year or two. But if they're to be kept for four or five years, then they have to be dried out somewhat and this will often impair germination.

GRAINGER: It is the same with hazel. Though demand has been so high that we've sown all the seed that we can get.

ZIEMKIEWICZ: Pre-germination treatments. What must be done to get these seeds to germinate? For example, is it better to plant the seed in fall and let it stratify naturally or to stratify it artifically and plant in spring? Also, how many of the dormancy problems are simply the result of hard seed coats? e.g. pincherry or chokecherry.

VAARTNOU: I tried acid-scarification of pincherry seed but with no success. However, after six months of stratification ($40^{o}C$) we got 50% germination. Sub-freezing temperatures may crack the hard seed coat. It seems that best germination is achieved if pincherry seed is collected around July, remembering that the date will change as one travels from north to south. Also, if the seed is not picked at the correct maturity stage pre-germination treatment becomes critical.

ZIEMKIEWICZ: Pincherry is known to germinate vigorously after fires. The fire may crack the seed coat and provide a heat treatment necessary for germination.

LAIDLAW: If you let pincherry germinate naturally under field conditions there's no problem getting high germination, it's just the amount of time involved, isn't that right?

GRAINGER: Yes, we've had problems with pincherry for this reasons and have given up trying to produce it on a large scale.

ETHERIDGE: Relevant to this discussion there seems to be a need for some sort of seed lot classification system.

ZIEMKIEWICZ: On the basis of seed source?

ETHERIDGE: Yes.

VAARTNOU: It is important to keep these differences in seed source in mind even within a species.

ZIEMKIEWICZ: Germination tests. When moving to commercial-scale production, this will be critical. With agricultural varieties there are standard procedures for germination testing. This includes standardized testing temperatures for example, is there anything similar to this for shrubs?

VAARTNOU: Do you mean live seed or viable seed?

ZIEMKIEWICZ: The distinction should be made. The commercial grower is more interested in viable seed. For direct seedings in reclamation knowledge of the percent live seed might suffice.

HILLSON: Agricultural species are bred to germinate at the same time whereas native perennial species have been selected to germinate over a wide time period so the seedlings do not all get killed by one disastrous event.

ZIEMKIEWICZ: I don't think we want to breed that out either if we're interested in self-perpetuating reclamation plants.

HOWE: Several companies are marketing seed germinators which control temperature and moisture. We purchased one some years ago, and used it for a number of years. The results we got from the germinator did not correspond to the results that we got in the field. So now we run our germination tests in greenhouse flats. We are trying, incidentally, to sell a germinator if anyone wants it.

GRAINGER: Have you measured a correlation between field germination and greenhouse germination?

HOWE: Yes, germination tends to be better in the greenhouse. Also, this tendency holds true for poplar cuttings where we might get a nearly 100% take in the greenhouse, but only 50-60% in the field. We cannot figure out why.

ZIEMKIEWICZ: Could this be attributed to small mammal damage?

HOWE: No, in fact, they will start to flush then suddenly die.

ZIEMKIEWICZ: Do you use sterilized soil in the greenhouse?

HOWE: No, not for cuttings.

HILLSON: It may have something to do with soil temperature.

HOWE: Possible.

VAARTNOU: It may be due to fungus disease on the roots. This can often kill young seedlings.

LAIDLAW: When seedlings grow in the wild they undergo stratification under natural conditions. When we stratify artifically we take pains to ensure that temperatures do not go below $0^{o}C$, because we do not want to damage the seed once it has taken up water. Yet, in the wild, this exposure to sub-freezing temperatures during stratification must often occur. We still don't understand everything about the natural stratification process.

VAARTNOU: These rules were made for other areas and other plants. They may not apply here.

HILLSON: More knowledge of the effects of freezing would be helpful, particularly in the case of heavy-walled seed like pincherry.

LAIDLAW: It would be helpful if we could monitor field seedbed conditions and record the soil temperature during natural stratification and germination of, say, pincherry.

VAARTNOU: We have experience with native legumes where, even after scarification in the laboratory, we couldn't get them to germinate in the field. They did not come up the first two years. So we planted something else in the rows and in the third year the legumes came up.

ZIEMKIEWICZ: So, I guess I can safely say that there are no standard germination tests for shrubs that are widely used by shrub growers.

GRAINGER: Some of the international seed testers rules are followed to determine germination percentage, but it does not indicate viability or germinability.

VAARTNOU: This germination data would not readily indicate viability under field conditions.

GRAINGER: Right.

ZIEMKIEWICZ: Raising from seed. How does raising from seed compare with raising from cuttings? Some shrubs that would be excellent reclamation plants just do not seem to produce sufficient viable seeds. For example, mountain alder. The USDA Woody Plant Seed Manual places its germination at 3%. This would dictate raising mountain alder stock from vegetative material.

VAARTNOU: We worked with mountain alder and found that after four months of stratification we got very good germination. Less than four months and germination was very poor. Alnus crispa did not require any stratification.

LAIDLAW: I've obtained high germination of Alnus crispa without stratification. However, stratification accelerated germination. In general, without stratification, alders germinate much more slowly than birches.

ZIEMKIEWICZ: What are the advantages of raising stock from seed versus from vegetative material?

VAARTNOU: Raising from seed is 1/2 to 1/3 the cost. (general agreemen

ZIEMKIEWICZ: With a species such as willow do the long seed hairs make handling difficult?

VAARTNOU: No, we just plant a catkin in each pot. Then thin out the extra seedlings so it's much easier and quicker to just collect the catkins than to collect cuttings.

LAIDLAW: On highly disturbed sites we often don't know what genotypes are most appropriate. By using cuttings we start out with a much narrower genetic base than if we plant material grown from seed. This is particularly true if your cutting material is collected from just a few clones, as has often been the case.

HILLSON: Yes, this can happen in any vegetative propagation. And may even be used to good advantage in reclamation where you're selecting for often very narrow site requirements.

VAARTNOU: In willows there can be as much variation among varieties or ecotypes within a species as among species. In Salix glauca some varieties set seed in spring and if you do not collect it within a week, you lose everything. Others are ripe in April or as late as October.

ZIEMKIEWICZ: Does this follow an elevational or latitudinal gradient?

VAARTNOU: Yes, as you go north the willows tend to set seed earlier.

ZIEMKIEWICZ: Some studies have tried direct seeding of shrubs in reclamation though I haven't found any reports where this has worked.

VAARTNOU: Willow, birch and alder may be planted this way. They should be harrowed in along with the grass seed. They should not be hydroseeded.

HOWE: In the Whitemud Watershed in Manitoba direct seeding was done with saskatoon, chokecherry and others. The results have been very variable, it all seems to depend on site preparation.

HILLSON: Dr. Vaartnou, you've collected quite a lot and over a number of years, particularly in regards to cuttings. Do you find yourself collecting in a given area or do you sort of randomize your collecting sites?

VAARTNOU: We select ecotypes, we select the plants that we are using on the basis of species and ecotype, we recognize these by their appearance.

HILLSON: I was wondering if you could conceiveably overcome the difficulties in collecting cuttings by treating these wildlings almost as nursery material, by cutting them back to ground level then taking the cuttings from the re-growth.

VAARTNOU: Yes, this winter I brought some plants from the Yukon to my nursery in Victoria, and that's exactly what I'm trying to do there.

HILLSON: But do you do it on site, in the wild?

VAARTNOU: No, I can't go to the Yukon everytime I need cuttings, so I selected the plants and replanted them in my nursery.

LAIDLAW: I was discussing this with fellows working in the Eastern Slopes, this idea of cutting them back, stooling them on site. It was suggested that this might cause problems with moose browsing the young shoots. Do you think this might be a problem?

VAARTNOU: Maybe, but I cannot say for sure, for now I would not consider that an important factor. On the pipeline route where moose were numerous, we planted wildling shrubs and trees 30-45 cm tall with a good root systems. We had nearly 100% success and the moose did not pull up the plants. When we planted in the fall we had the best success, spring plantings were not nearly so successful.

LAIDLAW: You said, then, that you were comparing small planting stock to large stock, and spring vs. fall planting.

VAARTNOU: Right, and small plants in spring were not good at all.

We did a project in Dixonville, Alberta, where the slopes were very high in Aluminum (pH 3.2). The slopes were bare except for a few pincherry creeping in. We tried grass seeding, liming, fertilizers, etc., and we had no success. Then we went to the shrubs and we got at least 60% success.

They were still growing after three years though I don't know how long they'll last. Pincherry, roses, raspberry and Potentilla fruticosa all grew well. The material was grown in the greenhouse from seed in containers.

ZIEMKIEWICZ: Getting back to the willow plantings that you did, did you take any soil with those roots?

VAARTNOU: No, we just pulled them right up. But we waited until the soil was quite moist.

ZIEMKIEWICZ: A benefit of using wildlings is that you've got whatever mycorrhizal organisms or N-fixing bacteria that are available to the wild plant.

It is difficult to get innoculation on shrubs planted on sterile mine spoils? I'm thinking of shrubs like snowberry and buffaloberry.

VAARTNOU: No, in my experience the innoculum for native N-fixing shrubs is unbiquitous even in Oil Sand Tailings, we planted the seeds of native shrubs and when the shrubs developed they had nodules.

ZIEMKIEWICZ: So the innoculum could be on the seed coat?

VAARTNOU: Perhaps, though innoculation even occurs on cuttings.

HOWE: Even on caragana this happens, though often not until the second year. Nodulation occurs whether or not caragana had ever been there. The innoculum can become airborne and apparently spreads that way.

VAARTNOU: Innoculation of native material is no problem. One thing I don't know about is the mycorrhizal fungi, how much do they aid shrub growth and how easily do they innoculate shrubs on mine spoils?

ZIEMKIEWICZ: Cutting storage. This seems to be a problem with operators using vegetative material. Particularly where storage facilities are scarce. What conditions are necessary to keep the material viable over the winter.

HOWE: There are two kinds of cuttings: softwood and hardwood, softwood cuttings are taken during the growing season and still have the leaves on. This type of cutting is usually put directly in a misting bed and rooted. Hardwood cuttings are taken in the fall and winter. Hardwood cuttings, large and small, are easy to store. They are usually kept just above $0^{o}C$. Poplar and willow are easy to store this way. Usually the cuttings are dipped in captan prior to storage.

The biggest problem is making sure that when you cut your stools off that you make them into cuttings in a cool place, then put them into storage immediately. A large box of cuttings, say 1,000 lbs., gives off a significant amount of heat so care must be taken to ensure that they are cooled off rapidly. It may take two weeks to get the temperature down.

ETHERIDGE: With the six inch cuttings are you taking into consideration the number of buds on the section?

HOWE: We took several thousand cuttings of different sizes and planted them on a production basis. We found we had the best results with 15 cm cuttings (poplar and willow).

GRAINGER: Was there any increase in growth rate with larger cuttings?

HOWE: Even with 15 cm rooted cuttings, by the fall after planting some grew as much as 6 ft. So there is enough food reserve in the 15 cm cutting to give a pretty good stand. So, I see no advantage to a longer cutting.

ZIEMKIEWICZ: Do you have a diameter limitation?

HOWE: We have criteria simply because our cuttings planter will not take larger cuttings. The ideal diameter is about the size of my little finger.

GRAINGER: We found that the best size was between 3/16 and 3/4 inch. Larger cuttings work well, but become more difficult to handle.

VAARTNOU: Have you done any work with alder cuttings?

HOWE: We don't produce alder for shelterbelts because they are not drought tolerant.

VAARTNOU: Has anyone had any luck with alder cuttings? GROUP No.

HILLSON: What time of year do you take your cuttings?

VAARTNOU: Usually in February.

HOWE: Has anyone had any luck rooting Russian olive cuttings? GROUP No.

ETHERIDGE: What do you dip your cuttings with and why do you do it?

HOWE: For fungus control while in storage, though I have my doubts as to whether it is worth it. We may change this practice.

HILLSON: Benlate seems to stimulate rooting as well as control fungus.

HOWE: We tried Benlate for cuttings. We found no significant stimulation of root growth.

LAIDLAW: Captan used for damp-off control in seedlings may have some adverse effects on seedlings of small-seeded plants.

HOWE: Some work was done in 1969-70 on seed coatings with Captan and various fungicides with conifer seeds. It was found that most of these had deleterious effects.

LAIDLAW: Particularly, fungicides seem to affect the cotyledeon stage of plants such as Arctostaphylos. At the growth stage when you're most tempted to use it as a precaution that's just when the fungicides seem to do the most damage.

HOWE: I would suggest that for the hard to grow shrubs (excluding chokecherry) that there would be benefit from use of soil fumigant. It would cost about $500/acre, but compared to the cost of raising the stock and planting it, it is cheap insurance.

LAIDLAW: Only a few species are really susceptible to damping-off.

ZIEMKIEWICZ: Are fungus problems greatest in seedings or cuttings?

VAARTNOU: Seedlings, particularly small ones.

HOWE: If you follow the correct cultural practices for deciduous species, it isn't even much of a problem with seeded material Just prior to germination the seedbed can be sprayed with a chemical known as "Nodamp". This makes a big difference.

LAIDLAW: I've used "Nodamp" and I'd say that with some species even using correct procedures, you can have a problem with damping-off. But only a few species are susceptible: aspen, Arctostaphylos uva-ursi, saskatoon. Aspen is particularly vulnerable in the first 24-48 hours, just as it begins to germinate.

VAARTNOU: The damping-off fungus seems to be carried on the seed coat. I found this to be true with buffaloberry.

HOWE: Have you tried seedcoat sterilants.

VAARTNOU: I feel that they do as much damage to the seed as the fungus would. Particularly shrubs like Vaccinium, Dryas, Arctostaphylos.

ZIEMKIEWICZ: Do you get seed damage with chlorox?

VAARTNOU: We tried it with the large seeds but not with the small ones.

LAIDLAW: There is certainly room for research into ways of disinfecting seeds of many of our native shrubs species and not just the seed coat, but the seedlings environment as well.

VAARTNOU: But seed coat sterilization may, at the same time, kill nitrogen fixing organisms also carried on the seed coat.

LAIDLAW: Are the spores carried on the seed coat?

VAARTNOU: I strongly suspect that they are. Because even on sterile oil sands tailings, shrubs nodulate with no artifical innoculation. There is no other way that the innoculation could come in.

LAIDLAW: On some of these shrubs, like Elaeagnus and Prunus, the seedlings are very vigorous and no special treatment is needed. For others that are more susceptible, seed coat sterilization and seedbed fungicides seem like an attractive system, but I think that we need to know more about what deleterious effects these sterilants might have on the seeds and whatever mycorrhizal fungi might be present.

HILLSON: This points up one of the advantages of the polyfilm type greenhouse. This type allows you to periodically expose the greenhouse interior and thus, remove a lot of the fungal spores. The standard permanent greenhouse is a marvelous means of perpetuating every plant disease organism on the face of the earth.

GRAINGER: By spraying chlorox on the greenhouse walls and practically everything else in the greenhouse once a year, we have virtually eliminated our disease problems.

ZIEMKIEWICZ: Do you tend to get more damping-off problems in container grown seedlings than in those grown open beds?

HOWE: With conifers we plant them in beds with sides and if we do not fumigate with mylone, forget it. With mylone you may lose 10% of the seedlings but we just overplant to compensate.

LAIDLAW: At what concentration and time interval do you use chlorox for seed coat sterilization?

HOWE: We used Javex as a 1-2% solution in greenhouse tests prior to stratification. We apply it before the seed has imbibed moisture.

ZIEMKIEWICZ: Preplanting treatments for cuttings. Are any special treatments required prior to rooting?

HOWE: As long as the cuttings were stored at or near $0^{o}C$ there is little more that could be done. Slight elevations in storage temperature were tried prior to rooting in an effort to increase rooting rate, but this was found to have no effect.

ZIEMKIEWICZ: Are there any special handling considerations that haven't been mentioned yet?

VAARTNOU: Which is the best cutting angle and the best location of the cut?

GRAINGER: The cut should be made in the node at a 45^{o} angle.

ZIEMKIEWICZ: Is there any advantage in growing stock in the greenhouse from seed or vegetative material where you put it out in the nursery for one or two years, then transfer the stock to the field?

HOWE: All of our shrub stock, except oak, is grown in the field from seed. Only oak is grown in the greenhouse. This is because bare root oak, grown for two years in the field, then undercut and transplanted the next spring, had a survival of only 10%. We are just wasting our time. Container grown burr oak had a better survival rate.

ZIEMKIEWICZ: All containerized growing is done in the greenhouse and all your bare root stock is grown entirely in the field?

HOWE: Right.

GRAINGER: We do just the opposite for conifers. This year we transplanted in August after raising in the greenhouse for 12 weeks then we put them outside for the summer then planted in the fall. That gives us about two years growth. The shrub material is all grown in containers then the native material is transferred to larger pots because Provincial Parks likes the larger pots.

ZIEMKIEWICZ: So the native shrubs are grown in the greenhouse and transferred from containers to pots, then moved to the field.

GRAINGER: Right.

VAARTNOU: Do you see any difference in container grown and seed grown bare root stock survival later on?

GRAINGER: The only statistical work I've seen was done by Selner when he was getting stock from us, and the containers were far better than bare root system in survival after outplanting.

VAARTNOU: How long after outplanting was this?

GRAINGER: Two years.

VAARTNOU: I hear that after 4-5 years the bare root stock was better.

LAIDLAW: Many papers report that bare root stock has done better. However, we really do not have many good comparisons between containerized and bare root stock because of size, age and quality differences in the two types of material being compared.

ETHERIDGE: We've designed the nursery for 50% bare root and 50% containers with the understanding that on some sites bare root is superior while on other sites containerized stock is better. Containers should be used where there has been site preparation or the least amount of competition. On harsh sites or where there is competition the more vigorous bare root stock is better.

HOWE: There seem to be varying ideas on this. Containers tend to cause root deformities and we are concerned about the effect of containers on the wind resistance of our trees. However, you do not have the same problem. You are not talking about something that is going to be 80 feet tall.

VAARTNOU: I've found that container grown stock never has the same vigor as bare root. Container stock will stay alive and grow a little bit each year but it is very slow to develop.

HILLSON: What type of container are you talking about?

VAARTNOU: Paper, peat pots and Spencer-LeMair.

HILLSON: These are small containers. Plants should never be kept in the container for more than two years.

LAIDLAW: I think that most of the information regarding root deformation and stunting of containerized tree stock does not apply to shrubs. Many shrubs reproduce by suckering, so you only need the initial root system to last long enough to begin suckering.

VAARTNOU: There is no problem there unless they don't sucker or produce rhizomes.

GRAINGER: Remember that in North America pots had been used for years.

VAARTNOU: And that's why they have to replace the plants so often.

HILLSON: Many operators do not realize that while the container system is very compact and efficient it is on a very rigid time schedule. Many of the problems with root deformity are the result of leaving the stock in the containers too long.

ZIEMKIEWICZ: So, regardless of the size of the container it shouldn't be kept in the greenhouse for more than a year.

VAARTNOU: Well, it depends on the size of the plant.

LAIDLAW: On an economic basis, doesn't the whole operation become uneconomical after the plant has reached a certain size and the plants have to be repeatedly transferred to larger containers?

GRAINGER: When moving to larger plants (3-4 ft.) the economics start to favor pots rather than bare root because you get more stems per acre, weed problems are less and management costs are lower. Also, in large stock the survival of potted material is about 80% vs. 60% for bare root. Now this is large stock 8-10 ft.

You can grow willow in a container for $0.80 or you can grow it in the field for $0.20 it's much easier and cheaper to grow them in the field. But if you're growing oak in the field, you'll get the same growth in two years in the field as you would get in one year in a container. Also, it is cheaper to plant containerized stock.

HOWE: What size of stock are you talking about?

GRAINGER: Say, Hillson size two year old stock.

HOWE: You can apparently plant a lot faster with a tree planter using bare root stock than you can using containerized stock, because you can put them in that much faster due to less bulk.

GRAINGER: I can't agree with that.

ETHERIDGE: According to work done on the Coast, the costs of planting bare root and containerized stock are becoming similar.

HILLSON: Perhaps more important than planting cost is survival.

GRAINGER: The largest container operation in North America used to produce bare root stock, but now they are totally committed to containers because bare root stock was too expensive. Both in terms of numbers lost and numbers per hectare of saleable seedlings.

LAIDLAW: A study at Michigan State University looked into the costs of bare root and container grown seedlings and containerized stock came out very much superior both in terms of growth and value of the final product. This was partly due to the "accelerated growth" options available in the container program.

SUMMARY

1. Collection of Fruit

   A. Chemical Aids - G. Howe - abscisic acid is only in the testing stage.

   - G. Howe - other chemicals are available, but have yet to be tested.

   B. Mechanical Aids - G. Grainger - the small fruit harvestor works well if the fruit is mature.

   C. Time of Collection - G. Grainger - the timing of collection is more critical than the method of collection.

   - H. Vaartnou - the optimal times for ease of harvest and viability of seed do not necessarily coincide.

   - the viability of attached seed can change significantly within a short time

2. Seed Extraction

   A. Winged Fruit - G. Howe - dewingers are commercially available which operate effectively without damaging the seed.

   B. Pulpy Fruit - G. Grainger - the Dybvig extractor works well for pulpy fruit. A new contractor has been developed in the U.S.A. which has four times the capacity of the Dybvig.

   - G. Howe - another method of dealing with pulpy seed is is simply to let it rot until soft, grind until soupy then sow the soup.

3. Seed Storage

   A. Dormancy - dormancy may result after seeds are placed in a freezer or cold storage.

   B. Moisture & Temperature - G. Grainger - generally, seeds should be kept in cool and very dry conditions.

   - T. Laidlaw - however, some seeds may under go a drastic loss in viability due to dehydration (i.e. hazel).

   - G. Howe - also, some seeds such as oak are difficult to store because they tend to sprout within a year in cold storage while if kept below freezing the seed dies.

4. Pregermination Treatment

A. Dormancy - P. Ziemkiewicz - may be broken by stratification, freezing or other processes which would break a hard coat seed.

generally, if the correct techniques are applied native shrubs seed germination presents no problem.

- P. Etheridge - it would be helpful if these techniques were catalogued for shrub species of interest to reclamation.

5. Germination Tests

A. Standardization - it was agreed that a series of standard tests should be developed to characterize shrub seed quality. Such testing procedures already exist for commercial grass and legume varieties.

6. Raising from Seed

A. Economics - H. Vaartnou - 1/3 to 1/2 cheaper than by using vegetative propagation.

B. Genetics - T. Laidlaw - allows greater genetic diversity than would vegetative collections from small populations.

C. Direct Seeding in Field

- H. Vaartnou - may be successful under certain conditions where the correct genetic material is used.

D. Nodulation - the group agreed that where native shrubs are planted on disturbed soils root nodulation occurs without artificial innoculation.

7. Cutting Storage

A. Temperature - G. Howe - should be cooled off as quickly as possible.

B. Fungicides - G. Howe - prior to storage cuttings should be treated with a fungicide such as captan or benlate.

- R. Hillson - some fungicide mixtures may enhance rooting in cuttings.

8. Preplanting Treatment

- G. Howe - indicated that as long as the cuttings had been in stratification prior to planting no other special treatment was necessary.

9. Raising from Cuttings

   A. Cutting Size - G. Howe - best results with 15 cm long cuttings with diameters around 1.0 cm.

   B. Cutting Angle - the group agreed that cuttings should be made at the node at a 45° angle.

10. Nursery Handling and Treatment

   A. Containerized vs. Bare Root Stock - the group agreed that in the growing phase containerized stock was more expensive, but in the planting phase costs were not significantly differe

11. Containerized Stock vs. Bare Root Stock

   A. Containerized stock is more expensive to grow.

   B. Damping-off is a greater problem in containers.

   C. Planting costs are not significantly different.

   D. Containerized stock is hardier.

   E. Containerized stock allows a longer planting season.

   F. Containerized stock is more susceptible to frost heaving.

   G. Plants should not be kept in containers for more than one year.

Recommendations for Future Research

In the area of propagation few major areas in need of research were apparent. Generally, adequate information or experience exists to propagate nearly all native shrubs of potential interest to reclamation. Further research in native shrubs propagation should concentrate on cataloguing existing knowledge and, in a few cases, refining known techniques.

Following is a short list of areas for future study:

1. Propagation from seed-

   A. Catalogue methods for breaking dormancy of Native Shrub Species. In a few cases methods will need refining.

   B. Develop standard methods for measuring seed quality.

   C. Catalogue methods for preventing damping-off in susceptible species. In some cases new methods and fungicides will have to be developed.

2. More efficient methods of propagation.

WORKING GROUP II - Outplanting

Participants

Mr. Con Dermott, Moderator - Alberta Forest Service
Mr. Frank Flavelle - Saskatchewan Forest Service
Mr. Nick Horstmann - Western Erosion Control
Mr. Don Klym - Great Canadian Oil Sands
Mr. Carl Leary - Alberta Forest Service
Mr. Max Nock - Public Lands Division
Mr. Juri Peepre - Parks Canada
Mr. Bill Russell - Alberta Forest Service
Mr. Walter Yarish - Alberta Agriculture

Discussion Topics

Lifting of Seedlings
Planting Time
Planting Versus Seeding
Planting Techniques
Bare Root Versus Container Stock
Special Use (e.g. Bioengineering)
Growth Habit
Potential Factors Affecting Survival and Establishment
Site Adaptation
Vigor and Seed Production
Literature Review

DISCUSSION

DERMOTT: It appears to me that the conventional method of seedling lifting is probably the most acceptable for native shrubs, where they are lifted in the fall, and stored over winter for spring planting.

FLAVELLE: Yes. I would agree and further to that, in Indian Head deciduous and coniferous shrubs are stored in peat moss at -2°C greenhouse temperature with good success.

KLYM: In forestry practices, coniferous seedlings can be planted at generally known periods in the summer, but there appears to be a definite gap in the planting of deciduous reclamatio stock. Success at G.C.O.S. in past trials using deciduous stock was very poor. From our experience planting of trees after they flush, after spring moisture, and before summer rainfall is a complete loss. In the coniferous stock we hav planted on through to July 1st with good success. It appear to us that planting should be done in the early spring, before the leaves flush out and to accommodate the climatic benefit of spring moisture.

HORSTMANN: You likely hit on one of the keys to the success of planting, but success of planting has a lot to do with proper and adequate holding facilities on the site, along with proper site preparation. The holding facilities are extremely important for moisture holding, and therefore seedling quality at planting time. It is important to produce a a seedling which is given excellent care, not only in the greenhouse, but during transportation and during holdover on site prior to planting.

Personnel transporting and storing the seedlings prior to field planting must understand the importance of proper handling techniques to ensure the high quality of the seedlin is maintained. Another factor that is most important for seedling survival is site preparation. The success rate in shelterbelt programs should be better than reclamation sites, because on the average the conditions are better. Also, in the shelterbelt program you are using farmers to plant the seedlings, who are interested in what their success will be. Something we sometimes lack in planting programs are qualifie people to plant the seedlings.

FLAVELLE: We must ensure that wherever possible deciduous planting is done prior to flushing of the leaves, but this is also a very short period of time. Your program must be well scheduled ahead. In some ways this time period criterial is an asset even though there is a problem in planting scheduling. The asset being that if you lift them in the fall and have

them ready to move out for planting in the early spring, you also have created an excellent chance for survival as well as enhancing plant growth and development.

HORSTMANN: On a general basis climatic conditions are one of the most important factors. You can start out of the nursery with very healthy plants, however, if outplanted during dry weather periods you may obtain high mortality the first year. To be effective you must have the most healthy seedlings available for planting and then use the best climatic factors in your favour on tough reclamation sites.

On the other hand all the individual factors tie together which relate to survival ratio of seedlings that are planted on tougher sites. With reference to climatic factors I have seen seedlings planting during optimal climatic periods and still high mortality occurs due to poor care during transportation periods. During transportation or storage, if you leave the seedling roots unprotected to the air for a short time, drying out occurs and could be very damaging to the survival of the tree. In the shelterbelt program where site factors are more favourable the mortality again would not be as direct in comparison to tougher reclamation sites, but still a factor that must be considered.

KLYM: Let's assume that factors are favourable for planting, and you have a well-developed healthy plant, a good water holding capacity, and a suitable planting site. Can you then be relatively sure that planting in July will be successful?

HORSTMANN: If the plant has flushed out you have to use caution.

RUSSELL: The suggestion of July planting is very dependent on the site as well. If the soil is already dry you definitely would not want to plant, but if the moisture conditions in the soil are favourable you would be right to go ahead if the climatic records in the locality indicate July is a favourable rainfall period.

HORSTMANN: When we are discussing soil and plant moisture content you must also look at alternatives. In the past we have used retardents to hold moisture in the plants during transportation and planting. This moisture holding material is applied to the plant by dipping the plant into the retardent before moving or shipping and a higher survival rate has been shown in the past.

LEARY: How long is this retardent effective after treatment?

HORSTMANN: The length of effectiveness of the retardent is dependent on how much you use and what you use! A light cover is best, however, a heavy application on the entire plant

does not adversely affect plant survival.

DERMOTT: What to you use as a retardent?

HORSTMANN: Curasol. Available through our outlet in Edmonton.

FLAVELLE: At Indian Head we have used a similar moisture retainment material with good success. Algenure has been used for this process where the whole plant has been dipped into the material.

KLYM: Since this product is an antitranspirant, do you have to shade the plants after using the product, since plant leaves are cooled by transpiration.

HORSTMANN: I have found that shading should be used in this instance and feedback from a program in South Africa indicates the same.

DERMOTT: When would you spray this retardent on the plant?

HORSTMANN: You would be wise to spray or dip the plants when the best plant moisture conditions exist so that the plant has the least chance of drying out before the material is put on, especially in the case of larger trees.

PEEPRE: We've used an antitranspirant in other parts of Canada and found that in the late spring and the early part of summer it makes a difference, but in early spring or in late fall it doesn't make the same difference in planting survival.

HORSTMANN: You are quite right in early spring and late fall planting not being as critical, but are you willing to take a chance and not preserve plant moisture with an antitranspirant? Even in the coastal and high altitudes areas where moisture conditions are more favourable we still use the antitranspirant as a protection to moisture loss.

PEEPRE: You are right in referring to mountain parks where climatic factors are very different.

FLAVELLE: We use gelgard for a similar benefit in reforestation stock.

HORSTMANN: Another item that can't be overlooked during planting is the application of nitrogen, which should be applied.

YARISH: In fertilizer application should you apply it the first year? This could also be detrimental to the plant survival if a dry spell occurs shortly after planting.

HORSTMANN: Maybe not, if the site at planting is dry, to fertilize the next year would be better.

YARISH: I feel fertilizer application the year following planting would be more beneficial to the plant.

HORSTMANN: On shelterbelt sites you likely could wait a year, but on tougher sites fertilizer application should be the first year at planting time.

DERMOTT: How about the selection process when we are discussing native shrubs, what criteria should we be considering?

RUSSELL: One item that has to be considered when selection of shrubs is being discussed is the final land use criteria. We must know the desired end land use so that shrub selection can be made in part by this criteria.

KLYM: Yes. That is one item of several that one has to address.

DERMOTT: I think Bill is right, it's something that has to be looked at and there sure is merit here for proper selection. Another area that has to be considered though is what species are easier to collect and best propagated along with the ease of production of a particular species. I think before we get into planting techniques we should get into the use of container versus bare root first. It appears that there has been an obvious conclustion that containers are more desireable bare root stock because of past success of containers. If we do use containers, however, what size of containers is best? Do you feel as a group that containerized stock would be better? I'm thinking, in particular, of harsh reclamation sites.

KLYM: This item has to be an economical consideration also. We must look at the cost of raising the seedlings.

HORTSMANN: You can consider economics and I agree containerized stock is the right way to go, but should we look at something small and cheap to grow that is going to die when it is put into the field?

KLYM: Sure, there has to be an economical point where going to a larger container is not feasible. Also, container size must be considered separately for each species dependent on root development and plant growth.

DERMOTT: Which container size have you found to be the most successful?

KLYM: We really haven't since to date only one container has been utilized due to availability, but I would like to get into larger container sizes. I've never had the opportunity though to vary or study exact sizes required. Bare root versus container, we don't really have a good evaluation of either. In the past bare root seems to have been the better performer.

DERMOTT: This item is something we shouldn't disregard then. We shouldn't say we will go to containers and forget about bare root.

KLYM: Oh no, but we must look at containers to allow flexibility in the overall management of a reclamation and reforestation project.

FLAVELLE: How about direct application of cuttings? Has there been any use of this approach?

KLYM: We have tried direct application of cuttings, but with very limited success. It appears that establishment depends on timing and planting method. In an experiment this year we tried different sizes, different angles of cuttings inserted into the ground and three different species were used. We were unable to do a proper assessment this fall. It appears that the rodents (mice) got most of them, however, through girdling.

KLYM: In cases where a good seedbed has been available, the cuttings show good survival. From results obtained to date, I can't really say one way or another whether cuttings are successful. This approach is one of the alternatives that has to be considered, even though problems are evident.

HORSTMANN: In the use of cuttings in our work, we have found that we have to practically bury the cuttings to obtain success. In most sites we want only 1" or 2" sticking out of the ground, in drier areas no portion is left above ground level. We feel that not only soil moisture, but air moisture really is critical and affects new cuttings. When the cuttings are nearly or in some cases completely buried, this problem is not so severe. An example of this approach is at Cardinal River Coal, we produced 85% survival.

FLAVELLE: In the shelterbelt program around the South Saskatchewan reservoir we had 60% survival of cuttings installed.

LEARY: Nick, you indicated 85% survival at Cardinal River, what variety of species were you using?

HORSTMANN: They were poplar and willow cuttings.

LEARY: Was that also the site where you left the cuttings out of the ground one or two inches, and how long were the cuttings?

HORSTMANN: Yes, that was the system used at Cardinal River. The cuttings were approximately three feet in length.

KLYM: Nick mentioned a rougher surface. Why were you suggesting that aspect of site preparation?

HORSTMANN: For moisture holding on site especially in the drier sites.

KLYM: How do you (Horstmann) install the cuttings into the ground? Perpendicular or on an angle?

HORSTMANN: On angle and this is very critical for plant establishment success since the root hormone is affected, and therefore, root development is directly dependent not only on plant species used, but also on the angle of planting. If you are planting on a flat area you need at least 10^{o} angle to the ground. Another factor is where you have a slope and, in this instance, you have faster drying out in normal conditions and the cuttings must be installed deeper into the ground.

YARISH: If you went to a smaller cutting, say 6" or 8" in length, and in addition if you are looking at a 2" or 3" thick stem, the size makes the handling pretty cumbersome.

HORSTMANN: In the use of cuttings the root production and top growth varies dependent on cutting size. In the case of Salix cuttings smaller sizes were too stringy and did not work out very successfully. The harsh reclamation sites require a larger cutting than in a normal program. The Nursery is using smaller cuttings of 4" to 6" in length in the shelterbelt program and these are not large enough for our work. One other thing in Canada is that we have lots of species to work with, but we know very little about these, and therefore they are of little use. We must strive to find out more about each species.

HORSTMANN: An alternative to cuttings that has not been discussed is the use of the whole clump and then instead of the small cutting you have the entire root and tree system installed. Where this process is used in a short period, the tree is becoming established with minor plant disturbance if done properly.

YARISH: The island planting has been successful in other areas and is the best way to do it where feasible and practical.

HORSTMANN: The main problem is to coordinate planting programs and timing with construction engineers. We can't expect engineers just to undertake construction in the early spring, and we, therefore, must have cuttings stored for use anytime that construction is in progress so that planting can be incorporated with development.

DERMOTT: From the discussion in summarizing, then there is room for bare root, containers and cutting stock.

KLYM: I would agree with that. It also looks like we should be looking at more cuttings and different container sizes when planning site preparation.

DERMOTT: Yes, but in container size is there a definite size we can use as a standard?

HORSTMANN: No, because container size relates to the species we are using primarily because of root development. You may for example want a longer and narrower container dependent on site factors, such as where you have a 6" peat cover to be able to get down on the moisture level.

DERMOTT: But looking at reclamation in general should we be using a larger container in reclamation than in reforestation. In a forest there is plant cover and better site establishment factors than in most reclamation projects.

HORSTMANN: We definitely need a larger container for reclamation stock, especially for moisture holding capacity prior to outplanting and where bare root are drying out.

DERMOTT: In the analysis of planting techniques it appears that it pretty well depends on what we are going to do.

KLYM: As was previously mentioned, we must consider the quality of the people being used in planting programs. There are only certain things you can do to motivate people, but the stressing of proper planting practices has to be continually of concern.

YARISH: It would be very advantageous to a planting program if you could hire an individual who has liking and a feel for that type of work.

FLAVELLE: An area in planting that has to be passed on for information purposes are such items as what plants grow together in groups and what kind of a depth of rooting is required.

KLYM: It is fine for the supervisor to know this, but the tree planter is usually not aware of these things.

PEEPRE: True, but those factors have a large bearing on survival on site following planting.

DERMOTT: Are there any other planting techniques that certain people are aware of, techniques that will help survival other than just the conventional way of planting?

KLYM: I would think that in reclamation by afforestation one should definitely not just plug a seedling into the ground and forget it. You also may have very diverse soil conditions over a small area that have to be considered.

HORSTMANN: You could vary your techniques in plant preparation prior to planting. You may wish to use larger stock, also prune and trim plants down.

DERMOTT: By pruning, do you mean top pruning?

HORSTMANN: Yes, top pruning will help the plant and should be considered in reclamation stock production.

KLYM: It is wrong during reclamation planting programs to insist on "planting production". In reforestation you get paid by the number of trees you plant, but quality of planting has to be considered in any successful reclamation program.

DERMOTT: The end result is the deciding factor in any program. As in any planting program you manage according to the number of seedlings you wish planted, but at the same time you are most interested in quality.

HORSTMANN: In reclamation you don't need as many plants as in reforestation but quality and survival is of prime importance. Another mistake that we all make in reclamation is to plant very artificially in rows and we should be looking at species relationships. We are ending up in reclamation with blocks of spruce or pine, but we are not considering the objective of bringing the site back to its natural environment.

YARISH: Yes, but we should also be looking at the other species relationships as well, such as the symbiotic relationships of jack pine and alder. You then would be considering those types of combinations where pine may not survive all by itself since it has no additional source of nitrogen and alder is as a nitrogen fixer.

KLYM: In the terms of planting techniques is there anything to be said for having a sequence such as hydroseeding followed by shrub planting or cuttings the following season?

HORSTMANN: Always establish grass cover first before planting.

YARISH: This may vary, however, on the Prairie region. If yo establish grass cover, you'll never get a tree to grow due to the smothering and competition of grasses.

HORSTMANN: True, but in the case of the forested area you would avoid seeding at heavy rates (30-50 lbs./acre) in order to minimize competition with tree seedlings.

KLYM: The primary item to consider in reclamation objectives is that reclamation is site specific. If you want erosion control on a dyke, as in our case, you want grass first, then trees later. In the future we will have huge areas where pits are backfilled and will have a level to gently rolling topography. I foresee that muskeg treatment followed by seeding will be required, and it is therefore the nature of the site that one has to consider.

We have conducted tests where planting of trees in an unvegetated or low herbaceous cover produced 100% survival.

YARISH: Do you use mulching or cover?

KLYM: We spread 6" of muskeg and mixed it to a 1' depth, then establish grass and legumes by hydroseeding. The trees were planted later.

DERMOTT: Do you not think that on severe sites, like along the Eastern Slopes that we should try to establish some kind of light grass cover so that you have some protection for the seedlings that you're trying to establish?

HORSTMANN: I believe you should always have the grasses and legumes established before you plant trees so that you can eliminate the harsh environment that exists during reclamation practice

KLYM: The best way to ameliorate a soil is to get a plant growing in it, and where feasible, without chemicals.

DERMOTT: That is what we found out with some trials that were established on black coal fines and there was just no chance of seed even growing on the harsh site.

HORSTMANN: It appears that we should set long range priorities in this area to define what has to be tested regarding grass/legume competition on seedlings and seed application rates where we want trees and shrubs established.

DERMOTT: What about other factors that we do in the field that affect bare root or container survival?

PEEPRE: I believe that proper maintenance is a critical factor that has not been properly considered.

DERMOTT: When you refer to maintenance are you referring to mitigating competition or refertilization?

PEEPRE: A number of items such as fertilizing, thinning and other items along that line.

HORSTMANN: One of the prime factors in survival is actual site preparation prior to planting, which will give you better chances of survival.

KLYM: Is there any expertise with the use of sawdust in soil amelioration?

HORSTMANN: I recommend you be very careful in the use of sawdust as an ameliorant since you would have to apply large amounts of nitrogen to counteract that which sawdust decomposition would utilize.

PEEPRE: Do you believe that in the use of decomposed sawdust there would be any decided advantage?

HORSTMANN: No, past use of sawdust recommends against its use except in special instances in reclamation. An area people overlook is the use of soil matter on harsh reclamation sites such as Caw Ridge. The use of available soil really encourages the invasion of native grasses and without fertilizer applications.

RUSSELL: I conducted a study on abandoned mine sites. I looked at natural revegetation and found that the amount of total cover and the number of species invading an area depended to a large amount on the water holding capacity of the soil. This indicates that soil physical properties are important on a site as well.

KLYM: That would be another advantage of having a herbaceous cover first. If you want to, you could disk the cover into the soil prior to planting.

YARISH: You could also work a cover crop into the soil and then plant the seedlings.

DERMOTT: How about growth habits of different species, such as which species should we be looking at? Is this subject site specific or do we not have sufficient knowledge to discuss this topic?

RUSSELL: It appears to be based on what the final land use objective is, whether browse for wildlife or just cover is required. Once you define the final land use, then you could determine what species will best do the job.

DERMOTT: What about altered growth habits of an area? Do we create new environments by disturbance? Will the species which grew prior to disturbance be appropriate for reclamation? Should we be looking at wildlife habitat in an area that was a muskeg prior to disturbance?

RUSSELL: In a natural area (no disturbance) the shrubs have one growth form, but where cover has been artificially installed, they may display quite different growth forms.

PEEPRE: Sure the site will change following industrial development and selection will be site specific, but we have to select a plant for the site where the natural root system of a plant can adapt reasonably well to the site. For an area that has only 2-3" of soil over bare rock, shallow rooted plants are necessary.

HORSTMANN: In our mixture selection we must have a variety of many species that are adaptable to a variety of sites to ensure you have a better chance of survival and effective reclamation back to the natural environment.

NOCK: Is there any advantage to using fertilizer pellets with the trees?

KLYM: We've done quite a lot of work using starter tablets (agriform) and found no significant effect.

HORSTMANN: I have yet to see any success with the use of starter tablets.

KLYM: The AFS (AOSERP) program has tested many starter tablets on our lease and found that they were a depressant. There are variables such as poor moisture conditions, tablets not properly placed as people suggest. But the program was set up and assessed after the first, second and third seasons, and affects were neglible. Other factors have affected the usefulness of starter tablets, for example, maintenance fertilization and legume content of the cover.

DERMOTT: How about in special land use cases and the use of bio-engineering? The presentation this morning by Mr. Horstmann explained the system very well, but let's tie in plants and material we have for such a practice.

HORSTMANN: When we are discussing bioengineering I become very concerned since people do not understand the system. When a book on bioengineering is published for the first time in the English language, people will try the system without knowing and using proper procedures. This has already occurred in some areas, such as the Swan Hills where people attempted the process, but did not really know why or how to undertake site treatments. In the instances where people attempt a program, not understanding the reasons and procedures for bioengineering, they will get failures and assume the system does not work. We just don't have the knowledge in Canada on grass or shrub species. We must find out the shrub or grass root/top ratio and the number of roots/acre through field evaluation. We also have to be site specific whether the area is farming, wildlife or recreational requirements and they go by past experience in testing and evaluating the program. We must also have a knowledge of building materials, the best time of cutting storage and root development, and establish some adaptation sites for species evaluation. In addition we must know the shear strength, leaf size and evaporation-transpiration limitations. Where feasible, natural species should be used and a booklet produced on all species once concrete data is determined.

LEARY: Should we not be using present outplantings for this type of evaluation? You're not suggesting we set up duplicate sites of what we now have throughout Alberta? As I see it we can utilize plants growing on sites now for a lot of this information.

HORSTMANN: True, we can use the present sites, but I doubt that all species are presently growing in Alberta.

YARISH: What kind of laboratory or testing systems do you envision to test all these items you have listed? As I see it we would have to be working together and with an environmental institute for all the results needed and to avoid re-inventing the wheel.

HORSTMANN: I think we should evaluate what we know and then go from there. Our main building material has to be salix due to its variety and ability to grow on a number of different sites. Poplar grows over a lot of different sites and we could easily, over a year period, find out the best time to plant and their slope tolerances along with testing root development in the field from existing sites.

DERMOTT: We're really talking about selection and in doing so are trying to select a certain species considering factors such as site adaptability, vigour, and seed production.

We appear to need specific criteria and background data so that we can select that material for seed production in the future for good vigour on a specific site, and good root development for an end land use.

HORSTMANN: One further step is to eventually have a handbook that shows by demonstration, so that a foreman may have very simplified instructions and documentation on procedures to follow.

DERMOTT: Some of the work that has been done to date must have keyed some criteria done on selection. Are there any known species that will give us better results on certain sites? Can some species be eliminated so we can study certain ones?

KLYM: It's obvious willows are definitely going to be important, for in nature there is evidence of tolerance to widely varied sites.

HORSTMANN: We have many species which grow on a number of sites, and it's just a matter of testing them.

KLYM: We must also study the shear strength of a willow root, along with how many are required in planting on a particular soil/slope situation for stabilization.

HORSTMANN: We must know moisture utilization of each species or within a species to say which is best for a specific site. In European planting they already know exactly what and why they are planting a species for.

DERMOTT: Along with this we still have to conduct selection for wildlife and other land use. It appears our best approach to this objective is to try to use the natural vegetation as much as possible. Do we know about certain species that some selection can be made now?

KLYM: No. but we could make some selections with confidence.

DERMOTT: Which ones do well?

HORSTMANN: This depends on many site factors such as soil, vegetation cover, and moisture.

DERMOTT: From testing done to date then, we can not make species recommendations for a given site.

HORSTMANN: In the Fort McMurray area you could recommend a particular species for a site and obtain local information on testing conducted to date. If, however, you go into a dry sand

dune area you would only be working on luck. There are numerous species to be evaluated both in Saskatchewan and British Columbia that have proven successful and should be tried in Alberta. In Alberta we are fortunate that in most of our areas there are no toxic materials, and our reclamation is not as tough as other areas in the world.

DERMOTT: Has anybody got anything else on site adaptation, seed production, or species selection in general? It appears that as a group it is being recommended we must do more work in these areas, as we really don't know yet.

LEARY: Likely, the best way to start is to go back to what has been done through a literature review.

DERMOTT: That's right, instead of doing a species adaptation research program you'd better review what is available first.

HORSTMANN: Before growing native shrubs, I would recommend you take a close look at what Montana and the rest of the United States do along with what the Austrians do before spending money on the research work. The Austrians have had a nursery for years and are very keen. Why should we start from scratch? We have to know how our plants develop, how deep they penetrate, by digging out the plants we have now.

KLYM: I should mention that G.C.O.S. might be conducting some tests on our dykes directed toward root development. We did some preliminary work last year, and are planning a more systematic study of rooting characteristics of different trees that are growing on the dykes and overburden spoil sites. We don't plan on measuring any engineering characteristics, but need to see what root development we are getting in the tar sands and dykes areas, and if the roots are getting down to the moisture level.

RUSSELL: You can get these results from initial observations in natural systems.

KLYM: We would consider comparing dykes to the natural system.

RUSSELL: There are certain shrub species which are known to be compatible with grasses. In the foothills I have noticed shrubby cinqufoil doing well in natural grass lands. Shrubby cinquefoil has deep roots, which pentrate below those of the grasses.

DERMOTT: Would it not be important in the meantime to start doing long-term, properly designed studies at different sites within the Province with available species?

LEARY: In root sampling to date in the tar sands dyke, have you noticed any difference in the development of the root system on the tailing sands versus normal soils?

KLYM: We don't have sufficient information from the natural state but this is a problem in the tailing sands. Rooting is restricted to the shallow top layer of ameliorated soil. Few willows, which basically have a tap root, have been found to go deeper into the tailing sands.

KLYM: In the overburden situation in the tar sands area it's not the interface of peat/overburden, but the compaction factor in the spoil and dump itself after capping that causes the root development problem. It's very difficult for roots to penetrate this compacted material. One method would be to use an auger and put fertilizer into the hole to assist in root development.

LEARY: With reference to the root development study that G.C.O.S. is conducting, do you feel that moisture level and availability is a concern in the tar sands area? Should this be a factor to consider in the selection process?

KLYM: I don't know, but again a model could be developed to determine this. On a historical basis there is enough precipitation, but right at the surface you could have a dry zone which could be a factor in root dessication.

LEARY: I'm referring to the moisture retention period in the soils more than the amount of precipitation in the area.

KLYM: There definitely would be a surplus of moisture and sufficient retention, and the movement of water in the soils would not be a factor in establishing plant cover.

DERMOTT: When speaking of root development can anyone recommend what kind of container and size a specific species requires?

HORSTMANN: Not only should one be looking at a specific container size for a species, but we should be considering species requirements by individual site.

DERMOTT: The site condition is very critical, but I think it all depends on the length of time you are growing the container. If you are growing a container to seed in the spring and you harden it off in the fall, for spring planting, then you are pretty well confined to one container size because of root volume developed over that period.

HORSTMANN: A one year old seedling for harsh reclamation sites is too young.

DERMOTT: Then we automatically have to go to a larger container for all species due to root development in deciduous shrubs.

HORSTMANN: The first year seedling isn't very strong and in some favourable planting programs you may get away with a smaller plant, but on harsher sites where you run into hot-dry weather the smaller plant will not survive.

LEARY: When you refer to two year old stock you are talking about larger containers. You are undoubtedly reducing greenhouse space and therefore economics of the stock comes in.

HORSTMANN: I don't think in reclamation I would use small stock, and suggest not less than half a gallon or so.

LEARY: That's a little too big and I believe we have to go to a specific species and discuss Tinus versus Hillson containers or similar sizes. Holding them over two years, I'm sure, proves a problem in deciduous shrubs.

HORSTMANN: It depends a lot on the species being used as some varieties are very soft the first year. You would be better off using a smaller container if the nursery problem exists, cut the plant completely down, and really just plant the root system.

DERMOTT: You have to trim the roots in deciduous stock anyhow. Does anybody have any information or knowledge of what happens to the roots of a deciduous tree in a container?

FLAVELLE: That appears to be an area which poses a lot of concern, such as in the recent symposium on coniferous stock in Victoria last spring where they identified all types of malformities, weird shapes, and subsequent toppling of the trees. I wonder if we are facing the same thing in deciduous production.

HORSTMANN: You may have to undertake side and bottom root pruning to ensure proper root development in the nursery.

DERMOTT: In a container that's pretty hard to do. You would be defeating the purpose of container growth, and you might just as well have grown a bare root. When using a peat mixture in the containers the material is very loose and, therefore, in taking the plant out of the container for trimming, you lose the container benefit. We grew some containers in a sponge material once. They came in a block and you were supposed to break them off. They didn't break off easily so we removed them and trimmed

them down with a knife. The dibble we had for planting was too small so we trimmed the roots into a point shape. They grew the best of any we had because we removed [illegible], which we were able to do with that kind of container, but in the use of a peat moss container I doubt it.

KLYM: I would like to see containerized stock, especially in the later summertime. This would extend the planting season and one has to look at this aspect from an operational point of view. In the tar sand situation the yearly reclamation acreages which are available are very sporadic, and one could end up with 400 acres which you want to stabilize right away. We need the flexibility of containerized stock.

HORSTMANN: You can decrease the amount of plants you need as well if you use larger containers because your survival will be higher.

DERMOTT: How about fall planting instead of holding these over the winter?

HORSTMANN: Not in our climate in the case of cuttings as they just wouldn't give the survival we need.

DERMOTT: I guess why I feel that way is that it would be better to have them in the ground then have them sitting in shade frames.

HORSTMANN: They shouldn't be on site at all, but they should be coming from an area where they grow well.

DERMOTT: In order to produce a one year old seedling you must grow it in a container until June. Then it is placed under the shade frames for hardening. It is then planted out next spring. Why not have it in the ground and let it harden off there instead of in the shade frames?

HORSTMANN: But I would recommend not to raise it at all in our climate because the prairie climate is not tough enough. If you want a healthy tough plant you should start with one.

DERMOTT: Are you saying you are recommending that the trees be grown elsewhere and bring them back in?

HORSTMANN: Yes. In the United States border area or in two or three British Columbia sites.

DERMOTT: This has to be an economical consideration also to move the trees back to Alberta from outside points. The other consideration is that transportation of the stock is also one of the main problems you identified, so other factors would not permit this approach.

KLYM: There appears to be a contradiction here. You (Horstmann) are talking about the hardiness of the plant or stem system. If you accelerate growth conditions, I understand that even if you have a healthy plant the tissues are still very soft.

HORSTMANN: That depends on how the nursery treats it. If you treat the plants the way normal nursery material is treated there would be no problem. Say if you went to Kelowna to grow this stock where the climate is cool, but excellent growing conditions, you would end out with a good healthy plant as compared to Alberta. An example is Colorado spruce, a hardy tree, and one which you see in numerous areas. In Alberta, however, where you obtain a seedling, if it is sunburnt you really can't be assurred that it will make the summer. If you take that sunburnt Colorado spruce and dig it into the nursery in the spring and transplant it, the chances of its survival are very slim. You take a Colorado spruce from an area where the sunburnt condition didn't occur and plant it here, the chances of survival are very high.

LEARY: You must consider all factors, such as economics and practicality plus survival, and this approach in shelter-belt or ornamental stock may be the way to go in some species, but in reclamation production there are too many limiting factors.

FLAVELLE: How about the tree that's started such as Colorado spruce? Would you take the seed from California and bring the tree here or would you use seed from here, raise the tree elsewhere and return the tree here for planting?

HORSTMANN: The seed would have to come from here. This is the normal process in many of our ornamental evergreens.

PEEPRE: I may be able to help you (Horstmann) out on what you are saying. At Jasper, seed for cuttings were collected from the local site and shipped to Vancouver where they are being raised for two years. (White spruce, pine, rose). They are scheduled to be shipped back for planting in the spring of 1979. I'm not saying we have lot of data on this item, but we may have some.

HORSTMANN: The nursery people that supply experimental or reclamation stock know they have to produce the healthiest plant possible.

KLYM: I definitely agree with that because any success we've had at G.C.O.S. was related to the condition of the plant when received and at the time of planting. A point that I feel strongly about though is that a plant may look very

healthy on the outside when you grow it in California from a locally collected seed source, but is this seedling going to be susceptible to early frost or the harsh winter conditions because it is grown under accelerat conditions?

HORSTMANN: We need studies and we are making guesses, but we have to be very particular with reclamation stock and select a nursery where we know the stock we are getting will be hardy and healthy.

KLYM: Where you employ accelerated rearing, what happens to your root-shoot ratio?

HORSTMANN: You will get a good shoot-root ratio and balanced stock if you prune the plant back properly, which is what they actually do in selling of trees by grade in ornamental or Christmas tree stock.

KLYM: When ordering reclamation stock, should we specify root to top growth ratio?

HORSTMANN: That will undoubtedly have to occur in the future.

DERMOTT: If you have even size stock over a large area in reclamation projects the chances of complete failure are increased. It has to be advantageous to use a whole range of different kinds of reclamation stock if the objective is for establishment of deciduous and coniferous cover.

SUMMARY

1. Reclamation seedling stock should be lifted by the conventional method where you lift the stock in the fall and store over winter in shade frames for spring planting. The stock has been stored in peat moss at a greenhouse temperature of -2°, with a hardening off period of 3-4 months, and good success.

2. Reclamation stock should be planted during best moisture conditions and preferably in early spring before the deciduous stock has flushed out. Later summer planting success will be very dependent upon the site and favourable climatic conditions at that time.

3. Nursery stock should be treated with a retardent to hold the moisture in the plant prior to shipment. A higher survival rate has been shown in the past where such a process has been utilized.

4. Proper stock storage and holding facilities are extremely important for reclamation stock at field level prior to outplanting. Guidelines are required for the proper handling, storage and planting of native shrubs. These factors are considered more critical than in shelterbelt programs due to the harsh reclamation sites.

5. Proper site preparation is necessary to ensure the success of any planting program, including microsites to hold moisture and to make the site more receptive for plant establishment.

6. Seedling planting should come after a grass-legume cover has been established on any reclamation site to ensure some cover protection exists for the seedlings. In the Eastern Slopes a light grass cover is recommended followed by the establishment of tree cover. Heavy grassing should be avoided except where local conditions dictate this requirement due to serious erosion potential.

7. Broadcast seeding of native shrubs on harsh sites is not recommended. On good sites broadcast seeding of shrub species may be possible, but only with a mixture of various and widely adaptable species.

8. Any selection of a native shrub seed mixture should include a highly adaptable mixture. Further research is required on native shrub selection and it is recommended that any shrub selected must be widely adaptable and not specific or applicable to a localized situation.

9. Direct seeding of native shrub seed may be negated by the urgency of reclamation and stabilization. Seed may not be available for direct seeding in the quantity needed and the economics of this type of application has to be carefully considered.

10. At present there is not sufficient seed available for native shrub operational use and when selection has been finalized there will be some time before large quantities are made available. The cost of seed will remain high for some period of time, especially for certain hard to obtain species.

11. Grass, legume and deciduous seed had been applied in one application with varying and unproven results. The direct application of native shrub seed at present is not being suggested as the proper procedure due to seed availability and costs at this time.

12. It is important to ensure a dedicated and high quality of planting personnel are available for reclamation planting programs. Planting production should be secondary to quality in reclamation program planting.

13. Reclamation stock must receive more attention than shelterbelt stock in the nursery and during transportation and storage to ensure the healthiest of plants are being planted.

14. Starter tablets are not recommended for use in reclamation with trees as evidence to date indicate that they are not advantageous.

15. Pruning the roots and top of seedlings in a nursery has to be considered to assist the seedling when outplanted. Further criteria are required by species to confirm to what extent and when pruning should be done.

16. Reclamation programs should get away from the artificial planting in rows or with a single species, to a more natural environment.

17. The use of cuttings must follow proper procedures from the care in storage to the installation into the ground. The angle in planting of cuttings is very important for plant development and survival. The depth the cutting is inserted into the ground is also critical. Definite guidelines should be established for users of cuttings to follow. Larger cuttings are recommended for reclamation programs than are used for shelterbelt operations.

18. In reclamation programs containers are favoured since the survival ratio is generally higher than in the use of bare root stock on the harsh sites involved. Container stock also allows more flexibility in the timing of planting. Further study is necessary in this area, however, by individual species since there are numerous gaps evident where information is minimal.

19. Deciduous reclamation stock requires larger containers than normal coniferous stock due to the higher root ratio in the deciduous stock. Further evaluations of root development and proper container size is required by individual species for reclamation programs.

20. Bioengineering can be applied anywhere in the world, but in Alberta we need to know a lot more about our native shrubs which will be used in the application of this science. We must conduct tests and set up adaptation sites to determine:

    a) best time of obtaining cuttings by species
    b) best method and procedure for cutting storage
    c) have to determine root development by species

d) have to determine root/top ratio by species - grasses, legumes and shrubs
e) have to know the building materials involved
f) have to know root shear strength by species
g) have to know moisture utilization, leaf size and evapo-transpiration by species
h) practical booklet for field use is needed to outline the bioengineering process and include a to g above for the field personnel to use as a guide

Natural shrub species should be utilized as much as possible for bio-engineering practices. We must direct our selection process towards the end land use so that the species selected can be practically applied.

21. Site preparation is very important in reclamation and grass/legume seeding has to be done progressively with bed preparation so optimum conditions are utilized.

22. Soil moisture is considered an important factor in deciduous installation and has to be critically considered with regard to timing of planting and soil amelioration techniques designed to hold moisture levels at an acceptable level following planting.

23. Maintenance of reclamation programs and in particular of shrub planting is felt very important. Pruning and fertilization must be conducted where necessary to ensure adequate care of planted stock.

24. Cuttings and shrub plantings have been most successful during early spring periods when the ground moisture is the best. The worst period to plant is later in the summer when climatic and soil moisture conditions are unfavourable.

25. In the tar sands root pentration has been found to be abnormal due to the compaction in overburden piles and has to be considered a factor in shrub selection.

26. Island planting should be encouraged where feasible and practical as this has proven to be an excellent procedure and is more natural than single plants in reclamation programs.

27. The use of available soil has to be considered in the establishment of native shrubs as success in the use of limited amounts of soil base has proven very satisfactory in past performance.

28. It was suggested that one year old seedlings are not surviving on the harsh reclamation sites and that older stock, two year stock, is necessary. There are practical and economic nursery problems in holding these over, along with root development problems in normal containers. Also, the proper hardening off of the species is very critical. As well, proper site preparation, handling and storage techniques, and favourable climatic factors at planting time, followed by maintenance procedures, must be considered to improve the survival rates.

29. A literature review must be done on those areas known to require further study to identify where similar work has been conducted in other parts of the world, which would be directly applicable to Alberta's situation, especially Northern Montana, Utah, Saskatchewan and South Eastern British Columbia. A literature review should only be conducted on those gaps requiring field work to be undertaken.

30. The long term objectives of the presently active native tree and shrub project under the Alberta Forest Service were identified as being:

    a) to develop native trees and shrubs through selection for use in reclamation of disturbed lands in the Rocky Mountain Foothills of Alberta.

    b) to formulate prescriptions for establishing and maintaining them on disturbed sites for commercial timber production, wildlife habitat improvement, slope stabilization, and improvement of recreation areas.

    A literature search underway has covered 360 publications on native shrub literature directly relevant to Alberta. Some native seed has been collected from the Eastern Slopes with further collections to be conducted in the 1979 season.

RECOMMENDATIONS FOR FURTHER RESEARCH

1. Guidelines are required for the proper field storage, handling and planting procedures for shrubs being supplied for reclamation.

2. Information should be made available on the procedures involved and usefulness of antitranspirants or similar material used at the nurseries on plants prior to shipping and planting.

3. Guidelines are required on native shrub selection and should include such criteria as:

   a) ease of collection and storage
   b) ease of propagation
   c) species selected should be adaptable to many sites and not site specific
   d) species role in desired end land use

   Other criteria to be evaluated on native shrubs is the root/top ratio, the root shear strength, moisture utilization, leaf size versus evapotranspiration, by species.

4. Adaptability field trials are necessary which will be properly designed to evaluate long term performance of the most promising species which exist in Alberta (presently underway by W. Russell, A.F.S.).

5. Root and top pruning of reclamation deciduous stock requires further study to determine to what extent, how and when, pruning will be most beneficial.

6. The utilization of cuttings in reclamation programs shows promise. Guidelines are necessary for the users of cuttings as to time of cutting, type of cutting, methods of removal and storage, size of cuttings by species, and proper handling and planting techniques.

7. Deciduous reclamation stock requires larger containers than coniferous stock due to the greater root development. Studies are necessary to determine the optimum container for individual reclamation species being utilized.

WORKING GROUP III - Species Selection

Participants

Dr. Percy Sims, Moderator - Alberta Environment
Dr. Robert Hursey - Alberta Environment
Mr. Glen Dunsworth - Alberta Energy & Natural Resources
Ms. Gail Fitzmartyn - Parks Canada
Mr. Joe Soos - Alberta Energy & Natural Resources
Dr. Al Fedkenheuer - Syncrude Canada Ltd.
Mr. Ray Nyroos - City of Edmonton
Mr. Eric Stathers - Cominco Ltd.

Discussion Topics

Genecology
Seed Production
Harvesting
Growth and Vigor
Area of Application
Species Trials
Literature Review

DISCUSSION

SIMS: There are two lines of attack and one of them is the breeding program where you are actually trying to get specific characteristics and select for them and breed them and the other is take what you've got from around the site, try and get as much variation as you can in terms of seed production, root growth, top growth or whatever you are looking for and work with that.

DUNSWORTH: My personal opinion is to go the second route first, to look at what you have in terms of natural variability to see if you can utilize that. If not, if you can't get the species or genotypes to meet your needs, then perhaps you'd be warranted in developing a breeding program. But breeding, particularly with trees and shrubs, entails a long period of time. There is an extensive amount of natural variability that has not been exploited at all in Alberta.

HURSEY: We don't know enough about the site that we want to eventually grow the plant for and when you start a breeding program, it pre-supposes that you know the characteristics of the site. The breeding program assumes that you know your goals very clearly, because you're breeding for something. I would question the ability to breed for success on a variety of sites without doing a lot of work to define what those sites were. Switching more to breeding than to the selection program pre-supposes that you are going to put a good deal of effort into site characterization.

SIMS: Those objectives (whatever you want) have to be laid down but at what point do you think we can progress from a selection program to a breeding program if in fact you want to do that, and secondly, if you start a selection program and then go to a breeding program, how many species do you think you can handle in each? One can do a very careful selection for specific characteristics with grasses, you can license varieties, you can get people to grow then commercially. You have a whole agricultural background of knowledge and equipment to call on. In shrubs we don't have that so we're starting from scratch.

DUNSWORTH: I think the point is in any breeding program you've got to know what you've got in terms of gene pools-and to do that you have to sample the natural variability. We can do adequate listing to determine how species or genotypes are performing with regard to certain factors; and then once you've sampled a reasonable amount of the genetic variability within and among native species on the basis of site classification then I think you would be able to determine whether or not a breeding program is warranted to meet the objectives.

HURSEY: You would make the break from selection to breeding at the point where you had identified that the genetic material required to reclaim a site does not exist in any of your native genotypes.

DUNSWORTH: And you are still going to have trouble doing that because if you're dealing with out-crossing species any sample in a given year of open pollinated seed is only a sample of the potential genotypes that exist so you might have to run a program to be assured that you're getting a representative sample of genotypes over several seed years before you really know.

HURSEY: One of the things that Glen has done on his project is write out the criteria on which he has made the selection.

DUNSWORTH: (The criteria are):

(1) readily available seed: (2) adequately cold hardy; (3) adaptable to salt properties present on the disturbance; (4) ability to compete under primary seral conditions; (5) ability to fix nitrogen; (6) have low water and nutrient requirements; (7) provide a balance between deep and shallow rooters; (8) provide extensive ground cover or a closed canopy condition quickly.

FEDKENHEUER: We're talking about breeding particular species to cover a range of conditions. Do we really take that approach or do we take a different approach and switch from species "A" to species "X" when we go to a different site?

SIMS: One of the things we talked about at the beginning was just how site specific you got. It probably doesn't matter if the species is not a real good seed producer or that you can't propogate it very well from cuttings, if all you're looking at is a 100 acre area with a very specific problem. You might be able to get enough material and plant enough to do that area and not worry about it anymore. But there are a lot of other areas, say Alpine areas or the Tar Sands, where there is going to be an extremely large disturbance.

FEDKENHEUER: Has someone looked at the species that are being used in reclamation or are proposed for reclamation and looked at their Provincial distribution? Because then perhaps those are the species we want to take into an intensive selection program.

DUNSWORTH: Would it be fair to say that we don't know? That's why we're here.

SIMS: If you go to the Alberta literature you've got information, say with alder, anywhere from zero to 100% survival and in

no case is there any information that told you why you got a success or failure. I think the whole literature or information basis that we have is unfortunately of that type in Alberta. We should come up with some kind of concensus. Do you work with the natural variability? Is there any point in looking to a breeding program? What is the concensus of this group? Is it worthwhile somewhere down the line to start breeding native shrubs as you do grasses for drought resistance, seed production, etc.? The next five years are critical to us. If somebody says to us no, not for another ten or fifteen years, if it's twenty years before we get into that, well I don't think we have to worry about that right now in terms of research.

FEDKENHEUER: I don't think we can get into a breeding program with the native shrubs for at least ten years. It will take us at least that long to evaluate what we can expect of the native species.

SIMS: In terms of doing that the Oil Sands is no different than any other area in Alberta. So, if we had $100,000 dollars right now to spend on research, we would be best advised to solicit proposals to select promising species and populations within species in specific areas of the Province and evaluate them.

SOOS: What I would like to ask you is, okay it's nice to propagate, have seed and what not, but if you plant it out and the mice are going to wipe it out what would you accomplish? What I would like to see, for instance, in the States it has been proven that they can breed Douglas fir and white spruce which are most resistant against browsing by deer and elk, etc. and I really think that this would be a good area for genetic research. If we could know what kind of species could be grown in Ft. McMurray where there is a problem with mice or rabbits or whatever. We try to come up with a particular genotype which is not going to be hit.

SIMS: I see that Joe, but do you start breeding for that right now or start selecting, and somewhere along the line you find a particular ecotype or individual that the mice aren't touching for some reason, then take that one and start looking at it more closely?

Some of these other problems can be attacked in other ways. That is with the rodent problems, as I see it, the problem is if you give the rodents the habitat in which they are going to multiply ten times in a year then you're just asking for trouble. Do you start a breeding program to get rid of that or do you start dealing with the ecosystem that is involved? I think we know more about that than we do about

breeding. Also there are species differences. In Manitoba scotch pine was planted with jack pine in the Sandylands Forest Reserve and the mice ate the scotch pine; they never touched the jack pine.

BOLWYN: It goes to show you, you can't look at any single aspect. You're dealing with the whole ecosystem.

SIMS: Okay, I quess the concensus is for natural variability. Glen raised another point earlier, and that was limiting factors. If you're going to do any kind of species evaluati with respect to limiting factors you have to have site classification.

FITZMARTYN: You have to decide what degree of reclamation you're talking about. It won't be the same on every site and again it gets back to management objectives. Until you decide your degree of reclamation you can't go any further. On most sites I don't think you can reproduce the natural situation because merely the fact that it has been disturbed has created a new situation and you can't say, well, this plant grows right next to it so it will grow here, because nine times out of ten it won't. So you have to have a very specific selection criteria which involves a lot of preplanning.

BOLWYN: Do you (Parks) try to rehabilitate to the original state or have you looked at what is a desirable end use even though it may be different from what was there before?

FITZMARTYN: In the past it's largely been reclaiming with whatever we could get, availability was the leading factor. One year we could get willows, etc., so everything we did that year was willows and it's just getting to the state now where we can say, okay, first of all let's look at the objectives for the site and this is the site that is going to be used for recreation, like a campground then into your criteria you're going to have to build in say a tolerance to trampling or continued shading, and those kinds of things. We're just starting to get into that. We really haven't done a lot of research into reclamation in the past and now we are approaching the point where we can see that projects we've done in the past have been failures and most of those have been because we didn't know enough about the species that we were trying to produce. We need a lot more basic autecological information on the species that we are working with.

We believe that (vegetative) propagation is the way to go. That is the way the majority of the projects are being done in the States with good success. And it's also an instantaneous type of solution. You don't have to wait for ten years. Most of our projects (Parks) are small enough that we can go about it that way and have a great deal of success; we don't have millions of acres to cover. We only have

smaller areas that are scattered throughout the mountain and coastal national parks. So it's easy for us to do on that basis. If we had to go to major projects then we might consider breeding. But for our purpose vegetative propagation (of wildlings) is the only way to go.

In terms of Parks policy, the new draft policy which has not come out yet, wherever possible native plants should be used. So our emphasis is to switch everything to a natural situation. The problem now is that there are very few of those plants available. We have a good idea of what plants first of all we would be considering from our bio-physical inventories. We asked the parks to respond and they sent us a list of species they thought would be useful and to those we will add species we think will be useful and through literature research we can immediately eliminate a lot of the plants because they are difficult to propagate or whatever. There is a fair amount of material available from the United States.

SIMS: There is one thing that bothers me though about this whole program, that is the elimination of species because they are difficult to propagate. Do you really know how much effort has gone into the propagation? There are a lot of good species, and just like with survival, you eliminate some good species because they haven't survived but do you really know why they haven't survived or do you really know why they won't grow from cuttings or from seed? If we have a good species, then I wonder whether we should throw it away just because someone couldn't germinate it.

FITZMARTYN: If it's a really good species it can still be transplanted and it will work, it will survive. On a large scale that won't work. But I think you have to start somewhere and I think there's no point in starting from the beginning all over again and if you find that the ones you haven't discarded, and have shown promise in other areas, can be used, is there any point in going to a lot of work to try and get other species that could be more difficult?

BOLWYN: Is this an area that we should be looking at? A (suggestion) has been made to me as head of Plant Sciences, Environmental Centre, that one area that needs looking at in reclamation and revegetation is seed physiology and seed germination. The establishment of seedlings and/or better techniques to propagate vegetatively so that people like Gail and other users can go on with those species that for now will give them what they want, even if it's only one or two out of fifty, and that a body such as the Environmental Centre can take on the work for the benefit of all in seed physiology, if indeed a crew like this feels that is where the major gap is in our understanding.

DUNSWORTH: I think you will find from the propagation and outplanting sessions of this meeting that there is definite need for seed pretreatments for Alberta species and for techniques of vegetative propagation and seed germination.

HURSEY: Another one of the things that will come along with that is the need for additional autecological studies. If the reclamation was successful, you would not have to pour the additional barrels of oil in the form of fertilizer and caterpillar time and this sort of stuff onto it.

SIMS: As Gail just said, if you plant something and can't walk away and leave it because after it's grown for eight or nine years, like Russian olive as was mentioned this morning, it's gone and you're back to square one. Its got to be able to reproduce in one way or the other and fill in that site or at least prepare it in a successional stage for surrounding material to come in. What comments to people have on selecting species in terms of those three and any other characteristics? Is seed production the most important thing, is growth and vigor? Is the ability to harvest it and get the material the most important? What sort of priorities should we place on research?

HURSEY: I think we have to approach all of these plus other things on the basis of phenology (growth phase) and we've got to learn enough about the plant to recognize that when we have a bad seed year, the cause can be months prior to the time when we realize we have a bad seed year. An area of very important research would be strictly the phenology of plants, of the different activities of plants. I think we've overlooked it in general as foresters, in range management, and agriculture. I think the agricultural people have done the best with phenological studies, getting the crops to ripen at the same time, this sort of thing but particularly in forestry, we've never paid any attention to it.

SOOS: I agree. A great many times seed treatment problems arise precisely because we completely ignore the physiological state of seed selection.

BOLWYN: We suffer from mobility in today's society in that we don't get people really in one area developed as an ecologist who is concerned with 25 years of work. We find people who are looking at 2, 3, 4, 5 years and if they haven't moved in 5 years then they find they are in a rut. I think the government has to provide a climate where these people can develop an expertise and start on a project today and retire with a project and be recognized and respected for the work that they've put in over a lifetime.

SIMS: If you could start an institution like the Environmental Research Centre and establish a climate there where someone can get established and work for ten years on a project, I think you are going to get a lot of returns from it.

HURSEY: It is a particularly appropriate subject to think about when you start talking about species selection or breeding programs as we are, because phenological studies require years, selection studies require years, any type of autecological work requires years. In seed physiology you may get lucky and solve it quickly but usually it requires years. It's an area where there is a very low probability of rapid answers and possibly we ought to make a recommendation that any commitments made in this area of species selection be made with a realization that they are long term, they are not to be made on a short term basis.

SIMS: I think species selection and genetics is long-term and I think people involved on the Technical Advisory Committee, people who are funding that type of research realize that. Because there is no other way to go, we've used contracts exclusively. We could make that recommendation. I think people understand it now but I don't know if we could guarantee it.

DUNSWORTH: You asked about priorities and I'm not sure, in terms of species selection, whether seed production is really that critical because I visualize the situation where we can test species and test populations within species and perhaps find certain populations which are adapted to certain given situations. Now on those sites they may not produce seed but if we have seed available from these populations we can start a seed orchard. I think this may sound a little way out, but I think this is the to go, if we're really commited to reclamation with trees and shrubs in Alberta. There is going to be a very large demand in the next ten years for a lot of seed. If we do any significant selection a lot of selected seed will be required. I think you're looking at the establishment of one or several seed production areas or seed orchards. Selection on site for seed production may not be that essential, but the development of the source of selected seed may be.

BOLWYN: You are saying that you do have a start on that in the collection that is now at the Environmental Centre in Vegreville.

DUNSWORTH: You may be able to use this material for testing treatments to initiate flowering and induce heavy seed production.

SOOS: Whenever you plant your material to the reclaimed site do you want to see seed production on those particular species, do you try to select for seed production, is it advantageous?

If we are looking for a characteristic for either trees or shrubs, they should originate, themselves, from seed. This is very important thing to test out.

DUNSWORTH: Now a lot of those species you plant initially may, in the end, never produce seed, they may just survive. What does it matter if it reproduces, as long as it serves the purpose of stabilizing the site and providing a good condition for succession to take place.

HURSEY: What it matters, Glen, is that we've got to know that something is going to invade under it. Because that's happened in a number of cases where we used agronomics, once the agronomics start to go, nothing else will come back in.

SIMS: If you create a natural situation there it shouldn't really matter if you get invasion or not. If you've got a boreal area and you put boreal species in it, if they ever reproduce themselves, then you don't need to worry about the natural succession.

HURSEY: It should modify the site so the next stage in succession will come on or if it hasn't modified the site by the time it begins to decay and go out it should reproduce itself. One of these two things should happen. If it doesn't then we've got a problem.

DUNSWORTH: This also brings up Gail's point, Percy. If you are going to say seed production is a prime requisite of a good reclamation species, how much seed production, how viable does that seed have to be, 50% germination, 20%, 10%; where is the limit?

SIMS: It depends on how much is there. If you can only put a 100 units of that species on an acre and you're going to depend on seed, then probably you have to be pretty concerned about seed production. If, as with grass you can seed the whole area to a 100% cover, if every grass produces a viable seed or two, every head, then probably you're alright. But with shrubs you're into something different. And if you're depending on them reproducing from seed you ought to be pretty concerned initially, unless you want to go to a great expense just to cover the area you have.

Again, if you're very, very site specific, you're not going to be concerned about seed production areas, right? If you've got a species you can plant all along the foothills on every site that is mined, or every road side or whatever, then you are going to be concerned about commercial production of that seed. Is that what you're getting at?

FEDKENHEUER: Are we talking about just the species in general or are we talking about ecotypes of that species? If we're talking about ecotypes of that species and if we're talking a seed orchard, will we then try to keep separate ecotypes in that seed orchard?

SIMS: Now if you have a lot of ecotypes in your seed production area and you knew that if you harvested that seed and sowed it on any area in the foothills or in the boreal that a few of those ecotypes would reproduce, 70% of them might be no good at all, but a few of them would reproduce, is that what you want or do you want to take one single ecotype and make a seed production area from it and you're limited to putting it on a restricted area? Now which way do you want to go?

FEDKENHEUER: Wouldn't you really be looking at growth and vigor as your number one priority? Once you determine how well an ecotype or species grows, then you can look at those that are producing seed and the complications involved in harvesting.

SIMS: All I'm saying is that if you have in your line an ecotype that will grow on acid soil, one that will grow on calcareous soils, one that seems to be drought hardy and one that seems to be cold hardy, if you've got a mix of those, you can take a handful of that and throw it on a site and if that site happens to be acid some of them are going to grow; some of them will die.

BOLWYN: You can't develop a program for revegetation along the same lines as you do for agriculture because the objectives are quite different.

SIMS: When the United States Soil Conservation Services produces a line and has it licensed it contains a number of genotypes.

DUNSWORTH: If you select from a population you've a number of genotypes. If you put individuals from that population in that seed orchard you've also got a number of genotypes.

SIMS: This is what I'm getting at. In selection, you don't want to select too far down the line so that you're getting, in a sense, a monoculture of one ecotype.

DUNSWORTH: You wouldn't get that until you clone it. If you restrict yourself to even 50 mothers in a seed orchard and have them freely out-crossing, then I don't think you would have any problem.

SIMS: If you selected on the basis of vegetative production and took those species into a seed production area, would that productive capability be maintained in seed produced?

DUNSWORTH: It depends on how closely it's linked genetics, for one thing. And the seed you're producing in the seed production area, where is your pollen coming from? Are you cross-pollinating, just wind pollinating or are you going to do the cross-pollinations from given mothers?

SIMS: If it's a seed production area, you're not going to mess around with that kind of stuff.

DUNSWORTH: What we are saying is we go out and test and we find ten genotypes survived well in this site, okay we'll clone each one of those and put them in a seed orchard and collect the seed from those and hope that adaptation is genetically linked. If you cloned them and put them in a seed orchard, collected the seed from them, you'd have a wider range of genetic variability, probably still have adaptation, although not as good as your clones, but you'd still have better adaptation than what you started with and you'd be safe in terms of insect, disease and abnormalities.

HURSEY: Any time we start looking at growth and vigor we are talking about a site specific characteristic that has the capability of growing well but that's true of any genotype. You wouldn't have to worry too much about which scheme you undertook (seed or vegetative propagation) as long as you didn't go out and plant a large area from one clone. If you had ten clones, randomize your chunks and spread them out and you would be alright.

I think everybody would agree on survival (as a priority). I think everybody would agree on growth and vigor, with a caution that it is not a highly heritable trait, that it tends to be site specific.

SOOS: When people are talking seed or no seed, don't you think about the birds, don't you think about wildlife? That's part of the ecosystem.

HURSEY: There are two sides to that one. I think palatability is one of the things that has to be considered because if it's too palatable, it's going to draw wildlife in to the point where it will destroy your reclamation. If it's not at all palatable, why then it has no value. Especially if you start fertilizing you run the risk of raising the palatability way up. I think at this stage it'a fairly low priority concern.

SIMS: The concensus seems to be for growth and vigor and I'll go along with the majority but I think between growth and vigor and seed production you have to be site specific. In some areas you may be very, very concerned about growth and vigor for erosion control, getting an area covered in, wildlife, etc.

But in some areas you may be more concerned about seed production and I don't know if we can put a priority on growth and vigor over seed production. It depends upon site, and you just mentioned wildlife production. Growth and vigor for pheasant cover, for any upland game is probably not as important.

HURSEY: What about pollution resistance?

SIMS: Factors like palatability, aesthetics and tolerance to specific things like pollution, I don't know if you can put priorities on them because they're going to be very, very site specific, but in an overall program, and maybe that goes for seed production too, survival, growth and vigor are the two priorities and anything else you look at depends on end use. Is that the concensus? If you are going to go into a selection program for reclamation, no matter what the end use, survival along with growth and vigor are your two big things to look at.

Generally those are the two priorities and there are a lot of other priorities that are site specific that you will have to consider.

SOOS: There are introduced shrub species which under certain conditions, may out perform our native species. I would like to leave the door open on the exotic species and exotic species trials.

HURSEY: I agree with you Joe, having a great tub thumper for natives I'm a little aghast at the idea that we are now going to ignore exotics. I think there is room for exotics.

SIMS: I don't think we're going to ignore them. I think it's just that this workshop is specific to native species because that's the area where we lack a lot of knowledge and I don't think we'll get away from exotic species. We'd be crazy if we did, but what about species trials?

DUNSWORTH: I would like to see trials carried out on a population basis not just species trials. I don't like the word ecotype. I would prefer to call them populations. If we're going to do species trials we should look at variability within the species, collect populations and look at site variables for those populations. We could then see how collection site variables relate to the disturbed site variables.

HURSEY: The Progeny test design is one the best designs I know for species trials or populations trials (I prefer ecotypes to populations) but I think this is the classic sort of trial that need to be set up, where we can get as homogeneous as possible an environment and then plant in a random design the different test populations and genotypes, and then evaluate them. It's a long term type of work.

SIMS: What about microclimatic measurements?

HURSEY: I think they're important, very, very important.

SIMS: There isn't any back up information at all for the trials that are going on now.

One of the things I wanted to get to is priorities for what factors we should look at when we do a species trial. If you take so many ecotypes or whatever, individuals and plant them, what kind of measurements should you take from the natural site that you got them from and from the site that you're putting them on? I think we've got to assess some priorities because it's almost impossible to look at everything. We don't have the money, the time, the people.

HURSEY: I would answer that by saying that the next subject you should look at on a given species would depend upon what you've learned from the literature for that species, because for each species a different set of factors interacting in a different fashion will be critical. So what factors you would have to be looking at depends on what species you are looking at.

SIMS: If we go out and solicit a proposal from somebody for a species trial, then one of the first things we should ask is a complete literature search, on say a half dozen species, that we tell them to look at, or if they come to us and say we want to do this, this and this on these three species, they better have the literature pretty well covered. Is this what you're saying?

SOOS: Whatever you need to do with this, if you don't know any better, start out with large, say biogeoclimatic zones where there isn't too much variation. Okay, you can talk about subalpine vs alpine or certain parts of the boreal zone against alpine, narrow it down.

SIMS: What you're saying is initially you select some of the broader more general factors that might affect survival and screen on the basis of that before you get into more detail. I guess we're out of time and coffee is upstairs. I think we covered some things in too much depth and some things in not enough depth but in 2 hours or 2½ hours I got a lot of ideas from each other. Thank you very much.

SUMMARY

(1) General Genecology

SIMS: - Two possible lines of attack
  (i) Selection from natural variability of native material
  (ii) Breeding for specific characteristics

DUNSWORTH: - Selection better than breeding, unless desired characteristics does not exist.
- Breeding is long term.
- Extensive unexplored variability in Alberta.

HURSEY: - Breeding assumes knowledge of goals. We have not defined our sites.

SIMS: - Shrub breeding program does not have background of knowledge, or equipment of an agricultural program.

FEDKENHEUER: - Can't get into a breeding program for another 10 years.

SOOS: - Breed to select genotypes resistant to specific factors.

SIMS: - Not all problems need be solved by genetics - some are ecological.
- Should not eliminate species on the basis of lack of knowledge about them.

FITZMARTYN: - Should make an initial general selection based on existing information.

HURSEY: - Autecological and phenological studies are needed to compliment genetics work.

SOOS: - Physiological factors are important.

SIMS:)
HURSEY:) - Microclimatic measurements are also important in genetic selection and testing.

SOOS: - Should select on the basis of broader and more general factors and screen on that basis before looking at other factors in more detail.

BOLWYN: - The government has a responsibility to provide the climate, facilities and funding for this type of research.

(2) Reproduction of Material

DUNSWORTH: - In a given year of open pollenated seed one obtains only a sample of potential genotype.

FITZMARTYN: - Vegetative reproduction is the way to go on small projects.

BOLWYN: - Seed physiology has been highlighted as a critical area for research.

DUNSWORTH: - There is a definite need for seed pretreatment and techniques of vegetative propagation.
- Seed orchards will be the way of the future. There is going to be a demand for a lot of seed.

BOLWYN: - Seed production is not guaranteed from year to year.

BOLWYN: - Management may not want to get into seed production. Should be turned over to private individuals once one has identified species and established how to get seed production.

DUNSWORTH:)
HURSEY:) - Treatments to enhance seed production or ripen seed uniformly etc. will probably not be genetically linked in following generations.

SIMS: - Seed production areas will contain numerous ecotypes including a number of valuable characteristics. Seed orchards are man-produced and contain specific genotypes.
- Is good vegetative reproduction a heritable characteristic?

DUNSWORTH: - Even if a genotype reproduces well vegetatively, seed orchards are required in order to ensure supply of material.

SOOS: - Can do it all vegetatively?

DUNSWORTH: - Seed production is safer.

HURSEY: - Whichever method has proven to be of value in maintaining the species in the past should be selected.

(3) Selection Characteristics

DUNSWORTH: - Selection criteria are:

(a) readily available seed
(b) cold hardiness
(c) salt tolerance
(d) competative ability
(e) ability to fix nitrogen
(f) low water and nutrient requirements
(g) balance of rooting habit
(h) provide quick cover

FITZMARTYN: - Seed production on selected plants should average higher than in natural state in order to ensure natural succession.

HURSEY:)
SIMS:) - Have to be sure that whatever we plant will reproduce itself and allow invasion or succession of native species.

SIMS: - Seed production requirements depend upon the number of plants to be used in reclaiming an area.
- Seed production requirements vs. vegetative production depends upon how site specific one wants to be.

FEDKENHEUER: - Growth and vigor is number 1 priority. If you select for this then you can start trying to improve seed production.

HURSEY: - Growth and vigor should be a priority, with the caution that it is not a highly heritable trait.

SOOS: - Aesthetics and wildlife (palatability) should also be priorities.

SIMS: - There are many priorities which are site specific but growth and vigor is important everywhere.
- Growth and vigor may have to be sacrificed to an extent in order to provide other site specific characteristics.

(4) Area of Application

SIMS: - Program depends upon how site specific one wants to be.
- Limiting factors must be considered in selection program. Site characterization is needed.

FITZMARTYN: - National Parks program more site specific.
- Can't always rely on surrounding vegetation because the site is changed with disturbance.
- The program (Parks) is just getting up to the point where site objectives can be assessed and species selected accordingly.

HURSEY: - Should not plant a large area to one clone (monoculture); a random mixture protects longevity.

(5) Species Trials

SOOS: - Should not neglect exotic (introduced) species.

DUNSWORTH: - Species trials should be carried out on a population (ecotype) basis. Observe how site variables from area of selection relate back to site variables on disturbed area.

HURSEY: - Progeny test designs are excellent for this sort of test.

(6) Literature Review

SIMS: - So far, research in Alberta does not tell us enough about success or failure.

DUNSWORTH:)
SIMS:) - Whether a genetic research proposal is solicited or unsolicited, it should be backed by an adequate literature review.

RECOMMENDATIONS FOR FURTHER RESEARCH

(1) Alberta should concentrate on selection of desirable genotypes (ecotypes) from within the natural variability of native species.

(2) A limited breeding program should be carried out where desired genetic characteristics do not exist in the native populations.

(3) A full scale breeding program should be considered in the future, but not for at least ten years.

(4) Native species in the Province should be screened and rated for potential.

(5) Suggested criteria for selection are:

(1) availability of seed
(2) cold hardiness
(3) salt tolerance
(4) competitive ability
(5) drought hardiness
(6) low nutrient requirements
(7) provide a balance of rooting habit
(8) ability to fix nitrogen
(9) provide adequate ground cover quickly

(6) Selected genetically based characteristics should be considered in terms of their value in general reclamation as compared to site specific reclamation. Research priorities should be assigned accordingly.

(7) Survival, growth and vigor are considered to be characteristics of highest priority.

(8) Seed production and related seed physiology work is of only slightly lower priority to those listed in (7).

(9) Site specific traits (palatability, aesthetics, ability to withstand pollution) are presently of secondary priority.

(10) Research into vegetative propagation of genetic material is probably of greatest importance for site specific problems.

(11) Autecological studies (ecophysiology and genecology) are considered to be extremely important.

(12) Phenological studies are considered to be of high priority in the context of (11).

(13) Species trials (progeny tests) of selected genotypes should be carried out and should include detailed observations of variables from the site of collection and their relationship to variables on the disturbed test sites.

(14) Microclimatic studies are considered to be of high priority in the context of (13).

(15) Seed orchards or seed production areas consisting of selected genotypes or clones of genotypes should be established.

(16) External treatments to enhance seed production in seed orchards or seed production areas should be investigated.

(17) A research program on the genetics of native species for reclamation should not be carried out to the exclusion of exotic species. The latter have much to offer in both short-term and long-term application.

(18) Solicited and unsolicited proposals for research into the genetics of native species should be backed by adequate literature reviews.

(19) The Government of the Province of Alberta should make the commitment to initiate and support a long-term program of genetic research on the use of native species for reclamation and other purposes.

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