IR-76

Right-of-Way Rehabilitation of Sandy Slopes in Northern Ontario

-- Phase 2

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Right-of-Way Rehabilitation of Sandy Slopes in Northern Ontario
-- Phase 2

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Abstract:	Various species of grasses and sedges have been investigated as potential reclamation plant material for problem sandy slopes in northern Ontario. This report presents the results to the end of the second of three phases of revegetation research. A variety of sedges and prairie grasses normally found in sandy, drought-prone habitats were planted on the sandy approach fills to a bridge structure near Gravenhurst, Ontario. Planting was done in the fall of 1985 and the spring of 1986, on both north and south slopes, to determine the effects of season and aspect on the initial growth of these species compared to the growth of a standard MTC seed mix. The sedge species performed poorly and their potentail as rehabilitation species will rely upon improvements in germination rate by locating more fruitful populations or by better techniques to break seed dormancy. The grass species tested appear to hold some promise for 'problem' slopes; however, more monitoring is required to determine their longevity under roadside conditions. The standard MTC seed mix outperformed the test species in the initial growing season; however, it is expected that the situation will change over time. The three grass species tested have a natural tolerance to infertile soil and droughty conditions and will likely outperform the MTC seed in the long term.
Comments:	A third phase of this investigation will involve monitoring of the species to determine further germination of the sedges and their longevity in field conditions
Key words:	sedges, prairie grasses, sandy infertile soils, droughty conditions, revegetation, erosion, germination
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-- Phase 2

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EXECUTIVE SUMMARY

This report summarizes results to the end of the second of three phases of revegetation research. Phase One dealt with the characterization of 'problem' slopes along Central and Northern Ontario right-of-ways, and the investigation of sedge species as potential reclamation plant material. Problem slopes were characterized by droughty, infertile conditions.

Phase Two involved a further investigation of certain sedges as well as some grasses, distinguished from sedges by a variety of morphological characteristics. Sedge seeds unavailable commercially, were collected in the field. Various treatments were tested to stimulate germination of these seeds. The seed of grasses selected for study were obtained from American seedhouses. The selected sedges and grasses, all normally found in sandy, droughty habitats were then planted on slopes of approach fills to a bridge structure near Gravenhurst, Ontario. Planting was carried out in the fall of 1985 and the spring of 1986 on both the north and south slopes to determine the effects of season and aspect on the initial growth of these plant species in comparison with growth of a standard MTC seed mix.

The grass species tested appear to hold promise as potential rehabilitation vegetation for 'problem' slopes. A Phase Three monitoring of the test plots is necessary to determine the longevity of these plants under roadside conditions.

The sedge species tested responded with poor germination success. The potential of the sedges studied as rehabilitation species will rely upon improving the germination rates either by locating more fruitful populations or by using better techniques to break seed dormancy. Again, Phase Three monitoring of the test plots will be required.

The MTC seed growth outperformed that of the test species in the initial growing season. It is expected that the situation will change over time. The three grass species tested, each with a natural tolerance of infertile soils and droughty conditions, will likely outperform the MTC seed. The poor germination success and results of test plot growth thus far suggest sedge species may not outperform the MTC mix over time.

ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of a number of MTC staff during the study. Gravenhurst District staff provided planting bed preparation and hydro-mulching services. Mr. D. Boucher assisted with coordinating those activities and monitoring the plots.

Mr. J.E. Gruspier and Mr. R. Dell provided very valuable technical comments throughout the study.

Agri-food Laboratories of Guelph and Oseco Incorporated of Brampton provided soil and seed testing services, respectively. Mr. W. Crins assisted with the identification of seed sources for the sedges tested.

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1.0 INTRODUCTION

1.1 BACKGROUND

Phase One of the study began in June, 1982. The study was initiated to address the rehabilitation of steep, sandy, infertile, roadside right-of-way slopes in northern and central Ontario.

Legumes and grass mixtures have been used traditionally on those slopes. Grasses were unable to cope with the low fertility present while legumes proved susceptible to herbicides used to control woody vegetation.

Native sedges were suggested as a potential alternative which may be able to cope with both of those situations (GLL, 1982).

Both a literature search and a contact program with other revegetation and botany experts were conducted in Phase One. Ministry of Transportation and Communications (MTC) and Gartner Lee Limited (GLL) staff visited eleven 'problem' slopes in Phase One. A detailed investigation of three of those sites showed all had dry, erodible, sandy soils with natural sedge populations forming a significant component of the plant cover.

Research suggested that six Carex species could tolerate site conditions and exhibit growth characteristics that would make them candidates for the revegetation of problem slopes in northern and central Ontario. Three of the six suggested Carex species were found to be growing naturally on sites investigated in detail. Those became the focus of study in Phase 2.

Phase 2 occurred between June 1984 and November 1986. It included a detailed study of three sedge species as well as three grass species thought to hold promise for revegetating study slope conditions. It involved an examination of the growth of those species in comparison with growth of an MTC seed mix on the remainder of the slopes.

1.2 STUDY GOAL AND OBJECTIVES

The goal of the Phase Two study was to determine the growth characteristics of selected plant material, when planted on an infertile sandy slope in central Ontario.

A number of objectives were established to meet that goal.

- To identify sources and obtain desired seed.
- To determine the viability of the wild seed collected.
- To establish and monitor test plots of the desired sedge and grass species and to compare growth in those plots with an MTC seed mix planted on the remainder of the slopes.

2.0 APPROACH

From the numerous candidate species examined, three sedges and three grasses were selected for detailed study.

Sedges:	Carex aenea	Sedge
	C. houghtoniana	Sedge
	C. lucorum	Sedge
Grasses:	Andropogon scoparius	Little Bluestem
	Panicum virgatum	Switchgrass
	Sporobolus cryptandrus	Sand Dropseed

Reasons for selection of the sedges have already been addressed (GLL, 1982). The grasses were selected for a number of reasons. All three are characteristic of dry prairie grassland or sand dune habitat similar in many respects to the problem sites of MTC roadsides. Each has a vigorous rooting system, important for slope stabilization.

Little Bluestem in Ontario is restricted primarily to sand dunes and shorelines of Lakes Huron and Erie and the Ottawa River (Dore and McNeill, 1980). The bluestem roots in American studies have reached a depth of 1.6 m with a lateral spread of 0.5 m (Weaver, 1968).

Switchgrass in Ontario is again restricted primarily to shoreline systems including Lakes Huron, Erie and Ontario. This sod-forming species has amongst the longest roots of all prairie grasses, reaching depths of almost 4 m (Weaver, 1968).

Sand Dropseed, is a pioneer species with the ability to colonize bare sand (Dore and McNeill, 1980). It possesses tremendous drought tolerance owing to its extensive root system. The roots form a dense mat spreading approximately 0.4 m laterally and over one metre in depth (Weaver, 1968).

Dropseed is native to dry sand along shorelines of Lakes Huron, Erie, Ontario and Georgian Bay (Dore and McNeill, 1980).

Some of the prairie species have already been studied for roadside revegetation by Landers and Kowalski (1968), Landers (1970), Cull (1976) and Ode (1970). They have been found to provide effective roadside vegetation cover.

Several tasks formed the study approach: a literature review, seed source identification, seed testing, planting and monitoring. Each is briefly described.

2.1 LITERATURE REVIEW

Extensive literature review and a contact program were carried out to obtain information on seed collection, germination treatment, storage, planting techniques and planting schedules. Literature reviewed and contacts made are listed in Appendix A. No literature was located about the propagation of the specific sedges selected.

2.2 SEED SOURCE LOCATION AND SEED ACQUISITION

While the grass seed was available commercially, the seed sources for the sedges had to be identified from native populations. Assistance was provided by W.J. Crins (Erindale College Herbarium) in identifying those locations. In addition a review of specimens was conducted by GLL at the main University of Toronto herbarium.

Of approximately 18 stations identified for the three sedges, nine were visited. The nine were selected based on herbarium notes suggesting the individual populations might be large enough to support seed harvesting. They were selected from similar geographic and climatic conditions to the proposed study area.

The seed source locations ranged from Parry Sound to Buckhorn to Petawawa. At each location, a number of factors were assessed: species presence, seed ripening stage, seed amount, habitat and accessibility.

Sufficient stocks of Carex lucorum (Petawawa, Ontario) and C. houghtoniana (Middle Muldrew Lake, near Gravenhurst, Ontario) were located for testing and planting. C. aenea populations provided adequate amounts of seed for only germination tests.

The Petawawa collection trip coincided with a mature ripening stage of Carex lucorum seed. The C. houghtoniana seed at the Middle Muldrew Lake site required three monitoring and collection trips in an attempt to coincide with the optimum ripening stage. Ripe C. aenea was collected from one trip to an area north of Craighurst.

The grass species selected were available only from American seedhouses. Numerous seedhouses were contacted to locate the desired species and to find out where the seed had been grown, and when it was harvested. Recently harvested, viable seed was desired from plants grown in a similar climatic zone to the study area for winter hardiness.

The Plant Health and Plant Products Directorate of Agriculture Canada was contacted regarding the weed potential of the grass seed imported from the Sharp Brothers Seed Company in Healy, Kansas. The seed was cleared and authorized for test planting by the Federal authorities (Agriculture Canada, 1985).

2.3 SEED TESTING

Testing was conducted only on sedge seeds. Germination rates for grasses had already been determined by the seed company.

Germination tests of the collected sedge seeds were carried out by Oseco Incorporated. The germination results (Section 3.1) proved useful in the interpretation of field trial results.

The selection of testing techniques was determined from a review of literature and agency contacts. Numerous studies have been done on the germination of seeds other than sedges. Isely (undated) examined Scirpus seeds, Justice (1946) examined Cyperus and Blake (1935) investigated several prairie grasses and forbs.

While no literature discussed germination tests for the three *Carex* species examined in this study, the germination results of other sedge species have been published by Taylor (undated), Amen (1962) and Dorph-Peterson (1924).

In addition, more recent unpublished, germination studies of sedges were discussed with Winterhalder (1985) and Reznicek (1985).

A wide range of techniques were presented by those investigators. The results were equally as variable. For example, Amen (1962) found that two sedge species occupying a common habitat, required dramatically different treatments to break seed dormancy. *Carex ebenea* seed required specific light conditions while *C. albo-nigra* seed required scarification.

Other investigations found that the amount of oxygen present affected germination rates (Bibbey, undated) or that heat treatments enhanced germination (Justice, 1946).

This tremendous variability of treatments and results and the lack of existing information regarding the three sedge species in this study were addressed by testing the most commonly successful treatments.

Those included:

- wet stratification - keeping the seed cool and moist for a period of time
- scarification - mechanically thinning the achene (tough inner seed coat)
- pre-chill - keeping the seed cold but dry for a short period of time

- heat treatment - heating the seed prior to germination

Wet stratification and pre-chill treatments simulate over-wintering conditions for the seeds, while the heat treatment simulates the high temperatures often found on ground level in the sand flats that some Carex species naturally populate (see Figure 1).

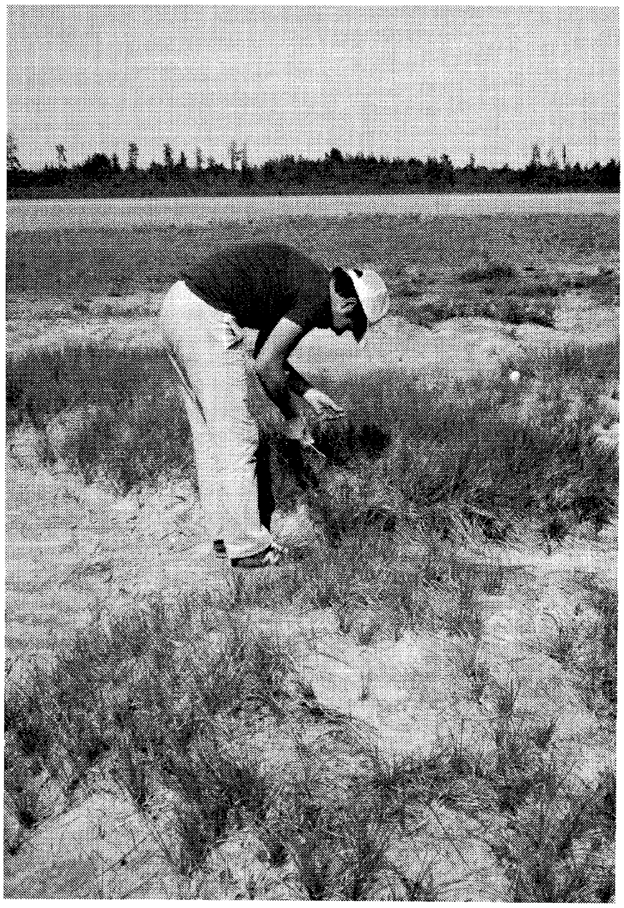
Details of the treatments are contained in working files.

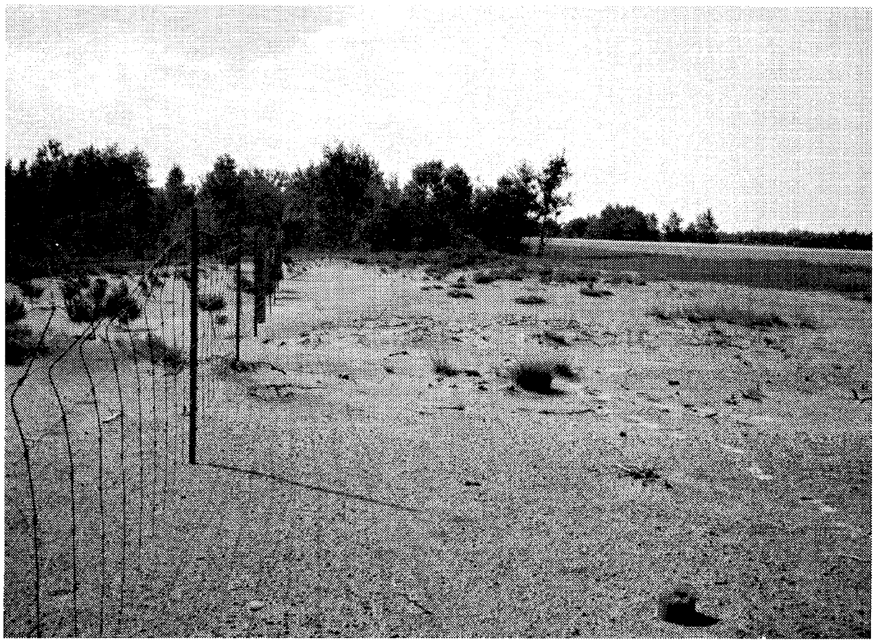
In this study, the seed was treated using each of the four dormancy-breaking methods discussed and combinations of them prior to germination tests. The seed treatments used during germination testing follow.

- Control - no treatment prior to germination testing
- Pre-chilled - for periods of 3,7 and 14 days at 5°C to 10°C
- Wet Stratification - for periods of 1, 2 and 3 months at 7°C
- Heat Treatment - 3 hours at 51°C
- Scarified and Pre-Chilled - for periods of 3, 7 14 days
- Scarified and Stratified - for periods of 1, 2 and 3 months

Figure 1 <u>Carex lucorum</u> Stands

Both photos display the <u>Carex lucorum</u> stands near Petawawa. Note the dry, sandy, site conditions.





- Heated and
  Stratified - for 2 months

Prior to testing, the seed was separated from stems and chaff by forcing the mixture through progressively finer screens (Canadian Standard Soil Sieve Series). The seed screening, wet stratification and heat treatments were all completed at GLL offices prior to submission to Oseco Incorporated. The pre-chill and scarification treatments and tests on all pre-treated seed were carried out by Oseco Incorporated under the direction of GLL.

The seed germination tests at Oseco Incorporated ran a total of three months at an average temperature of 25°C. The germinating trays were switched from a germinator with a constant temperature of 25°C to a germinator that varied from 30°C (day) to 20°C (night) halfway through the tests, because of other germinator space requirements.

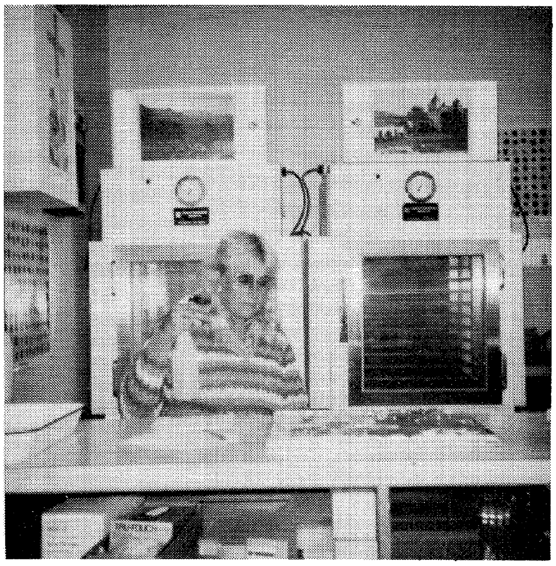
Four replicates of 25 seeds were tested for each species and treatment. In the control tests and all treatments not involving stratification, the seeds were spread out on blotting paper-lined trays. The wet stratified seed (mixed with sand to hold moisture during stratification) were spread out on open petrie dishes.

The blotters and sand/seed-filled petrie dishes were kept moist throughout the three month test period with distilled water (Figure 2). The seeds were checked daily for new sprouts. Seedlings were counted as germinated when both the coleoptile (shoot) and root were present, as was done by Isely (undated) with Scirpus seeds.

During testing, a mildew appeared on some of the seeds. Research suggested that the mildew might either adversely affect germination or it might be part of a natural process to destroy the outer seed coat. This issue was addressed by treating half of the replications with a light dosage of a recommended fungicide (Captan 10). This wettable powder was mixed with water and sprayed over half of all seed lots.

Figure 2 Germination Facilities

These photos provide a view of the germination facilities used at Oseco Incorporated. In the top photo, a lab technician applies distilled water to petrie dishes containing seed.



The mildew did not spread after Captan application and its effects on seed germination were variable.

2.4 TEST PLOT PLANTING

The study site selected was on approach fills of a newly constructed overpass (North Kashe Lake Road) on Highway 11, 10 km south of Gravenhurst, Ontario (Figure 3). The test plots were located on north and south-facing slopes west of Highway 11, on the slopes of approach fills to a bridge structure. The slopes were constructed of fine sand from one borrow pit 1.6 km southeast of Kilworthy (MTC, 1985).

Soil samples were collected from the slopes, at surface and from a depth of 0.3 m. These samples were tested by Agri-food Laboratories for nutrient analyses. These analyses contributed to the determination of the appropriate fertilizer application rate.

Each of the four test areas measured 4 m by 30 m and were situated approximately 4 m from the top of the slope, and 8 m to 12 m from the bottom of the slope. Two test areas were established on the north slope and two on the south. North and south test area replicates were planted in the fall of 1985 and the second set was planted in the spring of 1986. In this way, the effects of planting season and aspect on the establishment of the selected plant species were compared.

The individual plots within the test areas ranged in size from 3 m by 3 m to 1.2 m by 1.2 m depending upon seed availability. The largest plots were the control and grass plots while the sedge seeds were planted in smaller plots. Figure 4 depicts the relative plot locations and size as well as the seeding application rates.

Once the individual plots had been staked and tagged, fertilizer (5-20-20) was evenly applied to each plot at a rate of 700 kg/ha, using a perforated juice can. The plots were then lightly raked to work the fertilizer into the surface soil. The appropriate seed was then applied to each plot by hand or by using the perforated can, or a large salt shaker -- the application depending on the seed size and weight. Plots containing larger seed were lightly raked and then tamped down using the back of a grass rake. The plots

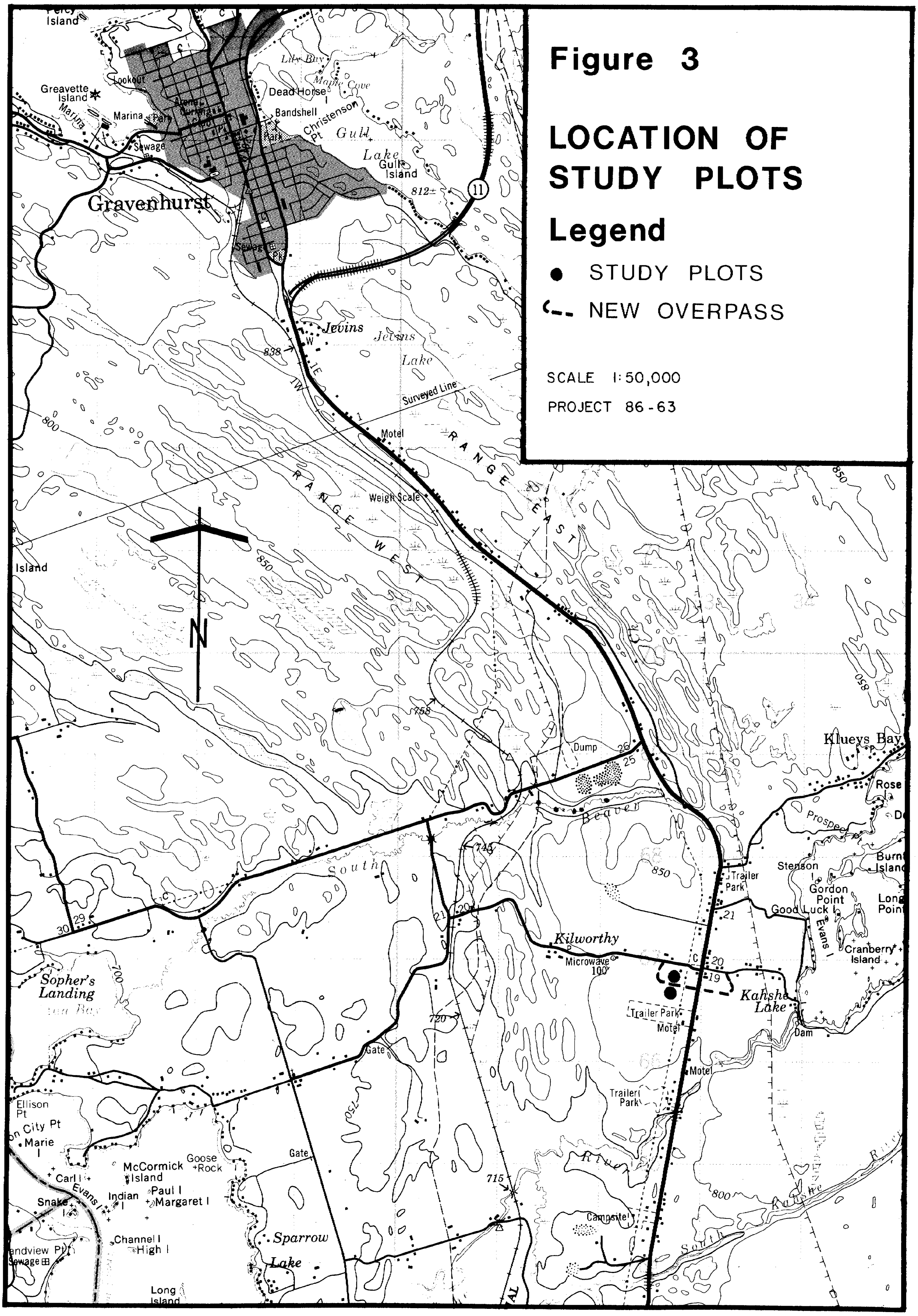


Figure 3

LOCATION OF STUDY PLOTS

Right of way
Rehabilitation of Sandy
Slopes in Northern Ontario

PLOT LAYOUT

North Kashe Lake
Road Overpass on Hwy II
Gravenhurst District

LEGEND

B 60
Species Code Application Rate (kg / ha)

SPECIES CODES

- B Little Bluestem (*Andropogon scoparius*)
- S Switchgrass (*Panicum virgatum*)
- D Sand Dropseed (*Sporobulus cryptandrus*)
- CL *Carex lucorum*
- CLS *Carex lucorum* (stratified)
- CLT *Carex lucorum* (transplanted)
- CH *Carex houghtoniana*

CONTROL: No seed was planted, plot received mulch and fertilizer

Scale
0 1 2 3 m

FIGURE 4

Scale 1cm = 1m
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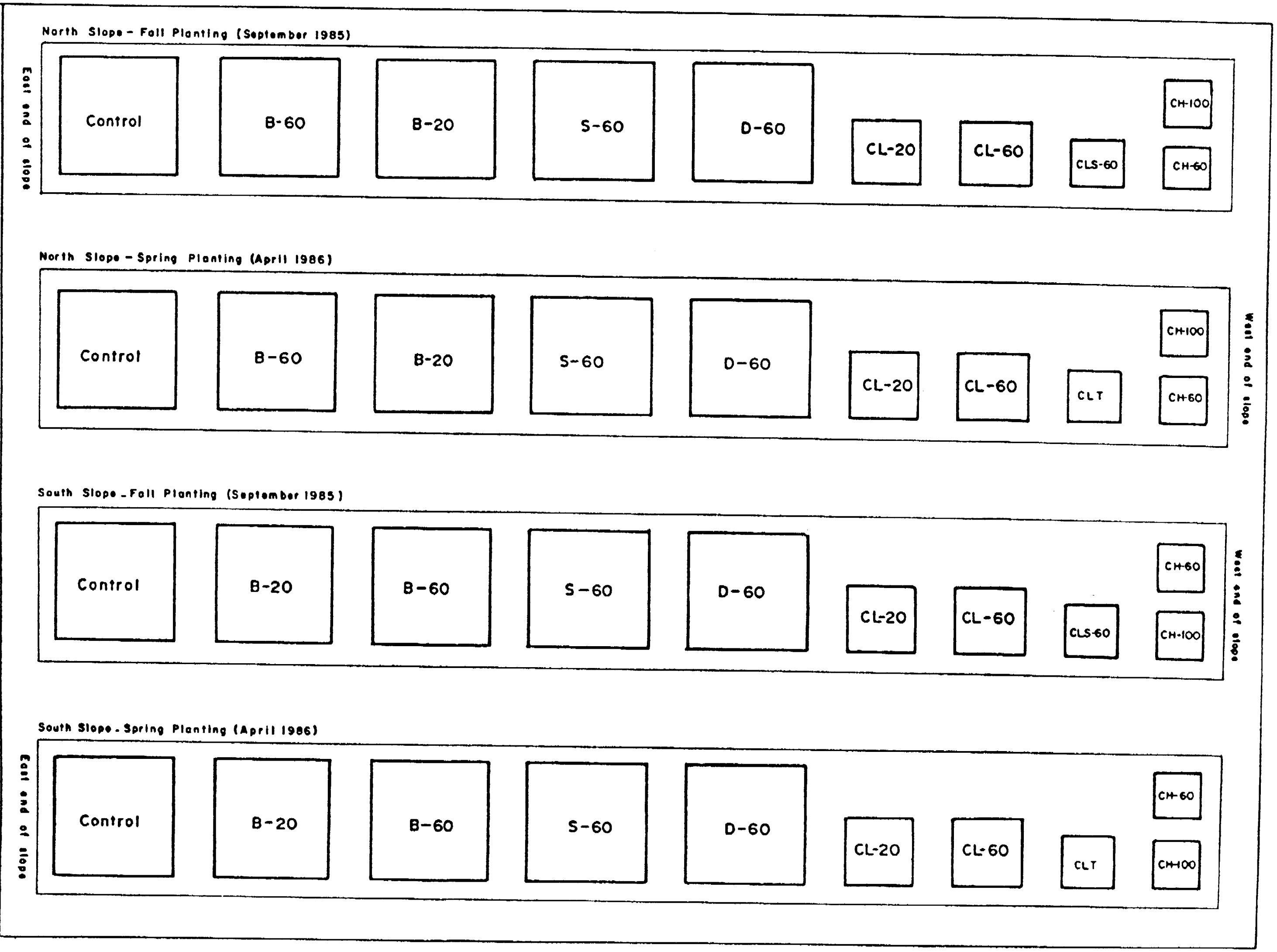


containing small seeds were tamped only. The control plots received the fertilizer and preparation treatments without any seeding.

The fall test areas were planted on September 23, 1985.

The day following planting, all plots were hydro-mulched by MTC personnel using a Bowie Hydro-Seeder tank truck. Verdyol Mulch (shredded straw with some newspaper) was applied at a rate of approximately 1600 kg/ha (Figure 5). The mulch was sprayed from the top of the slopes of approach fills to a bridge structure. The mulch tended to clump and move downslope slightly, providing an uneven cover.
The planting of the spring plots proceeded on the north and south slopes using the same methodology as the fall planting with the exception of the mulch application. The MTC hydro-seeder was unavailable when test area planting took place on April 24, 1986 so the mulch was applied to each plot by hand at a rate approximating that used the previous fall. The slopes were then watered by MTC personnel using a fire pump and water filled drums to simulate the hydro-mulch system previously employed.

The spring planting of Carex lucorum plugs replaced the fall planting of stratified C. lucorum seed because of a seed shortage. The plugs were taken from a roadside location approximately 8 km north of Gravenhurst. They were collected, soaked, bagged, transplanted and watered within a two hour period on April 24, 1986. They were planted on approximately 20 cm centres.

The slopes surrounding the test plot areas were seeded June 2, 1986. The mix of seed referred to in this report as the MTC mix, included; Bird's-foot Trefoil (Leo), Canada Bluegrass, Creeping Red Fescue (Fortress), Hard Fescue (Biljart), Alsike Clover and Annual Ryegrass.

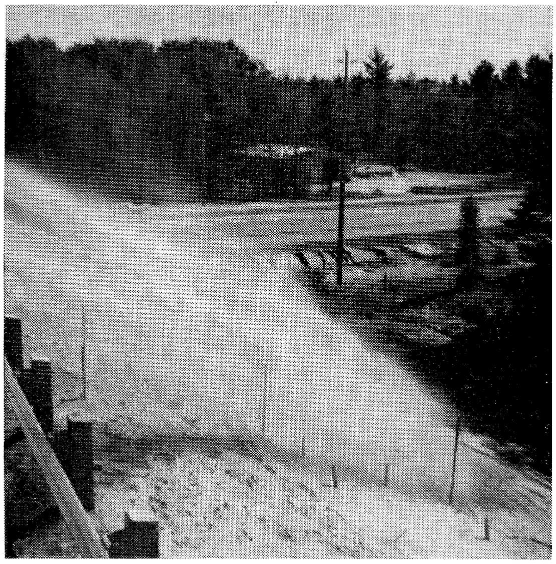
2.5 TEST PLOT MONITORING

Plot monitoring methods evolved to meet changing plot conditions.

The first intensive round of plot monitoring took place on October 22, 1985, approximately one month after the fall plots had been planted. A piece

Figure 5 Hydro-Mulching

Slopes were hydro-mulched by MTC personnel using a Bowie Hydro-seeder tank truck.



of stiff polyurethane foam sandwiched between two layers of cardboard, with a 10 cm by 10 cm square hole cut from it was randomly tossed onto each plot. The plant stems rooted within the 10 cm by 10 cm square were counted. This was repeated within each plot until an area equal to 3% of the plot area had been sampled. No attempt was made to classify the percent cover of individual species in each plot.

This same method was employed on June 2, 1986 to monitor the growth on the fall plots. Visual assessments of percent cover on each plot were carried out on May 9, May 21, May 28 and August 13, 1986. Plot monitoring visits were supplemented by photographs of plot and slope conditions. Qualitative observations were made of the growth of the MTC seed mix outside of the plots.

On September 23, 1986 a final intensive plot monitoring visit was undertaken. Owing to the height of some of the species planted (up to 50 cm tall), the polyurethane foam square method of plot assessment was no longer feasible. Instead the plots were assessed with a visual and photographic system.

This was achieved by mounting a Polaroid Land camera on a platform atop a 3.7 m pole with a remotely tripped shutter release, to reduce the angle at which each plot was photographed. This system yielded polaroid photos of each plot upon which the different species present were delineated using coloured grease pencils. The system has provided a permanent record of the plant species present and their distribution. Accompanying these photos were notes on plot condition and the percent coverage by each species.

Within each plot a visual estimate was made of percent cover for each species present. Every clump of each species was compared to an area equivalent to 1% of the plot size. The total cover was obtained by adding the cover produced by all clumps of each species.

3.0 SUMMARY OF FINDINGS

A discussion of results from both the germination testing and planting are presented.

3.1 SEED TEST RESULTS

The number of tests conducted on sedge seeds were limited; however, they have provided some very valuable observations. Each is briefly summarized.

- all sedges tested had generally poor germination success (0 - 70%)
- all sedge seeds were slow to germinate, taking on average almost two months
- germination rates varied dramatically for the same species harvested from different populations
- germination rates varied for the same species and population harvested at different times during the growing season
- Carex lucorum provided the highest germination rates of the three sedge species tested
- Carex houghtoniana testing resulted in negligible results
- of all pre-treatments, only those involving scarification appeared to result in improved germination success
- the grasses tested by the seed house provided much higher germination rates than the sedges

A summary of all seed test results is presented below. Each is then discussed on a species by species basis. A more detailed examination of results is presented on Figure 6.

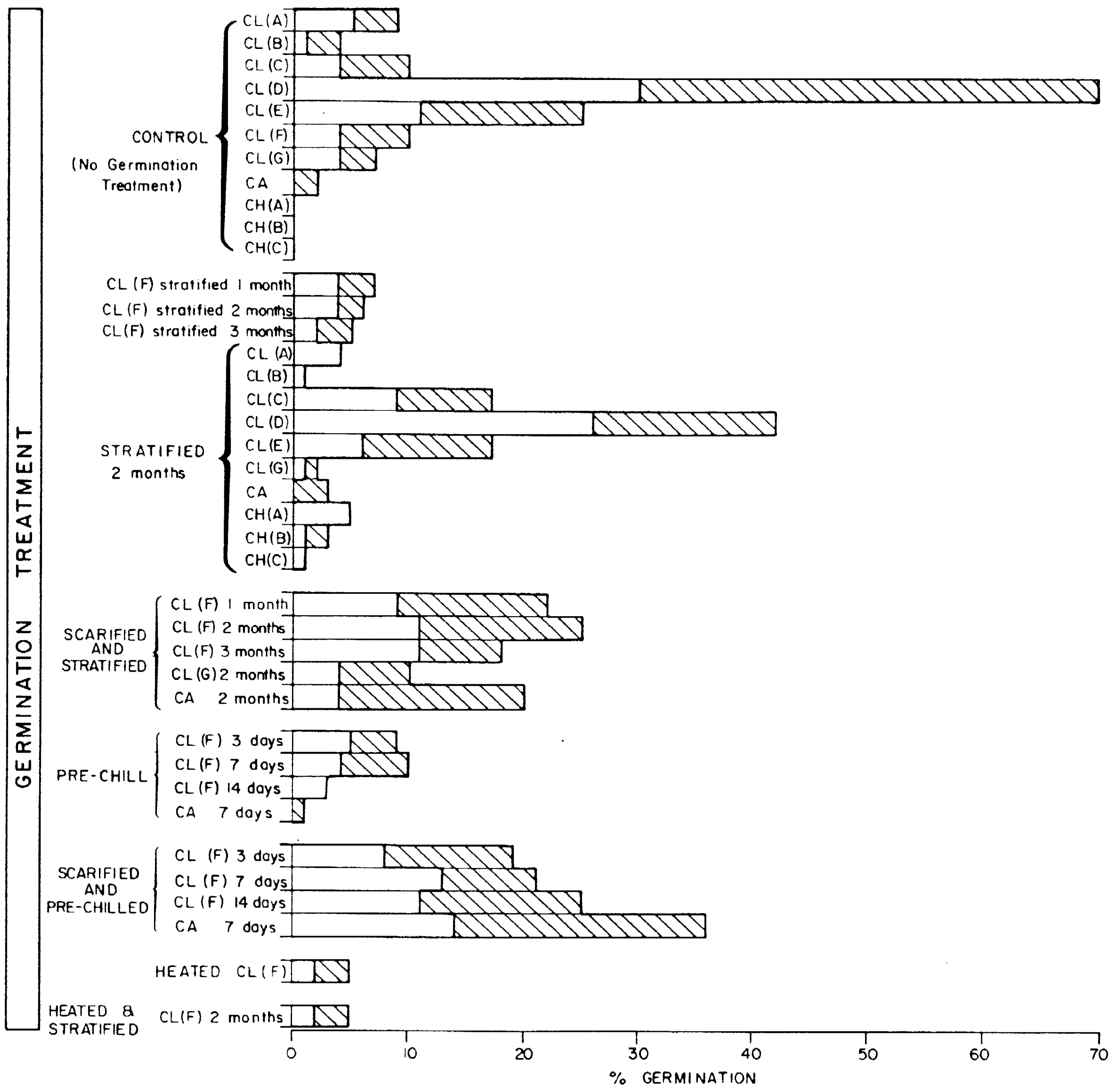


FIGURE 6

GERMINATION TEST RESULTS

LEGEND

◧	TOTAL SEED LOT FOR EACH TEST
☐	HALF OF SEED LOT WITH CAPTAN APPLIED
▨	HALF OF SEED LOT WITHOUT CAPTAN APPLIED
CL	Carex lucorum
CA	Carex aenea
CH	Carex houghtoniana

(A)
(B)
(C)
(D)
(E)
(F)
(G)

Seed lot : Different population (Carex lucorum) or different collection date (C. houghtoniana)

NOTE - All tests were continued for 3 months

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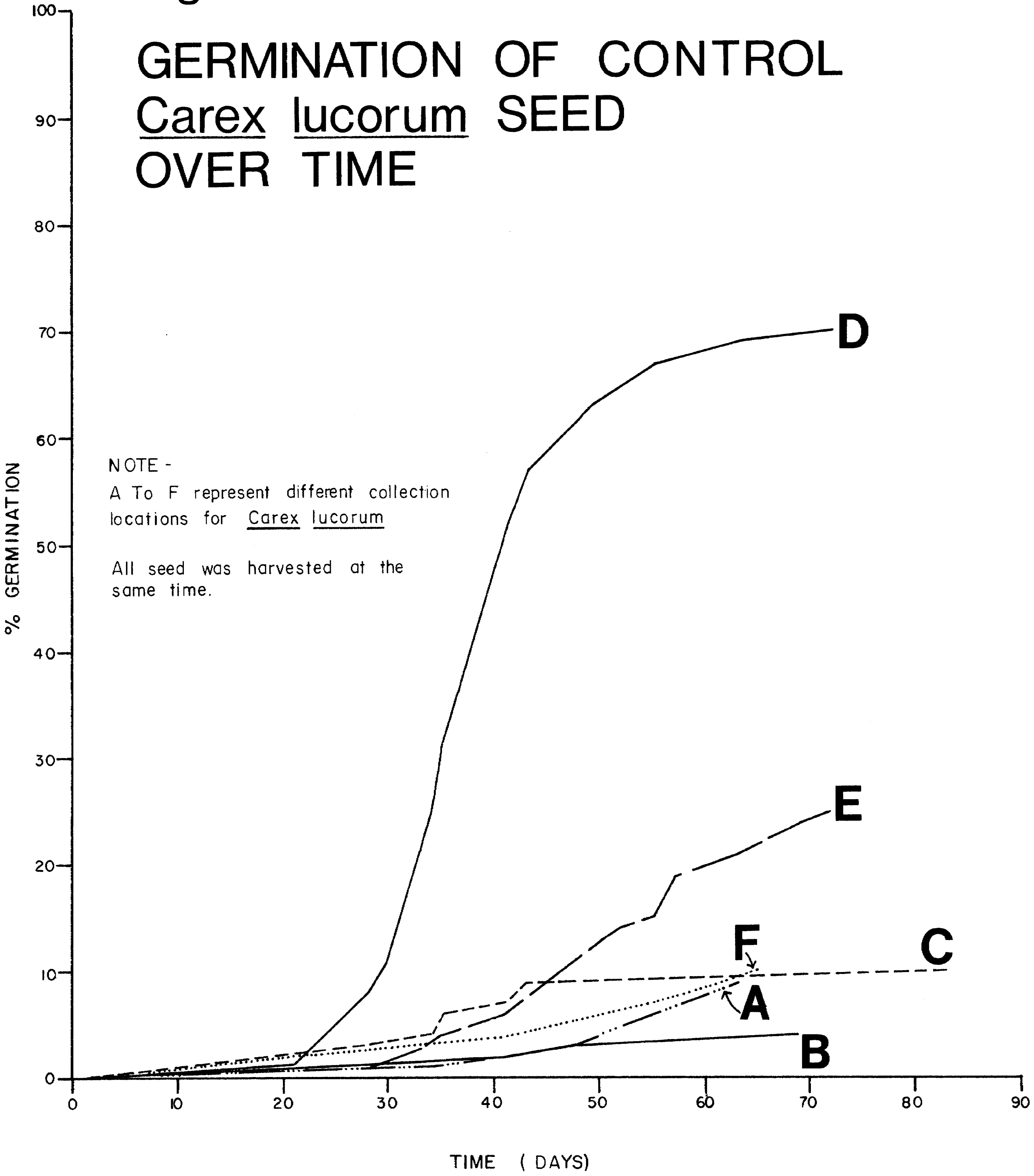


Figure 7

GERMINATION OF CONTROL *Carex lucorum* SEED OVER TIME

NOTE -
A To F represent different collection locations for *Carex lucorum*

All seed was harvested at the same time.

Species	Germination Rates (%)
*Little Bluestem	78
*Sand Dropseed	77
*Switchgrass	97
Carex lucorum	1-70**
C. houghtoniana	0-5**
C. aenea	1-36**

*Test results from Sharp Brothers Seed Company. All others from germination testing conducted by Oseco Incorporated. **Dependent upon seed source and germination treatment.

3.1.1 Carex lucorum

Carex lucorum, because of the relatively copious amount of seed collected, was subject to the greatest variety of testing.

All Carex lucorum germination was very slow to occur (Figure 7). In all treatments (including the control tests) germination peaked between thirty to seventy days after being placed in the germinators. Even where the germination reached 70% (population 'D' control), this level was not reached until seventy days had elapsed. After thirty days only 10% of that population had germinated. By day fifty, 65% of the seeds had germinated.

A summary of results of the various tests is presented. The most positive effects were associated with the scarification treatments.

Control

Seven discrete populations were harvested, six near Petawawa (A-F) and one near Gravenhurst (G). All seven were tested as control lots; i.e., receiving no pre-treatment. A wide range of germination was noted for those populations. Population 'D' had a germination rate of 70% compared to a low of 4% for population 'B'.

Population 'D' was noted in the seed collection data as being one of the most ripe populations. It appears that the time of collection is important in achieving a high germination rate although Dorph-Peterson (1924) suggested that unripe seeds of some species might actually germinate faster than ripe seeds.

Pre-chill

Three different pre-chill treatment periods were used on Carex lucorum seed (3, 7 and 14 days). In none of these tests did the pre-chill treatment significantly alter germination over the control test for that species. In fact, the pre-chill duration of 14 days appears to have reduced the germination success (Figure 6).

Wet stratification

In almost all cases, wet stratification reduced the germination rate over the control tests for the same populations. The germination rate fell an average of 42% from the control test results. The duration of stratification (1, 2 or 3 months) appears unimportant.

Scarification

The scarification treatments used were combined with either stratification or pre-chill. In all cases those combinations improved germination over the treatment using stratification or pre-chill alone and over the control tests. A case in point is Carex lucorum, population 'F'.

- Control Test - 10% germination
- Stratified 2 months - 6%
- Scarified and Stratified 2 months - 25%
- Pre-chill 7 days - 10%

This suggests that scarification may play an important role in breaking dormancy.

Heat treatment

Heat treatment did not increase germination rates. When this treatment was used, results were half the germination rate produced by seeds with no treatments applied (control test).

3.1.2 Carex aenea

The Carex aenea seed tested was all collected from the same site on one occasion. The control (no pre-treatment) tests produced a very low (2%) germination rate.

Again as with the Carex lucorum, neither the stratification nor pre-chill alone achieved a higher germination rate than the control tests. However, when scarification was introduced as a factor with the cold treatments, success rose substantially. As depicted on Figure 6, a 7 day pre-chill with scarification achieved 36% germination. A germination rate of 20% was obtained for seed scarified and stratified (2 months).

The germination as with Carex lucorum was very slow peaking on all tests in the 40-60 day range.

3.1.3 Carex houghtoniana

The three replications of Carex houghtoniana tested (A, B, C) were collected from the same site near Middle Muldrew Lake, Ontario on three different occasions.

None of the seeds sprouted during the control test period (3 months).

The only treatment carried out on Carex houghtoniana seeds was a wet stratification of two month duration. That yielded a germination rate high of 5% and a low of 1%.

3.2 EXPERIMENTAL TEST PLOT RESULTS

The plots near Gravenhurst were carefully examined for species growth. An assessment of that growth to the fall 1986 provides preliminary information about the tolerance of tested plants to sandy, infertile conditions. The effects of aspect and planting season were evaluated. An initial comparison of test areas with surrounding slopes was made.

Several interesting observations can be drawn from the test plot results. Each is listed and some are then discussed in more detail.

- spring planting had a higher degree of success than fall planting
- for spring planting, slope aspect did not appear to influence results: fall planting results were confused by the accidental application of a non-test seed mixture.
- both Little Bluestem and Switchgrass provided almost 50% plot cover at a rate of 60 kg/ha
- other species tested, particularly the sedges showed a poor growth response: Carex lucorum produced small amounts of cover: C. houghtoniana did not appear.
- the remainder of the slope, which received an MTC seed mix displayed generally more complete coverage than any of the test plots. That mix was applied at 100 kg/ha.
- roots of grasses tested appeared to be more advanced after one growing season in Little Bluestem and Switchgrass than in Sand Dropseed
- some rhizome spread was noted on Carex lucorum transplants after one growing season.

The following figures summarize the range of cover present on the test plots to the end of the 1986 growing season.

TEST PLOT VEGETATION COVER SUMMARY

Fall:

Test Species	Amount of Plot Cover (%)
Little Bluestem	1
Switchgrass	1
Sand Dropseed	0-2
Carex lucorum	0-1
C. houghtoniana	0

Spring:

Test Species	Amount of Plot Cover (%)
Little Bluestem	5-40
Switchgrass	20-30
Sand Dropseed	7-10
Carex lucorum	0-2
C. houghtoniana	0

A more detailed summary of test plot coverage is presented on Figure 8.

Planting season

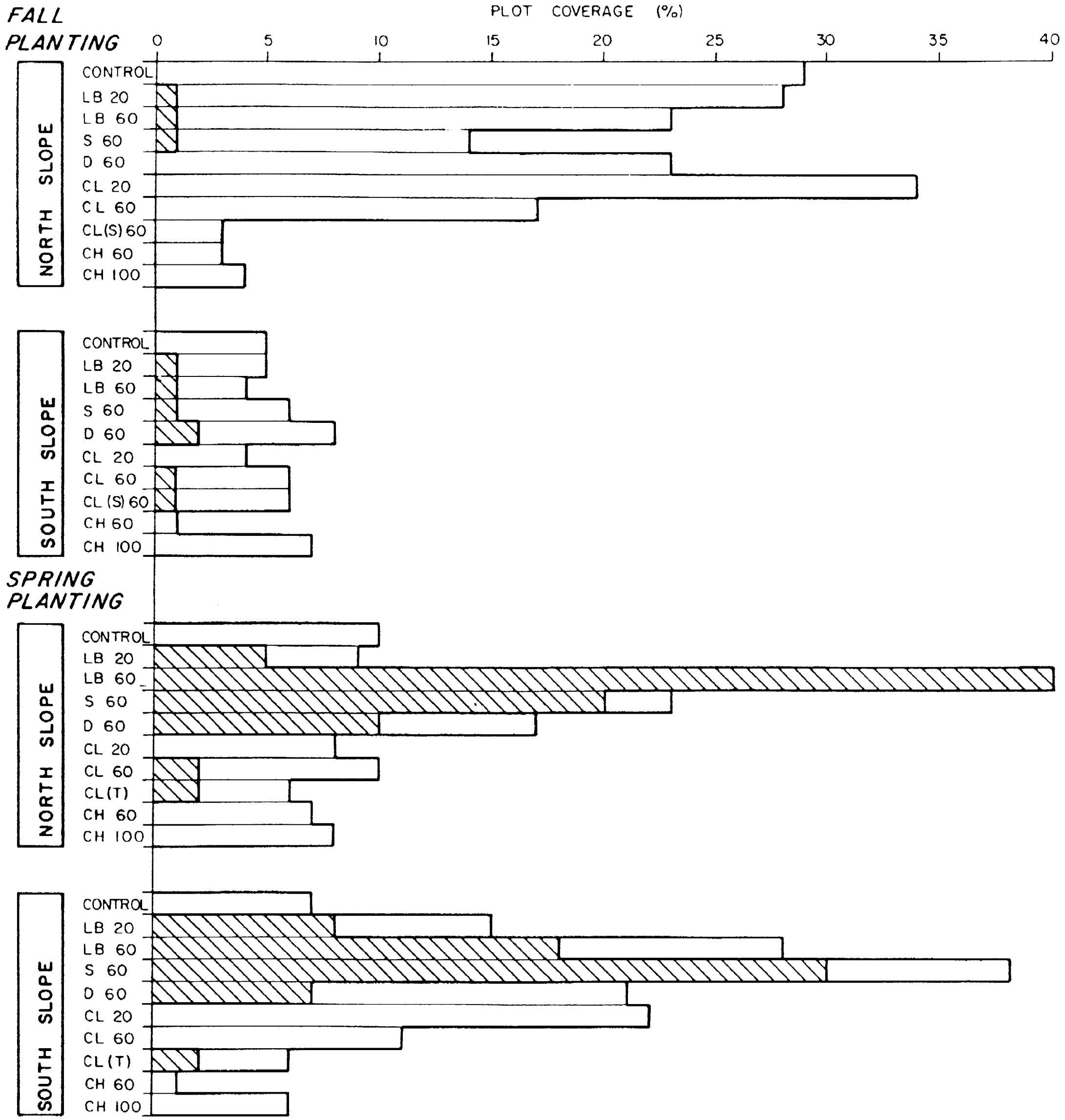
Generally, it appears from Figure 8 that spring planting was far more effective than fall planting. This is particularly evident from an examination of Little Bluestem, Switchgrass and Sand Dropseed results.

Slope aspect

The influence of aspect on results of spring planting is not well defined. While no conclusive statement can be made on this factor, other general observations suggest that the south-facing slope was further advanced. The grasses planted in the

FIGURE 8

EXPERIMENTAL TEST PLOT RESULTS



LEGEND

▨ GROWTH OF STUDY SEDGES AND GRASSES

☐ GROWTH OF MTC MIX ON PLOTS (and non-planted species)*

CL 60 ← SEEDING RATE (kg/ha)
↖ SPECIES

CL	*Carex lucorum*		
CH	*Carex houghtoniana*		
LB	Little Bluestem		
S	Switchgrass	(S)	Stratified
D	Sand Dropseed	(T)	Transplanted

NOTE - % plot coverage is based on a visual estimate made September 1986

* Non-planted species include those present from seed windblown or washed onto the slope

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spring averaged approximately 5 cm to 10 cm taller on the south-facing slope and more fruiting stems were found there for all plots of Little Bluestem, Switchgrass and Sand Dropseed.

The effect of slope for fall plantings is more complex. Results reflect growth of a mix of seed not intended for the slope; a mix with Creeping Red Fescue (Festuca rubra) and Canada Bluegrass (Poa compressa) as dominants. The mix was likely applied with the mulch by the Bowie Hydro-Seeder. Components of the standard MTC seed mix likely settled to the bottom of the tank during a previous hydro-seeding application. This contamination showed itself as a light coverage on all fall plots including the control plots.

As the rate of application of that non-study seed was not controlled, it is not feasible to use the fall results to discuss the influence of aspect.

Results also indicate that some species other than those tested or those planted by either MTC or GLL had established on the slope. Those include (Pin Cherry (Prunus pensylvanica), Staghorn Sumac (Rhus typhina), Evening Primrose (Oenothera biennis), Bracken Fern (Pteridium aquilinum) and Barnyard-grass (Echinochloa crus-galli).

Rooting characteristics

Of further interest are observations of the root growth of some species present. Several stems of planted species were dug up from locations outside either the north or south-facing plots. These occurrences are likely the result of seed being washed or blown outside the plots after planting.

The individuals of the grasses examined were products of only one growing season and all had reached a fruiting stage. By mid-September the Little Bluestem already possessed a moderately thick, fibrous root system penetrating to a depth of at least 30 cm.

Switchgrass, with very coarse and thick fibrous roots had penetrated to the same depth. Numerous rhizomes had just emerged from the base of the stems and were each less than 1 cm in length.

Sand Dropseed possessed a thinner and more delicate, fibrous root system penetrating to a depth of approximately 15 cm.

A clump of Canada Bluegrass planted by the MTC at the same time (spring 1986) had produced a very dense mat of roots in a sod formation. While extremely dense, the system penetrated to a depth of less than 10 cm.

The Carex lucorum growth on the test plots was also examined. While few seeds had germinated, the scattered, successful individuals displayed good growth and vigor. The one individual removed already possessed a rhizome almost 3 cm in length. The associated fibrous roots were very shallow.

In comparison, Carex lucorum removed and transplanted from a site north of Gravenhurst, had well-established rhizomes longer than 20 cm in some cases.

The transplanted Carex lucorum planted on north and south aspects in the spring had varied success. Transplants on south-facing slopes appeared to have suffered from droughty conditions after transplant. No apparent spread by the plugs was detected.

The results of the growth on test plots are presented on Figure 8. A description of the growth of both fall and spring planting is provided.

3.2.1 FALL PLANTING

North slope

The north slope, fall plots were dominated by Festuca rubra and Poa compressa. Small amounts of Little Bluestem and Switchgrass did appear on their respective plots, but generally covered less than 1% of the plot area. Neither the Sand Dropseed nor the Carex species were in evidence on their plots when monitoring was carried out on September 23, 1986.

South slope

The south slope fall plots were generally barren. The following summarizes growth of the study species.

- Little Bluestem - <1% coverage on both plots
- Switchgrass - <1% coverage
- Sand Dropseed - <2% coverage
- Carex lucorum - <1% coverage on the 60 kg/ha plot and the C. lucorum Stratified 60 kg/ha plot

The very sparse growth of Carex lucorum species relates in part to poor germination success. The seed planted on the test plots was a mix from several geographic locations. When analyzed according to percent germination for each location and proportion of each in the mix, it was determined that the Carex lucorum mix planted had only a 10% germination rate.

3.2.2 SPRING PLANTING

Two changes to the spring plots set them apart from the fall plots. First, the spring plots were mulched by hand due to mechanical problems with the MTC Bowie Hydroseeder. The second change was the use of Carex lucorum transplants in place of stratified seed.

North slope

All of the planted species germinated and grew to varying degrees on their plots, with the exception of Carex houghtoniana. Given the low results of the germination tests on the C. houghtoniana seed used in this study (0%, control tests) the findings from the test plots were not unexpected. This species did not grow on any of the plots where it was planted.

Little Bluestem provided moderate coverage when planted at a rate of 60 kg/ha and less when planted at a rate of 20 kg/ha.

Figure 9 Little Bluestem Growth, September 1986

North-facing spring plot seeded at 60 kg/ha.

Figure 10 Carex lucorum Seedlings

At the end of the pointer is one of several Carex lucorum seedlings on the test slope. Each division on the pointer is 10 cm.

The 60 kg/ha plot yielded a Little Bluestem coverage of approximately 40% of the plot area (Figure 9). Seeded at a rate of 20 kg/ha, Little Bluestem covered only 5% of its north spring plot.

Switchgrass on the north slope yielded 20% coverage at a seeding rate of 60 kg/ha. Sand Dropseed covered roughly 10% of its plot area, having been seeded at a rate of 60 kg/ha. The figure of 10% was estimated prior to the stems unfolding to allow the spread of the fruiting structures. The area covered was likely under-estimated for this species.

Carex lucorum had not covered much of the plots upon which it was seeded. Twenty-five plants covered roughly 2% of the plot area on the C. lucorum 60 kg/ha plot (Figure 10). No C. lucorum were evident on the C. lucorum 20 kg/ha plot by September, 1986.

South slope

The grasses performed best on the south slope, spring plots. However, the sedge species planted were not in evidence at all on these plot replications, with the exception of the transplanted Carex lucorum plugs.

Little Bluestem covered approximately 8% of the 20 kg/ha plot and 18% of the 60 kg/ha Little Bluestem plot.

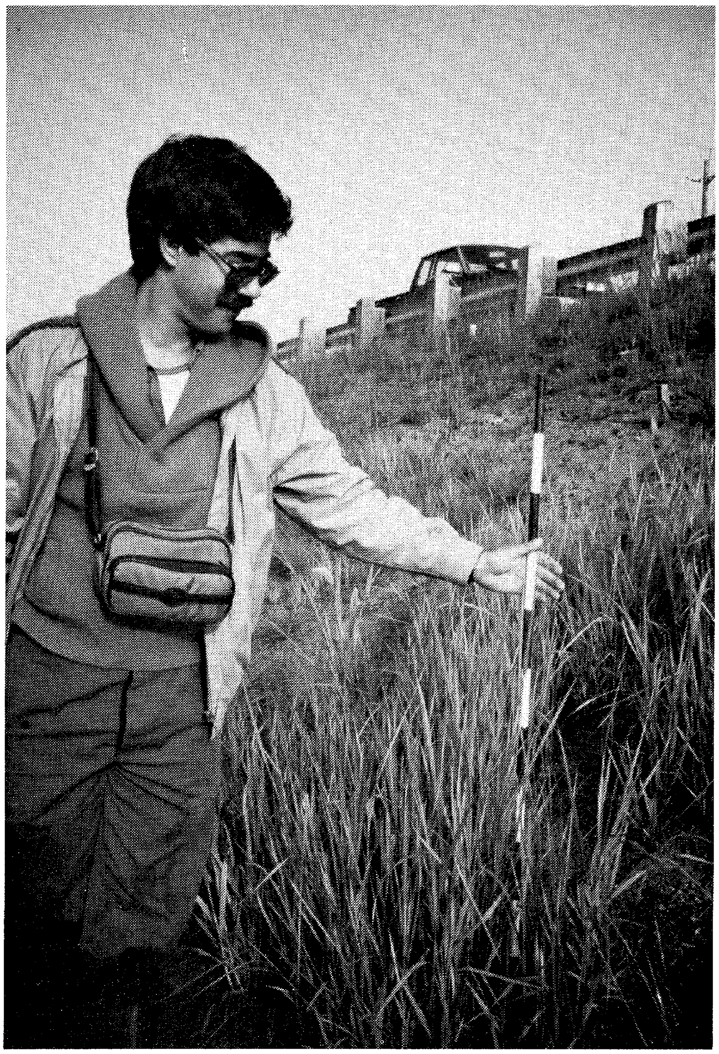
The greatest cover produced on the south slope, spring plots occurred on the Switchgrass plot, planted at a rate of 60 kg/ha. This species, with an average height of 50 cm had populated approximately 30% of the plot (Figure 11).

3.2.3 GROWTH OF MTC SEED MIX

The growth of vegetation in test areas was generally less than that on surrounding slopes. The MTC mix planted in June 1986 provided a fairly consistent slope cover by that fall. While no quantitative measurements were taken for the MTC mix on the slopes, the cover appeared from photographs and field observations, to be between 50 and 100 percent complete. The most conspicuous species on adjacent slopes were

Figure 11 Switchgrass Growth

This switchgrass growth represents the most successful plot to September, 1986. Note that the vegetation is already approaching 0.5 m tall.



the Annual Ryegrass (reaching approximately 0.5 m tall, scattered thinly throughout), Bird's-foot Trefoil, Canada Bluegrass and Creeping Red Fescue.

The only test area plots to rival the cover created by the MTC mix were those of Little Bluestem and Switchgrass. Cover of 20 to 40 percent was attained by south slope, spring plantings of those species, seeded at 60 kg/ha.

The seeding rates used likely contributed to the different slope coverage present. The MTC seed mix was applied at 100 kg/ha. Test species were planted at various rates, most commonly 20 kg/ha or 60 kg/ha. An analysis of this must be tempered with a review of the number of seeds of each species per unit weight. The same weight of different seed mixes can contain dramatically different numbers of seed.

Canada Bluegrass, for example, contains 5500 seeds/gm, Sand Dropseed; 12000 seeds/gm, Birds-foot Trefoil 827 seeds/gm and Little Bluestem 573 seeds/gm.

A more quantitative assessment of the test area versus the surrounding slopes will be made during future monitoring. The comparison is limited by the fact that the planting times were not coincident. Test areas were planted in April 1986; surrounding slopes were planted in June 1986. As well, the germination rates of species in the MTC mix are unknown. They could have been higher than any test species making a direct comparison of growth more difficult.

4.0 IMPLICATIONS FOR REVEGETATION

This program has revealed numerous implications for the use of grasses and sedges tested in this program.

4.1 SEDGES

The practicality of the sedges studied for revegetating sandy, erodible roadside slopes appears limited by a number of factors.

- In Ontario, seed availability is limited to scattered known populations: collection for large-scale propagation will be expensive.
- Germination rates were generally low and very variable; commercial propagation over several years could reduce the variability. Vegetative reproduction may be a more reliable and less costly means of propagation.
- Most germination rates were slow. These three species may not present an instant vegetation cover as do some more traditional cover crop grasses (e.g., Rye).

These limiting factors likely do not relate solely to Carex lucorum, C. houghtoniana and C. aenea.

Several authors have examined other sedges and grasses. Justice (1946) for example, noted that with the nutgrasses (Cyperus species), the proportion of viable seeds produced per culm was extremely low. He suggested that the plants were more likely propagated by vegetative reproduction (e.g., rhizome) than by seed.

Taylor (undated) observed that Carex flacca germination rates were in excess of 90% in laboratory tests, however, seedlings in the wild were very rare.

Very likely, the sedges studied have very specific requirements to stimulate germination. Isely (undated) made similar observations with respect to Scirpus seeds.

Those exact requirements may not have been duplicated in these experiments. This appears to be especially the case with Carex houghtoniana.

4.2 GRASSES

The grasses studied present more immediate potential as alternate revegetation species. The seed is commercially available with high germination rates. There would be no delay in locating or developing seed sources.

5.0 FURTHER RESEARCH

This program while limited, has provided much insight into the germination and growth of those sedge and grass species studied.

Most important is the need to monitor the plots established near Gravenhurst to determine longevity of the various species to the infertile, droughty roadside conditions. The following research is recommended.

- Test plots should be monitored for the 1987 growing season. Depending upon results, further monitoring over other seasons may be necessary.
- Particular attention should be paid to a comparison of test plot growth and the growth of the MTC seed mix on the surrounding slope.

Pending positive results from monitoring, other studies could be conducted.

- The most promising grasses could be hydroseeded on larger demonstration plots.
- The ability of the grasses to tolerate extreme northern Ontario conditions should be examined.
- There are other species of grasses that are native to sandy, dry, infertile conditions in Ontario. Further investigations are warranted to identify the most promising of those grasses and to test them in a manner similar to those in this study. Investigations should include a determination of commercial availability and/or testing of seed from wild populations.

- A more intensive sedge seed testing program could be implemented. Carex lucorum could be the focus of those studies. Vegetative propagation should be examined.

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APPENDIX

A. SOURCE LIST

APPENDIX A

SOURCE LIST

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