INTERIM REPORT ON SMALL MAMMAL POPULATIONS AND RELATED TREE DAMAGE IN THE AOSERP STUDY AREA, OCTOBER AND NOVEMBER 1977

by

JEFFREY E. GREEN
LGL LIMITED
Environmental Research Associates
Edmonton, Alberta

for

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ABSTRACT

The afforestation program in the Athabasca Oil Sands area has been only moderately successful, because of the high mortality of the planted seedlings--much of which is believed to be the result of high levels of small mammal damage. The objectives of the present study were: (1) to determine the species composition and densities of small mammals and the levels of small mammal damage to saplings in revegetation research areas, in naturally revegetating areas, and in woodland habitats and (2) to determine whether the species composition and density of small mammals on the revegetation plots differed between untreated plots and those treated with a rodenticide. However, because of the failure to obtain timely lease access to the revegetation research plots and the naturally revegetating areas, only the two woodland habitat study areas could be established.

Two three-day small mammal trapping periods were conducted on each woodland study area. Surveys of the species composition and density of ground cover and saplings, and of the levels of small mammal damage to saplings were completed on both woodland study areas. The results of the small mammal trapping program and the survey of small mammal damage to saplings are presented.

Based on the results of this study and those of a literature review of the methods of control of both small mammal populations and the damage that they cause, a program of research is proposed. The program is to assess the effectiveness of several control methods (habitat manipulation, supplementary food supplies, and repellents) in lowering the levels of small mammal damage to seedlings planted on the reclamation areas of the AOSERP study area. Populations of small mammals on the reclamation areas would be monitored using live-trapping grids. In order to establish baseline information on small mammal populations in areas surrounding the Athabasca Oil Sands development, two additional live-trapping grids would be established in a naturally revegetating area, and live-trapping would be continued in the two woodland grids that were established in the fall of 1977. A live-trapping

program to monitor snowshoe hare populations in woodland areas is also proposed to monitor the cyclic changes in abundance of snowshoe hares. Snowshoe hares have been known to severely damage nursery stock in other areas and the potential exists for a similar problem in the Athabasca Oil Sands reclamation areas.

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1. INTRODUCTION

Large tracts of land are being and will be disturbed during the operation of open pit mines and oil extraction plants in the Athabasca Oil Sands area. These areas will require an extensive program of reclamation and revegetation; such a program is already underway on the dikes of processed sand on the Great Canadian Oil Sands Ltd. (GCOS) lease. Because of high seedling mortality, however, the results of this afforestation program have been variable (Selner and Thompson in prep.). Damage by small mammals is believed to be a major cause of seedling death. With the expansion of revegetation programs that will accompany the expansion of oil extraction activities, damage to revegetated areas by small mammals has the potential to be a major problem in the Athabasca Oil Sands area. There is consequently a need to determine the real extent of the small mammal problem on these revegetation areas, and if necessary, to develop a small mammal damage control program that is effective, economical, and ecologically acceptable.

The present study was conducted during the fall of 1977 as a first step toward an assessment of both the density of small mammals and the extent and severity of small mammal damage on reclamation areas and on surrounding undisturbed areas in the Alberta Oil Sands Environmental Research Program (AOSERP) study area. The specific objectives of the study, as outlined in the terms of reference, were the following:

1. "In cooperation with AOSERP Vegetation Sector researchers, define the extent and severity of small mammal damage to revegetation research plots."
2. "On the assumption that there will be a problem, plan research to develop an ecologically and economically acceptable small mammal control program appropriate to the problem."

These objectives were to be accomplished through the following outline of work:

1. "Estimate the degree of damage to revegetation research plots by small mammals during early fall. This is to be done in cooperation with Vegetation Sector researchers and CWS personnel working on a similar problem."
2. "Determine small mammal populations on revegetation research plots by setting out eight live-trapping grids: four grids to be located in revegetation research plots on the GCOS lease; two grids to be located in forested areas off the GCOS lease but near the revegetation plots; and two grids to be located in naturally revegetating areas near the revegetation plots."
3. "Determine from the above trapping grid data if the species composition and density of small mammals differs between the revegetation research plots and the natural areas."
4. "Determine if the species composition and density of small mammals differs between the revegetation research plots and the GCOS revegetation areas by maintaining close coordination with Canadian Wildlife Service (CWS) personnel working on a similar problem."

A related study (Green in prep.) has reviewed the literature pertaining to methods of controlling small mammal damage, and has outlined the most promising control methods for use in the Athabasca Oil Sands area. Based on the conclusions of that study, a research program is proposed in this report to evaluate the effectiveness of several recommended control methods.

Mammalian nomenclature follows that of Banfield (1977). Plant nomenclature follows that of Moss (1967) for grasses, forbs and shrubs and that of Hosie (1973) for trees.

2. METHODS

2.1 ESTABLISHMENT OF PLOTS

Two small mammal trapping grids were established in suitable woodland habitat near the AOSERP Mildred Lake Research Facility (Figures 1 and 2). Grid A was established in a mixed forest of trembling aspen (*Populus tremuloides*) and white spruce (*Picea glauca*) with a ground cover consisting of bear-berry (*Arctostaphylos uva-ursi*) and a variety of grasses and low shrubs. Grid B was established in an open mixed forest of jack pine (*Pinus banksiana*) and trembling aspen, interspersed with alder (*Alnus* sp.) and a few white spruce. The main ground cover types were low *Vaccinium* sp. and reindeer lichens (predominantly *Cladonia* sp.).

Two trapping sessions were conducted on each grid--one from 8-13 October, one from 14-16 November. Information was also collected at these times on the species composition and density of saplings and of ground cover and on the types and amounts of small mammal damage.

The planned field study also included a program of small mammal trapping and vegetation surveys on what was thought to be a naturally revegetating area near the Poplar Creek diversion channel and on the afforestation research plots on the GCOS dikes. It was originally understood that the Poplar Creek area had been cleared (bulldozed) in 1974 and had been left to revegetate by natural processes. Recently, however, it was found that the area had been hydroseeded on several different occasions and that the area had been treated with fertilizer. The Poplar Creek diversion area is currently under lease to Chevron Oil Limited, but lease access is controlled by Syncrude Canada Ltd. (Syncrude). Although efforts were begun in late August to obtain permission for lease access to the revegetation areas from GCOS and to the Poplar Creek area from Syncrude, lease access permission was not received until December. As a result of the late date at which lease access was granted, no trapping grids were established in the Poplar Creek area or on the

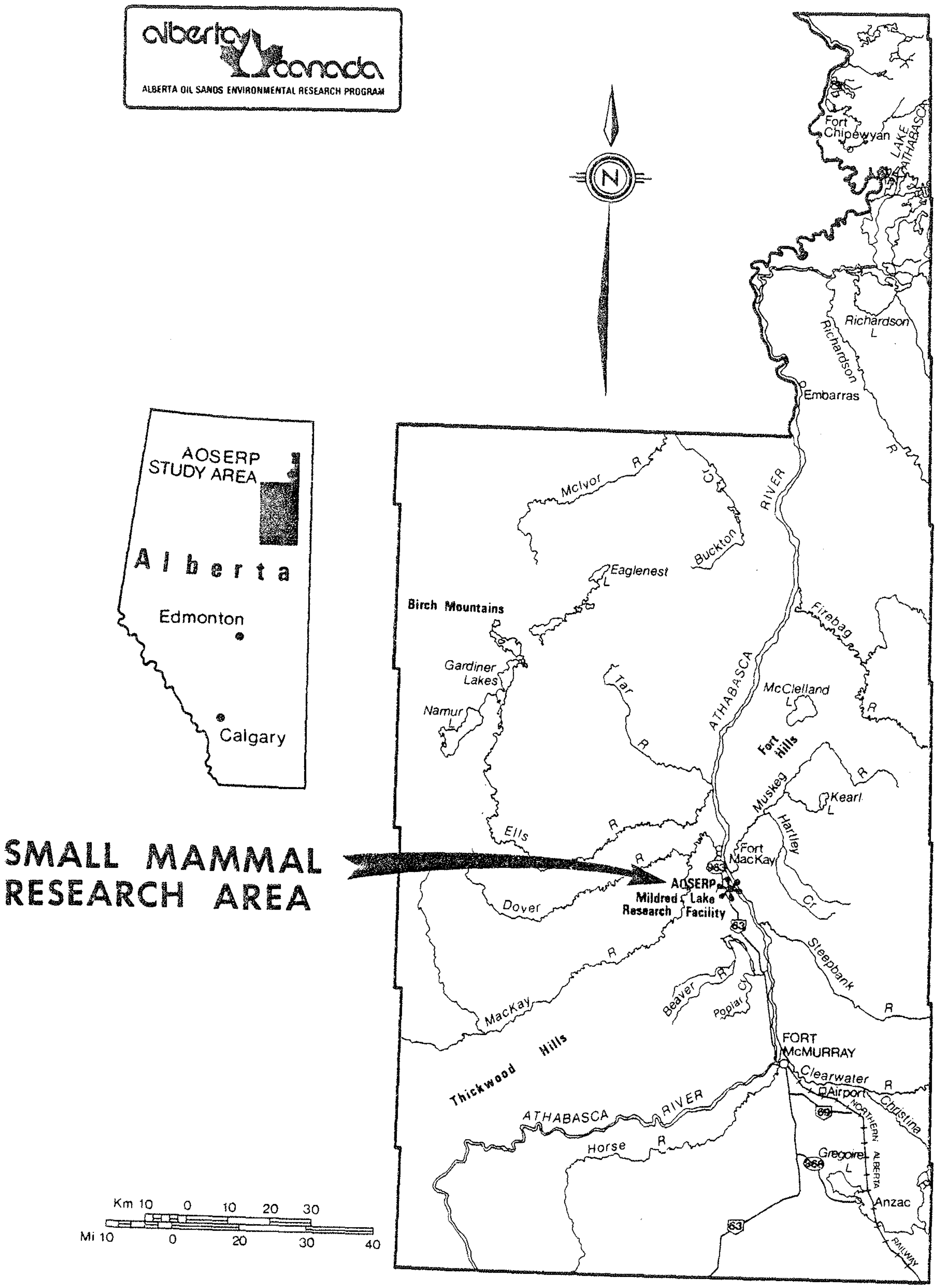


Figure 1. The Alberta Oil Sands Environmental Research Program study area and the general location of the small mammal research area.

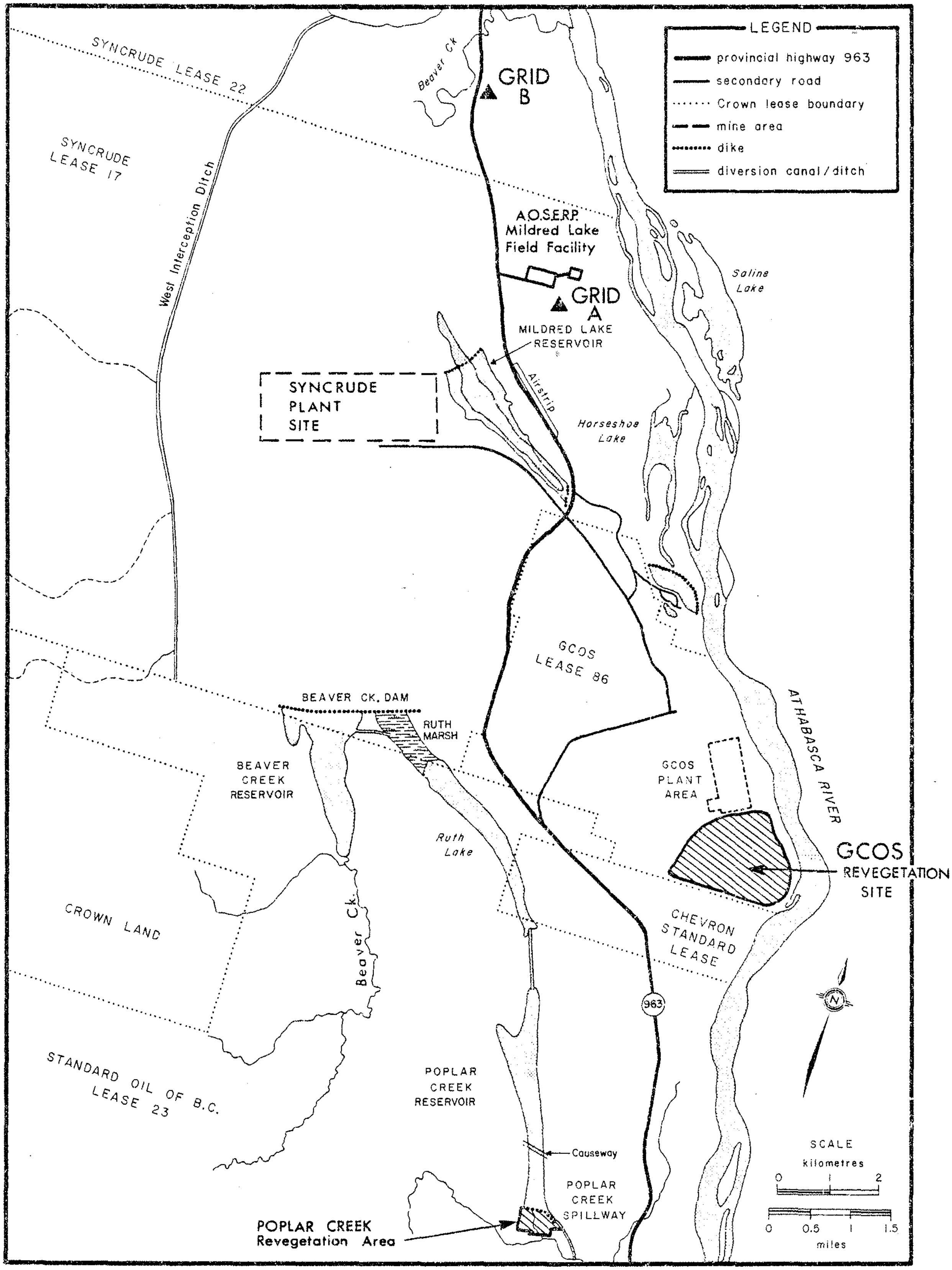


Figure 2. Locations of the two existing woodland small mammal damage study plots (Grids A and B), the GCOS reclamation area, and the Poplar Creek revegetation area.

revegetation research plots; snow conditions at this time prevented the establishment of an effective small mammal trapping program and a program to estimate small mammal damage to vegetation. The results contained in this report are consequently only for the two woodland plots.

2.2 SMALL MAMMAL TRAPPING TECHNIQUES

A program of small mammal trapping similar to that described by Krebs *et al.* (1969) was conducted. Trapping plots of 1.8 ha in size were established in each area. Each plot consisted of a 10 x 10 grid of trapping stations that were located at 15 m intervals. Each trapping station was marked by a painted wooden stake that was coded for the appropriate row and column. One Tomahawk mouse trap (Model #101) was placed within a 1.5 m radius of each trap station stake. Fifteen Tomahawk chipmunk traps (Model #201) were also placed on each trapping grid (at each end and middle of alternate rows).

All mouse traps were prebaited with whole oat groats, peanut butter and lab chow one week prior to the start of live trapping. Cotton bedding was also provided, and the backs of all traps were left open so small rodents could freely enter and move out of the traps. The two trapping periods each involved three days of trapping (11-13 October and 14-16 November 1977). On the first day of each period all traps were set in the afternoon, and fresh bait and cotton were added as needed. The backs of all traps were locked so that the animals had to enter through the front of the trap and so cross the treadle-door mechanism. All traps were checked and reset the following morning and again in the afternoon. On the third day, all traps were checked in the morning; they were then baited and locked open until the next trapping period.

Small mammals that were caught were tagged in the right ear with a numbered aluminum fingerling tag (Salt Lake Stamp Co.). The tag number, species, trap location, sex, breeding condition and weight were recorded for each animal, and the animal then was released. When the same animal was recaptured during the same trapping period, only its tag number and trap location were recorded. Animals that were tagged during the first trapping period and recaptured during the second period were treated as new animals (except that they were not retagged).

2.3 VEGETATION ANALYSIS

In order to determine the amount of small mammal damage to young trees on the woodland plots, the 10 closest saplings (deciduous or coniferous) to each trapping station were examined. Saplings were considered to be any deciduous or coniferous tree with a diameter of less than 3 cm at a height of 15 cm above ground level. Small mammal damage was considered to be any removal of the phloem and upper cambium layers that showed the tooth-mark patterns of small mammals. Damage was rated as old wounds (exposed woody tissue weathered, calloused growth around the wound) or as new wounds (exposed woody tissue not weathered).

Damage was estimated by visually examining the circumference of the stem (up to a height of 90 cm above the ground) for patches of bark removal by small mammals. Damage was rated according to the percentage (25% increments) of the total circumference of the stem that had been damaged rather than the total surface area that had been damaged, because the circular damage (regardless of area) can lead to an impairment of the transport of nutrients along the stem, and can eventually cause the death of the tree (Weier et al. 1970). Because the nutrients are mainly transported vertically in the phloem (Weier et al. 1970), two patches of bark damage that are directly above or below each other have the effect of, and were consequently treated as, a single patch of damage (Figure 3).

The densities of saplings and of ground cover have been shown to affect the distribution of small mammals and the degree of small mammal damage (Eadie 1953; Jokela and Lorenz 1959; Buckner 1970; M'Closkey 1975). Estimates were consequently made of the species composition and densities of saplings and ground cover on the plots.

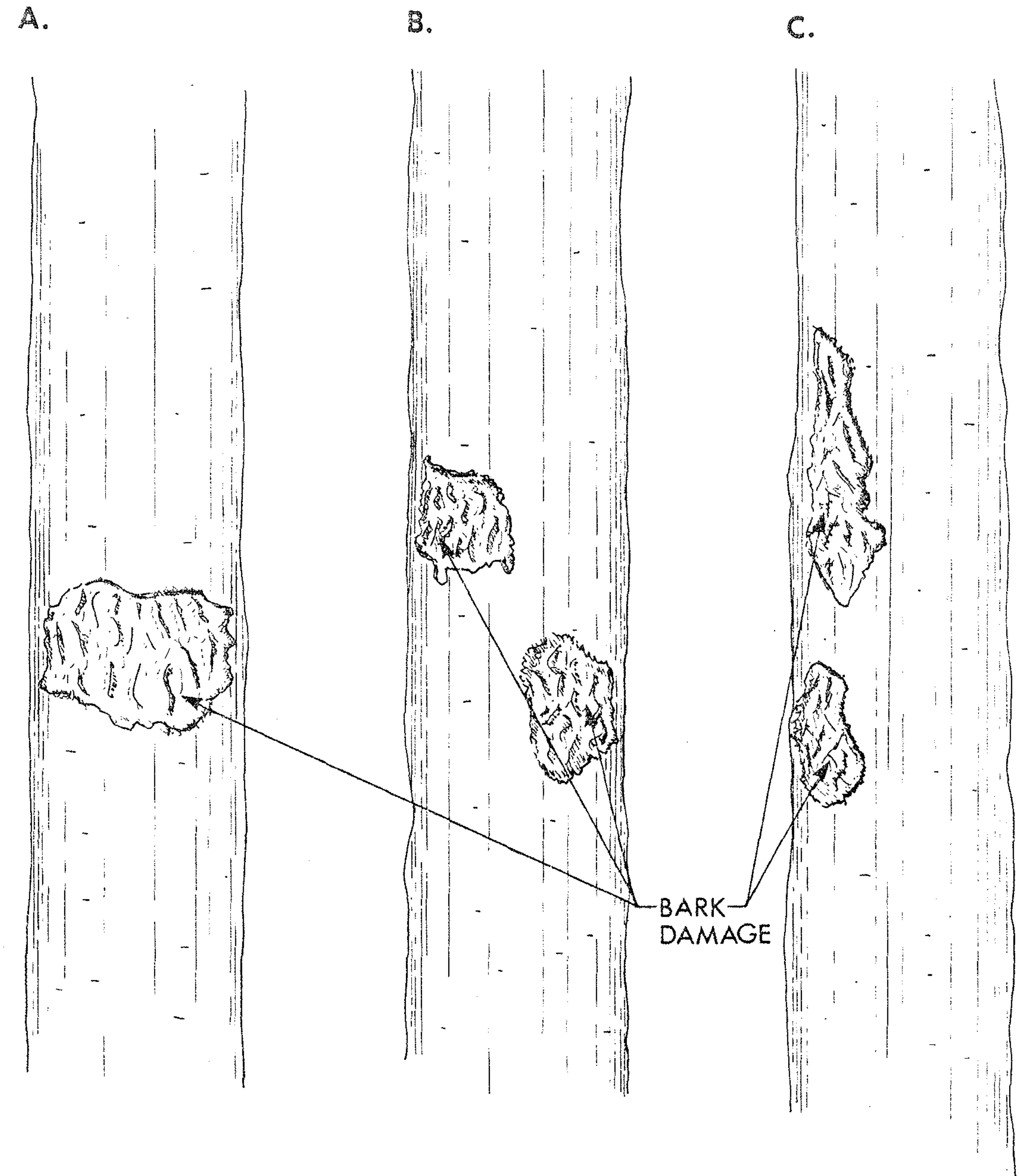


Figure 3. Examples of tree damage. (Examples A and B would both receive ratings of 25% < damage < 50%; example C would receive a rating of 0% < damage < 25%.)

The species composition and density of saplings were estimated using a line transect method. Transects of 15 m were conducted between each pair of stations along the trapping rows. The types and numbers of saplings that occurred on each 15 m transect (i.e., the stem of the sapling was on the transect line) were recorded. The species composition and percent cover of the ground vegetation were estimated using circular plots of 1 m in diameter. A circular frame was placed 1 m to the north of each trapping station, and the circular plot was then photographed from directly above the frame. Species composition and percent cover were estimated at a later date from the colour slides. A few plants could be identified to the species level and were treated as such; most could only be treated as plant groups (e.g., grasses, mosses). Plant cover estimates for each species or group were recorded using a modified Braun-Blanquet (1927, cited in Kershaw 1966) cover scale (Table 1).

Table 1. Cover scale for the estimation of the percentage of ground cover.[1]

Rank	Percent Ground Cover
1	$1 = 0\%$
2	$0\% < 2 \leq 5\%$
3	$5\% < 3 \leq 25\%$
4	$25\% < 4 \leq 50\%$
5	$50\% < 5 \leq 75\%$
6	$75\% < 6 \leq 90\%$
7	$90\% < 7 < 100\%$
8	$8 = 100\%$

[1]Based on the Braun-Blanquet (1927, cited in Kershaw 1966) cover scale.

3. RESULTS

3.1 SMALL MAMMAL POPULATIONS

The numbers of small mammals captured or recaptured on the two natural woodland trapping grids during the two trapping periods are given in Table 2. *Clethrionomys gapperi* and *Tamiasciurus hudsonicus* were the most abundant species of small mammals on the plots.

3.2 VEGETATION ANALYSIS

A total of 1000 saplings were examined for small mammal damage on each woodland study area (Table 3). Only 11 trees on Grid A showed indications of damage; all injuries were old calloused wounds, and the exact causes of the injuries could not be determined. No sapling damage that was attributable either to small mammals or to other causes was observed on Grid B.

The data concerning species composition and density of saplings and ground cover will be presented in a later report.

Table 2. Small mammal species and numbers captured on grids A and B, October and November 1977.

	Number Captured		Number Recaptured	Total Number
	October[1]	November[2]	November[2]	Tagged
GRID A				
Clethrionomys gapperi	15	7	3	19
Microtus pennsylvanicus	3	1	0	4
Phenacomys intermedius	1	0	0	1
Glaucomys sabrinus	1	0	0	1
Tamiasciurus hudsonicus	1	5	1	5
Mustela erminea	1	0	0	1
Total	22	13	4	31
GRID B				
Clethrionomys gapperi	7	4	3	8
Peromyscus maniculatus	0	1	0	1
Tamiasciurus hudsonicus	5	4	3	6
Glaucomys sabrinus	0	1	0	1
Mustela erminea	1	0	0	1
Total	13	10	6	17

[1] 11-13 October 1977.

[2] 14-16 November 1977.

Table 3. Observed damage to saplings on grids A and B, October 1977.

	GRID A				GRID B			
	Number Examined	Number Damaged			Number Examined	Number Damaged		
		Total	By Class			Total	By Class	
			Class[1]	Number			Class[1]	Number
Jack pine	3	0		-	52	0		-
White spruce	306	3	R2	2	111	0		-
			R3	1				
Alder	38	0		-	94	0		-
Trembling aspen	521	8	R2	4	715	0		-
			R3	4				
Willow	132	0		-	28	0		-
Total	1000	11	R2	6	1000	0		-
			R3	5				

[1]Damage Rating	Stem Circumference Damage
R1	No damage (not listed above)
R2	0% < damage ≤ 25%
R3	25% < damage ≤ 50%
R4	50% < damage ≤ 75%
R5	75% < damage < 100%
R6	Complete girdling

4. DISCUSSION

The number of sampling periods was insufficient to permit the determination of the species composition, densities, age structure, or sex ratios of the small mammal populations on the two woodland grids. The short field season did, however, permit us to assess the suitability of our vegetation and small mammal damage sampling techniques. The technique to estimate the amount of small mammal damage proved to be an effective and efficient field technique. Similarly the techniques for estimating sapling density and ground cover appeared to be both adequate for woodland habitats and capable of being conducted with a minimal expenditure of manpower.

Because of the failure to obtain timely lease access, the objectives of this study could not be met. However, the methods outlined in this report appear to be adequate to meet these objectives during a proposed continuation of this study.

5. PROPOSED RESEARCH ON METHODS OF CONTROL OF SMALL MAMMAL DAMAGE

Although it is believed that the high mortality of seedlings on some AOSERP study area reclamation plots may be related to the high levels of small mammal damage (as many as 55% of some deciduous tree species have been girdled [Radvanyi 1976; from data provided by the Alberta Forest Service]), no study has to date clearly established whether the small mammal damage is related to tree mortality that has occurred or whether small mammal damage is common throughout the reclamation areas. The Alberta Forest Service (AFS) is presently preparing a report that will examine the causes of seedling death; but there is still a need both (1) to determine the relationship between the densities of small mammals and the levels of small mammal damage to woody plants and (2) to develop an effective, economical, and ecologically acceptable program to control small mammal damage on the reclamation plots in the AOSERP study area.

The research proposal that is presented in this section has been designed to address these needs. *M. pennsylvanicus* and *P. maniculatus* are the most abundant species of rodents on the existing GCOS reclamation plots; small numbers of *C. gapperi* are also present (Radvanyi 1976). Because only *M. pennsylvanicus* and *C. gapperi* are known to consume bark (Thompson 1965; Zemanek 1972), *M. pennsylvanicus*, and to a lesser extent *C. gapperi* are believed to be responsible for most of the small mammal damage that has occurred. Any damage control program on the AOSERP study area reclamation sites should, consequently, concentrate on these two species.

Snowshoe hares can also severely damage young trees by girdling or browsing (Jokela and Lorenz 1959). Snowshoe hare populations fluctuate from low numbers to very high numbers and back to low numbers again about once every ten years (Meslow and Keith 1968). Snowshoe hares are presently increasing in the Fort McMurray area and are expected to reach peak numbers in the fall of 1979 (L. Keith, Univ. of Wisconsin, pers. comm., 24 April 1978);

the possibility of increased damage to young trees by snowshoe hares should consequently be anticipated during this time.

It is thus important to consider the effects of both small rodents and snowshoe hares on the afforestation program in the AOSERP study area. However, because the small rodent problem appears at present to be the major problem, the proposed research program deals specifically with the problem of small rodent damage. A program to monitor snowshoe hare populations in woodland habitats and possibly on the reclamation areas is also recommended; it should commence during the spring of 1978. If snowshoe hare populations do reach high levels in the Athabasca Oil Sands area and snowshoe hare damage to afforestation areas becomes a problem, then the research program to develop methods of controlling small mammal damage should be expanded to include snowshoe hares. Because of the long cyclic fluctuations of snowshoe hare populations (10 years), any program to develop techniques to control snowshoe hare damage would of necessity be a long-term study.

The success of a control program can best be measured by the degree to which it reduces the amount of small mammal damage to seedlings on the reclamation areas, rather than by the degree to which it reduces the small mammal 'pest' populations that occur on the reclamation areas. An effective program to control small mammal damage should emphasize an increase in seedling survival rather than an increase in the mortality of small mammals.

The success of a small mammal damage control program depends largely on the identification of the most effective control methods that are both economically and ecologically acceptable and on the development of means to apply these measures on a large scale. Based on a recent review (Green in prep.) of the different techniques of controlling either small rodent populations or the damage that they cause, the most promising methods for limiting small rodent damage to seedlings on the AOSERP study area reclamation sites appear to be ground cover reduction, the addition of supplemental food supplies, and possibly the use of repellents. A control program that incorporates the first two control methods (and possibly all three methods) is recommended over one that uses only one of these methods.

The effectiveness of each of the three control methods as well as the effectiveness of a combined program, should be investigated in a pilot study that would involve a series of controlled experimental plots on the reclamation site. A study of at least four years is accordingly proposed to examine the effectiveness of the reduction of ground cover, the provision of supplementary food supplies, and the application of repellents as methods of controlling the level of small rodent damage. The study would also monitor the survival of tree seedlings, the levels of small mammal damage to young trees and the abundance and density of small rodents and snowshoe hares in natural woodland areas and in natural revegetation areas.

The long-term objective of this proposed small rodent field program is to formulate a control program that will provide effective control of small mammal damage to seedlings on the afforestation areas in the AOSERP study area and that will be economically and ecologically acceptable. The specific objectives of the field program are the following:

1. To determine the effects of damage by small rodent populations on the survival of young trees on the revegetation plots;
2. To test the effectiveness of the reduction of ground cover, the provision of supplementary food supplies, and the application of repellents as methods to control small rodent damage (these methods were found by Green [in prep.] to be the most promising control methods for the Athabasca Oil Sands area);
3. To determine whether the levels of sapling damage differ among revegetation plots, naturally revegetating areas, and natural woodland areas;

4. To determine the species composition and density of small mammals in the reclamation area, in naturally revegetating areas, and in woodland habitats that are typical of the Athabasca Oil Sands area; and
5. To determine whether differences in the levels of small mammal damage between natural and reclamation areas (assuming such differences exist) are related to differences in the species composition and density of small mammals and/or differences in the type and density of ground cover and young trees.

Nine small mammal damage plots are planned in three different habitat types--five study plots would be established on the GCOS reclamation areas, two plots would be established in a naturally revegetating area, and two plots are already established in woodland habitat adjacent to the AOSERP Mildred Lake Research Facility (Figures 1 and 2). Individual small mammal control methods would be implemented on three of the five reclamation plots, a combination of control methods would be implemented on the fourth reclamation plot, and no control methods would be conducted on the fifth plot.

Surveys of tree damage and estimates of the species composition and density of trees and ground cover would be carried out twice a year on all plots--in spring and in early fall. Changes in small rodent populations would be monitored through an intensive biweekly program of live trapping; changes in snowshoe hare populations would be monitored through a monthly program of live trapping. Seedling survival and changes in the levels of seedling damage by small mammals would be monitored throughout the study on both experimental and non-experimental reclamation plots. Saplings in natural woodland areas and in naturally revegetating areas would also be examined for small mammal damage to determine whether the levels of small mammal damage observed on the reclamation sites are unusually high when compared to those observed in natural areas. All damage to seedlings that was caused by rodents or by snowshoe hares would be considered. Exclosure areas (areas from which small mammals would be excluded) would be used to separate the impacts of small mammals on young trees from the effects of insect damage, disease, nutrient deficiencies and damage due to transplanting.

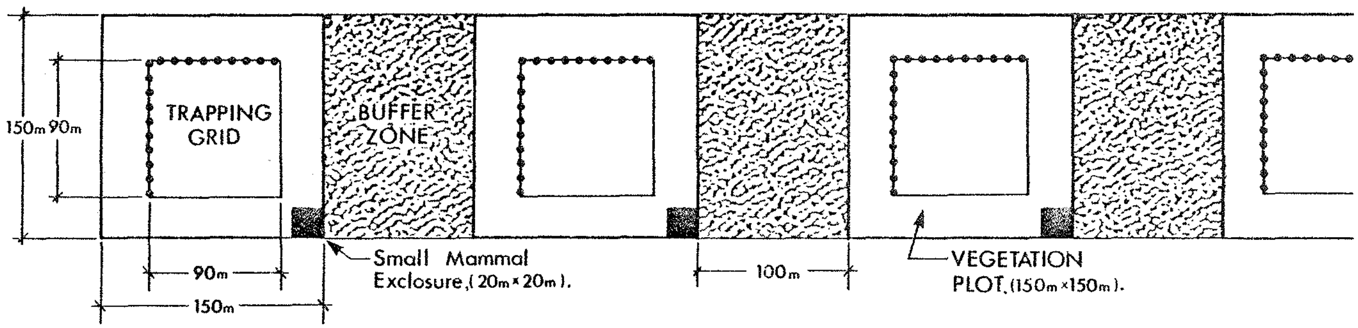
Small mammal populations would be monitored throughout the study on both experimental and non-experimental reclamation areas and in woodland and naturally revegetating habitats. The small mammal trapping program would monitor the populations of voles, mice, chipmunks, red squirrels, flying squirrels and snowshoe hares on the study plots. Monitoring of small mammal populations would be conducted in order to determine what effects the small mammal damage control program has on the distribution and density of small mammals. A small mammal trapping program would also aid in determining the relationship between population changes (particularly during population highs) in natural areas or reclamation areas and the rate of movement between areas. Levels of sapling damage may also be related to changes in the population size of the various small mammal species.

A brief description of the methods of estimating the species composition and density of young saplings and ground cover, the levels of damage to young trees, and the changes in the abundance of small rodents and snowshoe hares is given in the following sections; most of these methods have already been described earlier in this report (see Section 2. METHODS).

5.1 PROPOSED STUDY AREAS

5.1.1 Reclamation Study Plots

Five study plots would be established on a new reclamation area or on a recently revegetated (ground cover only) area, preferably in an arrangement similar to that shown in Figure 4. Each study plot would consist of one 2.3 ha vegetation plot containing



The experimental design would include 5 study plots:

PLOT A

SUPPLEMENTAL FOOD

- Standard tree stock
- Normal ground cover
- Normal fertilization
- Addition of supplementary food

PLOT B

REDUCED COVER

- Standard tree stock
- Reduced ground cover
- Reduced fertilization
- Possible reduction of cover by mowing

PLOT C

CONTROL

- Standard tree stock
- Normal ground cover
- Normal fertilization
- No treatment

PLOT D

COMBINED METHODS

- Standard tree stock
- Reduced ground cover
- Reduced fertilization
- Addition of supplementary food
- possible reduction of cover by mowing
- Application of repellents

PLOT E

REPELLENTS

- Standard tree stock
- Normal ground cover
- Normal fertilization
- Application of repellents

Figure 4. Proposed small mammal damage study plots on the AOSERP reclamation area. (A series of five vegetation plots separated by buffer zones would be established. Buffer zones would also be established on the outside edge of Plot A and Plot E. Small mammal trapping grids and small mammal exclosures would be established in each vegetation plot. Each vegetation plot would be treated as indicated. A total area of 20.3 ha [50 acres] is required for one replicate of all five vegetation plots and six buffer zones.)

a central 0.8 ha small rodent trapping grid. Each plot would be separated from adjacent plots by a 100 m buffer zone. Buffer zones would also be established on the outside edge of the two end plots. A total area of 20.3 ha would be required to establish the five vegetation plots and the six buffer zones.

To minimize variability due to habitat structure, all plots and buffer zones would be planted with the same ground cover mixture at the same density and all would receive similar fertilization. Three or four tree or shrub species would be selected according to the recommendations of the current AFS survey. Alder, balsam poplar, trembling aspen and willows are possible choices. Trees would be planted in a similar pattern on each study plot (e.g., 1 m spacing and a specific sequential pattern of tree species). For a 1 m spacing (which is currently being used by AFS on its afforestation research plots), 114,005 saplings would be required for the vegetation plots and 89,996 sapling would be required to plant the buffer zones. However, because it is unlikely that such a large number of saplings can be obtained on short notice, an alternative scheme would be to plant saplings only on the vegetation plots and to plant them on each vegetation plot at a 1 m spacing in ten randomly located 10 m x 10 m blocks. This planting method would reduce the number of saplings that would be required to 6,050. Small mammal damage control procedures would still be applied over the entire vegetation plot.

On each study plot, one 20 m x 20 m exclosure area would be installed in order to separate seedling mortality due to small mammal damage from seedling mortality due to other factors such as nutrient deficiencies, insect damage or disease. Seedlings would also be planted at a 1 m x 1 m spacing in each of the small mammal exclosure areas. A mouse-proof fence similar to that described by Boonstra and Krebs (1977) would be constructed around each such area using 6.3 mm (1/4 in) mesh hardware cloth extending at least 0.3 m into the ground and 0.6 m above the ground. All small mammals present in the enclosed area would then be removed. The exclosures would be inspected during each trapping period for evidence of small mammal activity; if any small mammals were present, kill traps would be used to remove them. By comparing the survival of seedlings in the exclosure to that of seedlings on the remainder of the study plot, the amount of seedling mortality that is directly attributable to small mammal damage would be determined.

The following treatments of the various study plots are planned to test specific hypotheses:

<u>Control Plot</u> (Plot C) - Normal ground cover mixture currently used by GCOS

- Normal fertilizer application currently used by GCOS

<u>Experimental Plot 1</u> (Plot B) - Reduced Cover.

Purpose: to determine whether the density of cover will affect the density of small mammals or the amount of small mammal damage to seedlings.

Treatment:
1. reduction of the ground cover seeding density to one-half, and
2. reduction of fertilizer to one-half.

<u>Experimental Plot 2</u> (Plot A) - Supplemental Food.

Purpose: to determine whether supplemental food will affect the density of small mammals or the amount of small mammal damage to seedlings.

Treatment:
1. same vegetation and fertilization as control plot, and
2. addition of one feeding station (consisting of half-gallon plastic jugs placed on their sides and containing whole oat groats that are resupplied as needed) at each trapping station.

<u>Experimental Plot 3</u> (Plot E) - Repellents.

Purpose: to determine whether repellents will affect the amount of small mammal damage to seedlings.

Treatment: 1. same vegetation and fertilization as control plot, and

2. application of a small mammal adhesive repellent mixture (such as that suggested by Radvanyi 1970) twice each year (once in the late spring and once in the early fall) to all seedlings.

Experimental Plot 4 (Plot D) - Combined Effects.

Purpose: to determine whether the combined effects of the reduction of cover, the addition of supplemental food, and the application of repellents will affect the density of small mammals or the amount of small mammal damage to seedlings.

Treatment: 1. same reduced seeding densities and fertilization as Plot B,

2. supplemental food supplied as in Plot C, and

3. repellent applied as in Plot D.

The effectiveness of each treatment would be determined by comparing the amount of damage, the growth rates of the saplings and the survival of the saplings on each experimental plot to corresponding quantities on the control plot. The species composition and density of small mammals on each area will also be compared to determine the demographic effects of these treatments on the small mammal community.

5.1.2 Naturally Revegetating Plots

Two study plots would be established on a naturally revegetating area. As no specific sites have yet been identified, a reconnaissance flight might be used to survey suitable study areas within the AOSERP study area. Naturally revegetating plots would be used to determine whether the levels of small mammal damage to seedlings that occur on reclamation areas are abnormally high in comparison to natural systems. Small mammal trapping and vegetation surveys (species composition and density of ground cover and young trees and the amount of small mammal damage to seedlings) would be conducted on each study plot.

5.1.3 Woodland Plots

Two woodland study plots were established in the fall of 1977 (Green in prep.). One plot is located in a white spruce-aspen forest; the other in a jack pine-aspen-willow forest. Both plots are located near the AOSERP Mildred Lake Research Facility (Figure 2). Small mammal trapping and vegetation analyses would be carried out on these plots to supply data on species composition and density of small mammals and on the amount of small mammal damage in natural woodland areas.

5.2 METHODS

5.2.1 Vegetation Analyses

Although most of the methods for sampling vegetation in the proposed research program are similar to those already described for the 1977 study, several changes have been made for statistical purposes. All saplings on the vegetation research plots would be examined for small mammal damage and two estimates would be made each year of the number and the species composition of saplings that were surviving; growth rates of these saplings would also be recorded to provide a more quantitative measure of the effects of small mammal damage to seedlings in the reclamation areas. In the woodland and naturally revegetating plots, the sapling density and species composition and the level of small mammal damage would be sampled using randomly located quadrats. Ground cover density and species composition would also be measured on all plots (reclamation research, naturally revegetating, and woodland) using randomly located quadrats.

5.2.1.1 Estimation of sapling density and small mammal damage. Surveys of small mammal damage to young shrubs and trees (saplings) would be conducted twice each year (spring and early fall) on each study area. All saplings within the revegetation study plots would be examined and rated according to the methods described in Appendix 7.1. In addition, the winter and spring-to-fall survival rates of each species and the growth rates of each species would be calculated in order to provide a quantitative measure of the impact of small mammal damage on the young trees. Growth rates would be based on a measurement of the vertical growth (maximum height above ground) and the diameter at 15 cm above ground level for each sapling within the revegetation study plots. The maximum height and diameter of each live sapling would be measured twice each year (spring and early fall).

On woodland and naturally revegetating plots, 50 randomly located sampling points would be chosen using coordinates selected from a random numbers table. At each sampling point, a 4 m x 4 m quadrat would be placed on the ground (Figure 5). (Oosting [1956] suggests that a 4 m x 4 m quadrat size is sufficient for sampling woody vegetation up to 3 m tall. The standard quadrat size to be used on all study plots might be altered, however, depending on the spacing and the number of saplings that were present on these areas.) Within each 16 m^2 quadrat, all saplings would be examined for small mammal damage and the number of saplings of each species present would be recorded. Mean sapling densities and species composition would then be calculated for each area.

5.2.1.2 Estimation of ground cover density and composition. The vertical and the horizontal components of ground cover may both be important factors in determining small mammal distributions. The vertical and horizontal components of both living and dead ground cover would consequently be measured in this study. Fifty randomly located sampling points would be chosen on each reclamation research plot. On the naturally revegetating areas and the woodland areas, the same 50 randomly located sampling points that were used to

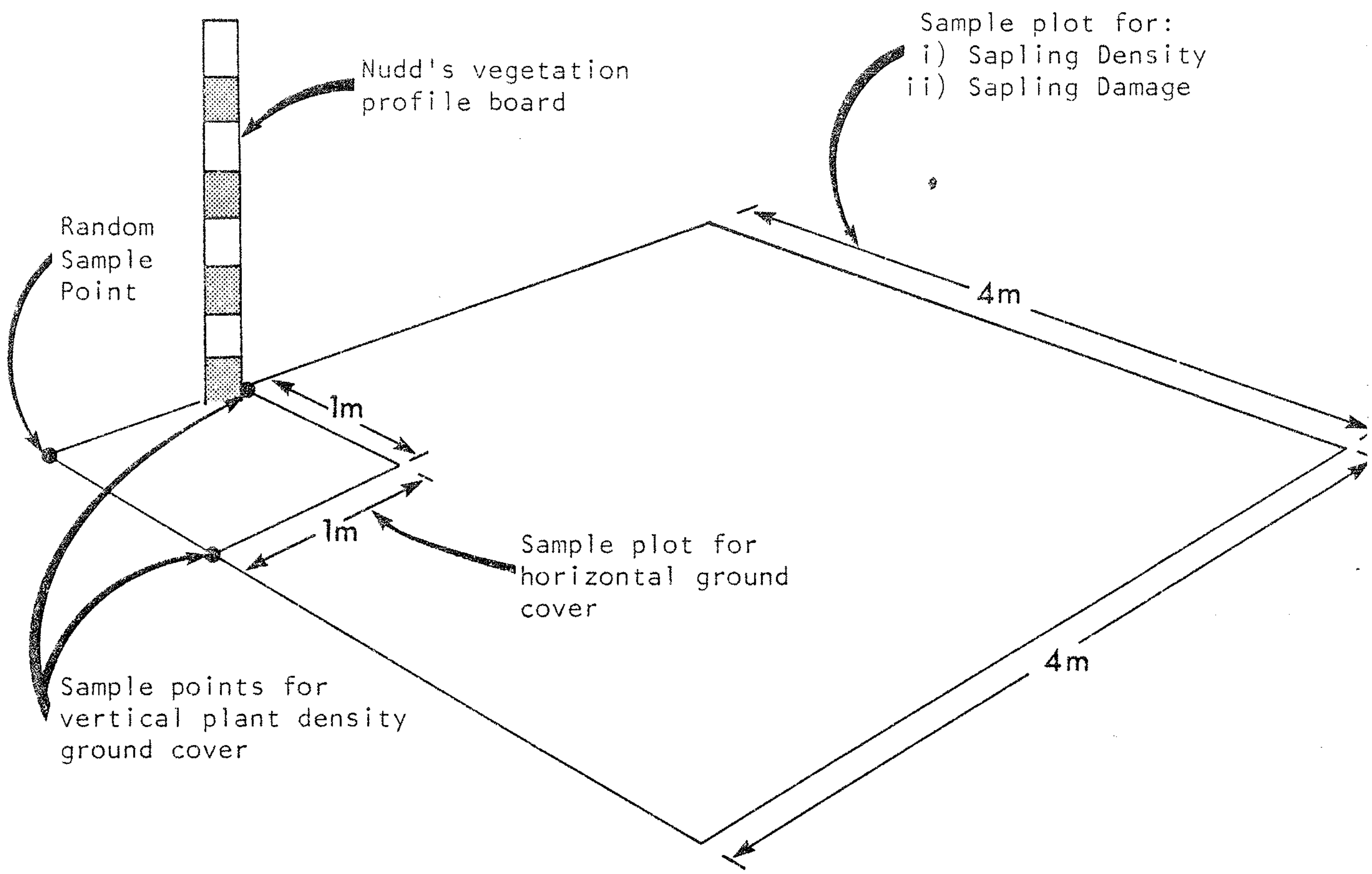


Figure 5. The proposed sapling density, sapling damage, plant density, and ground cover sampling plots.

sample sapling densities and levels of small mammal damage would also be used to sample the ground cover.

The percentage of the ground that is horizontally covered by each plant species and by ground litter within a 1 m x 1 m quadrat positioned at each sampling point would be estimated using the cover scale that has been described in Section 2. METHODS (see Figure 5).

The vertical component of ground cover would be measured at two adjacent corners of the ground cover quadrat (Figure 5). The vertical density (percent cover) of all vegetation in each 0.25 m vertical increment would be visually estimated using the vegetation profile board method of Nudds (1977). This method has been recommended for small mammal studies by R. Morris (pers. comm., cited in Nudds [1977]). Nudds' vegetation profile board is adapted from a board described by MacArthur and MacArthur (1961); it consists of a board 2.5 m high and 0.3 m wide that is marked in increments of 0.25 m that are painted alternately black and white. By standing a specified distance from the profile board, the investigator visually estimates the percentage of each increment that is covered by vegetation. As Nudds' method will only provide a cumulative figure for all plant cover, more specific information on the dominant species and the ground litter in each quadrat will be collected as follows. For each of the three most dominant plant species in each ground cover quadrat (based on the percentage cover), the layer of maximum vertical density would be determined and recorded. The minimum height of this layer (from the ground surface) would also be recorded. Similar measurements would also be made for plant litter (i.e., dead grasses, twigs, leaves, etc.).

5.2.1.3 Frequency of sampling. The number of sample points and the frequency of sampling for each type of vegetation analysis in woodland, naturally revegetating, and reclamation research plots are summarized in Table 4.

Table 4. Number of samples and frequency of sampling for the analysis of vegetation.

Vegetation Analysis	Woodland Plots		Naturally Revegetating Plots		Reclamation Research Plots	
	Number of Samples	Frequency Per Year	Number of Samples	Frequency Per Year	Number of Samples	Frequency Per Year
Small Mammal Damage to Saplings	50	2	50	2	*[1]	2
Sapling Density	50	2	50	2	*[1]	2
Horizontal Ground Cover	50	2	50	2	50	2
Vertical Ground Cover	100	2	100	2	100	2

[1]All saplings within the reclamation research vegetation plots would be sampled.

5.2.1.4 Data analysis. A correlation analysis would be used to determine whether the horizontal and vertical components of the ground cover and sapling density are related to the distribution of small mammals--particularly the microtine rodents. A similar analysis would be used to determine whether the levels of small mammal damage in the naturally revegetating and woodland areas and in the revegetation research plots are related to the local distributions of small mammals.

5.2.2 Small Mammal Trapping Techniques

The methods of live trapping of small mammals that would be used during this study are similar to those described by Keith *et al.* (1968) and Krebs *et al.* (1969). Each small rodent trapping grid would be 0.8 ha in size and would consist of a 10 x 10 arrangement of trapping stations at 10 m intervals. Each station would be marked with a wooden stake. One mouse trap (either Tomahawk #101 or Longworth trap) would be placed at each station. Two traps would be placed at each station if small rodent densities are high. In addition to these traps, 15 chipmunk/squirrel traps (Tomahawk #201) would be placed on each grid. Two snowshoe hare trapping grids would be established in the two woodland areas; they would require a larger trapping area than the small rodent grids. A snowshoe hare trapping grid would be 7.3 ha in size and would consist of a 10 x 10 arrangement of trapping stations at 30 m intervals. If snowshoe hare damage becomes evident on the reclamation plots or on the naturally revegetating plots, 15 snowshoe hare trapping stations would be established on the affected plots.

Traps would be prebaited for one week prior to the initiation of the first trapping session on each area. Small rodent trapping sessions would be continued throughout the spring, summer, fall and possibly the early winter at biweekly periods. Snowshoe hare trapping would be carried out once every four weeks.

Each small rodent or snowshoe hare trapping session would involve the setting and rebaiting of traps in the afternoon of the first day. On the second day, traps would be checked and reset in the morning and again in the afternoon. On the third day, traps would be checked and locked open until the next trapping period.

Each animal caught would be tagged with a numbered aluminum tag in the right ear. The tag number, species, sex, breeding condition, trap location, body weight and skull width would be recorded for each animal, and the animal would then be released. If animals are recaptured during the same trapping session, only the tag number and trap location would be recorded. Tagged animals caught in subsequent trapping sessions would be treated as new animals except they would not be retagged.

5.3 DURATION OF THE STUDY

Because numbers of *M. pennsylvanicus* and possibly *C. gapperi*, fluctuate cyclically (with population highs that occur on average approximately once every four years) a study program of at least a four-year duration is needed in order to allow sufficient time to evaluate the effectiveness of the proposed methods of controlling small mammal damage on the experimental plots. The plots would be strictly controlled to minimize, wherever possible, those factors that could cause undesired and uninterpretable differences among the plots. The proposed plots are also sufficiently large to permit an accurate determination of the small mammal populations on the plots. If the vegetation plots can be established in the early spring of the first year of the study and if the vegetation becomes successfully established by the end of the first summer, a four year study should provide sufficient time to assess the relative effectiveness of the control methods.

A four year program would permit an evaluation of the effectiveness of these control methods over at least one population cycle of these species. Following the first four years of the study (and assuming that the most promising control methods have been clearly identified), a lower level monitoring program should be implemented over another four year population cycle to provide data on the effectiveness of the control methods over longer periods of time. If snowshoe hares become a significant problem on the reclamation areas, the need might arise for a much longer study program to deal with the control of snowshoe hare damage to afforestation areas.

5.4 IMPLICATIONS OF THE RESEARCH PROPOSAL

Our proposal to study small mammal damage and control methods on reclamation areas in the AOSERP study area would involve controlled planting of ground cover and seedlings on a large area, as well as the implementation of ground cover reduction, provision of supplementary food, and the application of chemical repellents. Continued cooperation with the Alberta Forest Service, with AOSERP (Land System) and with the environmental staff of GCOS Ltd. and Syncrude Canada Ltd. is vital to the successful establishment and subsequent study of both the reclamation study plots and the natural plots. An area (approximately 20 ha) of unvegetated sand or a recently revegetated area on one of the GCOS tailings dikes would be required for the initiation of the project in the early spring of 1978. This area could be long and narrow (as in Figure 4) or square, but it should be a continuous and comparatively uniform area. Existing revegetation plots are unfortunately too small to establish plots that would allow accurate estimates of small mammal populations. Furthermore, the diverse treatments of various existing reclamation plots would add considerable variations of unknown magnitudes to the analyses. The research proposal presented here has deliberately attempted to minimize the number of variables, while remaining within a framework that should hopefully be acceptable to the current reclamation program.

It is our hope that an effective program to control small mammal damage can be formulated by this study through the cooperative efforts of AOSERP, Great Canadian Oil Sands Limited, Syncrude Canada Limited and LGL Limited and that the control methods that are formulated will allow the afforestation program on the Athabasca Oil Sands reclamation areas to successfully fulfill the requirements of the Alberta Land Surface Conservation and Reclamation Act.

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7. APPENDIX

7.1 TECHNIQUES OF ESTIMATING SMALL MAMMAL DAMAGE

A means of estimating the type and amount of vegetation damage that has been caused by small mammals is an essential part of any study to evaluate the effectiveness of a small mammal damage control program. Unfortunately, there is little information available on the methods of evaluating small mammal damage to vegetation. Damage to seedlings can involve browsing by ungulates and leporids, and bark consumption by rodents and leporids. We have considered only means of estimating bark consumption injuries.

Girdling and related stem injuries by rodents and leporids commonly occur on the lower stem, the lower branches and the surface roots. The maximum height of such injuries is determined by the distance that the animal can reach above the ground or snow level. Jokela and Lorenz (1959) found that stem injuries by mice were largely confined to within 15 cm of the ground level and that injuries by mice rarely involved branches. J. Sherstabetoff (Alberta Forest Service; pers. comm.), however, found severe girdling injuries as high as 75 cm above ground level on the stems of some saplings on the GCOS reclamation plots; these injuries were attributable to small rodents.

Stem injuries usually involve the removal of the phloem and outer cambium layers in irregular patches on the stem; injuries range from one or more patches per tree to complete girdling of the stem. Girdling prevents the transport of sugars, proteins and mineral ions through the stem and eventually leads to the death of the tree. The presence of numerous patches of bark injury results in a general decrease in the ability of the plant to transport nutrient materials; this decrease can lead to nutrient deficiencies that in turn can lead to an increased susceptibility to attack by insects and/or disease.

An evaluation of stem damage should involve an estimation of the damage both around the circumference of the stem and vertically along the stem. Jokela and Lorenz (1959) rated such damage in terms of the percentage of the stem circumference that was damaged using a scale that increased by 25% increments (i.e., no injury, < 25%, 25-50%, 50-75%, and 75% to complete girdling). A similar technique (but using 50% increments) was used by the Alberta Forest Service (AFS) during their 1977 tree damage program; Table 5 is a summary of the factors and the rating system that they used.

For estimates of damage in the proposed program of small mammal control, we would use the technique of the AFS, but would use a scale of 25% intervals. We would also add a separate classification of snowshoe hare damage, would quantify vertically the amount of mouse damage (i.e., the percentage damage in 15 cm intervals above ground level up to a height of 90 cm), would measure the maximum heights of small rodent and snowshoe hare damage, and would estimate the age of rodent and hare damage, based on the degree of weathering of the wound and the extent of callous growth around the wound.

In addition to small mammal damage, a number of other factors, such as nutrient deficiencies, insect damage, disease and the presence of toxic materials, also contribute to tree mortality. Tree death may result from the combined effects of several of these factors. Black *et al.* (1969), for example, found that animal damage (combined ungulate, leporid, game bird and rodent damage) accounted for only 35% of the Douglas-fir seedling mortality and 51% of the pine seedling mortality in their study areas. To separate the effects of small mammal damage from the combined effects of these other factors, wire mesh exclosures can be used to exclude small mammals from small study plots (Black *et al.* 1969). Comparisons of caged and uncaged plots permit a better estimation of the direct effects of small mammal damage on tree survival.

Table 5. Factors considered by the Alberta Forest Service during the 1977 tree damage surveys.[1]

Factors Contributing to Mortality and Loss of Vigor:

A.	Stock	:Dead or living foliage not in evidence; buds have not broken.
B.	Planting	:Seedling not anchored; compaction lacking.
C.	Erosion	:Root exposure or soil deposition upon all or part of the seedling.
D.	Dieback	:Dead branches and stems present on a living seedling above a definite but unspecified height.
E.	Disease/Deficiencies/ Toxicities	:Evidence of abnormal discoloration, foliage dwarfism, scorching, lesions, galls, cankers, blisters, etc. that are probably severe enough to affect tree vigor.
F.	Mouse damage	:Observable damage caused by mice chewing on the bark.
G.	Insect damage	:Observable partial or total leaf defoliation caused by chewing or skeletonizing insects.
H.	Unknown	:The above factors were not observed.

Plant Condition:

0.	Dead	
1.	Poor	:Very little to no growth; poor colour; dead branches/foliage often.
2.	Fair	:New growth, often faded or chlorotic; may have some dead branches/foliage rare.
3.	Good	:Very good growth and a healthy colour.

Mouse Damage (Bark):

1. No damage 2. $<50\%$ 3. $\geq 50\% < 100\%$ 4. completely girdled

Insect Damage (Foliage):

1. No damage 2. $<20\%$ 3. $\geq 20\% < 50\%$ 4. $\geq 50\% < 100\%$

5. Complete defoliation

[1]Supplied by G. Dunsworth, Alberta Forest Service.

8. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs within the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters Upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigation into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather, a Feasibility Study
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant
14.	HE 2.4	Athabasca Oil Sands Historical Research Design (3 volumes) (in review)
15.	ME 3.4	Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Alberta Oil Sands Region Stream Gauging Data
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Evaluation of Organic Constituents (in review)
21.		AOSERP Second Annual Report, 1976-77
22.	HE 2.3	Maximization of Technical Training and Involvement of Area Manpower (in review)
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout (in review)
24.	ME 4.2.1	Review of Dispersion Models and Possible Applications in the Alberta Oil Sands Area (in review)
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26. AF 4.5.1 Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27. ME 1.5.1 Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976 (in review)
28. VE 2.1 Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29. ME 2.2 An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30. ME 2.1 Ambient Air Quality in the AOSERP Study Area, 1977
31. VE 2.3 Ecological Habitat Mapping of the AOSERP Study Area: Phase I

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Alberta Oil Sands Environmental Research Program
15th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6