Paper No. 5

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Title of Paper: "Coal Mine Spoils and Their Revegetation Patterns in Central Alberta"

ABSTRACT

The reclamation of land disturbed through surface mining is made mandatory in Alberta through the provision of the Land Conservation and Reclamation Act (1974). The objectives of land Reclamation are outlined in the Coal Development Policy for Alberta as follows:

> "The primary objective in land reclamation is to ensure that the mined or disturbed land will be returned to a state which will support plant and animal life or be otherwise productive or useful to man at least to the degree it was before it was disturbed. In many instances the land can be reclaimed to make it more productive, useful, or desirable than it was in its original state; every effort will be made towards this end."*

The term productive is ill-defined and open to different value interpretations. It implies, however, the re-establishment of a healthy and viable vegetative cover on the surface.

There has, in the past, been considerable public debate over the long-term implications in the maintenance of productivity on reclaimed land. There have been those who have predicted permanent loss of productivity, and those who have foreseen little if any change in productivity and even improvements in some cases. In fact, there is little hard evidence supporting the arguments of either camp, and many of the predictions are extrapolations based on current theories of the chemical, physical and biological behaviour of soils. There is, however, irrefutable evidence that short-term growth is dramatically improved by the selection and placement of more favourable growth media at the surface. This does not necessarily include the use of topsoil.

* Department of Energy & Natural Resources, Government of Alberta. June 15, 1976.

In view of the situation just described and of the recent nature of much of the research on strip mine reclamation, especiall in Alberta, it was essential to take a close look at some of the older spoils in the province. In this connection a historical study of the dynamic processes occurring in spoils was undertaken by Calgary Power through their consultants Montreal Engineering.

The study involved an examination of the vegetation and spo on five mine locations in the central Parkland of Alberta. These five locations represented different spoil types, and methods of mining. Within these spoil locations 44 sites were selected which represented spoil and vegetation conditions at different ages and topographic positions.

Some of the most important conclusions were:

1. The vegetative productivity of mine spoils in Central Alberta can be restored even given only a minimum of reclamation inputs.
2. The composition of the surface material is the most important factor affecting the reclamation of spoils. This factor can be manipulated by mining techniques.
3. The addition of topsoil to the spoil surface is not an absolute requirement to successful reclamation. However, topsoiling probably significantly reduces the time period required for reclamation.
4. Under conditions of natural plant invasion there are distinct successional stages leading to the eventual production of plant communities resembling those occurring in the original aspen parkland. However, these stages may be slowed or halted by adverse spoil conditions or overgrazing.

Coal Mine Spoils
And Their Revegetation Patterns
In Central Alberta

Alex E.A. Schumacher
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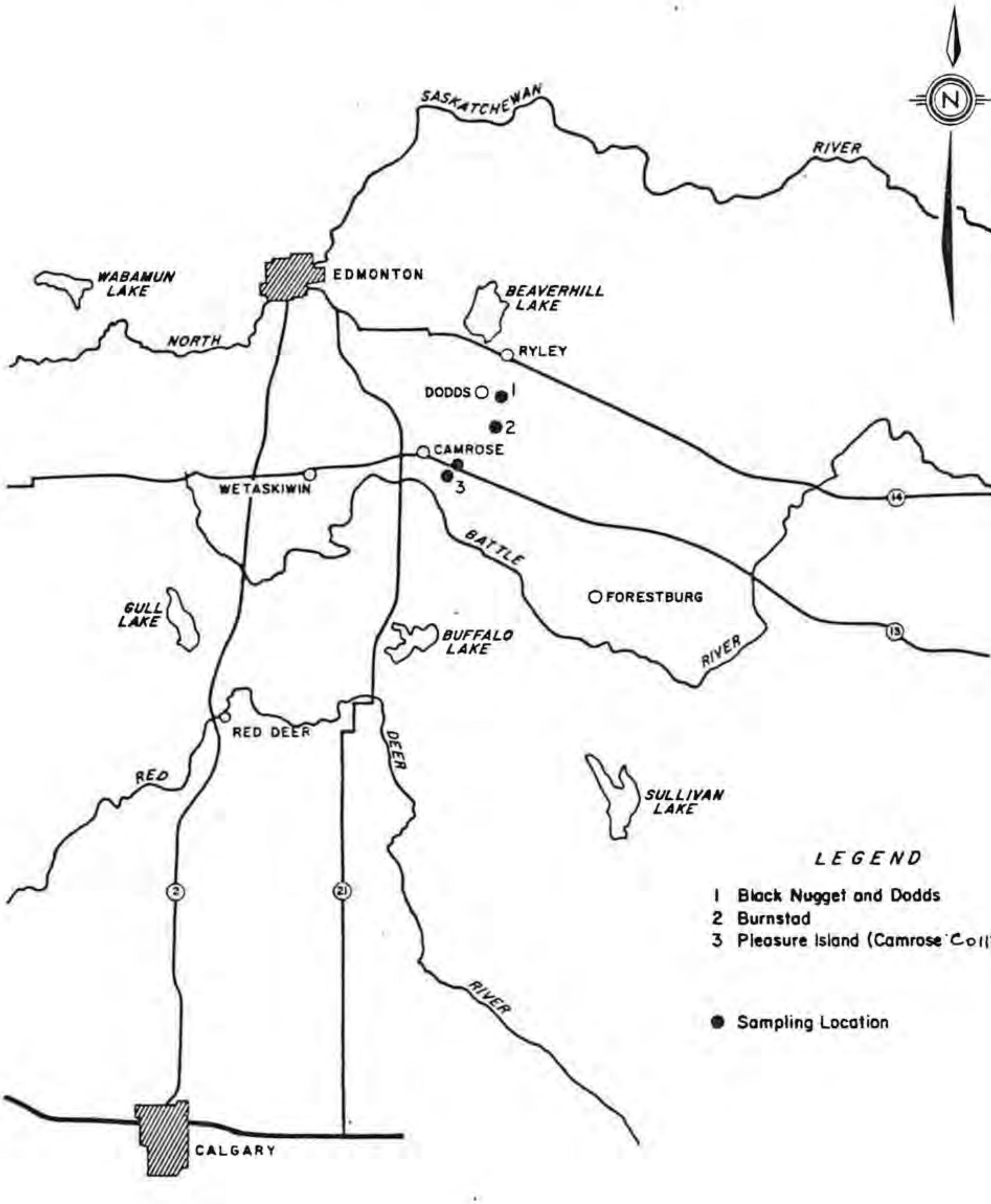
INTRODUCTION

There has been a relatively brief period in which methodical and scientific studies have been pursued, dealing specifically with the reclamation of mine spoils (Montreal Engineering 1976a, Packer 1974, Varies 1976, Wali 1975). There is thus a general lack of experience and knowledge of the changes occurring in spoils over time and of the changes that occur in the associated vegetation. This study, commissioned by Calgary Power Ltd., was designed to compensate for this lack of experience in the Aspen Parkland Region of Alberta by going back to abandoned spoils of various ages to investigate the manner in which they have changed with time. The relationship between the internal chemical and physical changes and the variation of surface vegetation was considered to be a particularly interesting aspect of the study because of the insights which it was hoped this would give into the sequences to be followed in establishing permanently self-sustaining plant communities.

The most important elements in attempting to achieve these objectives were considered to be: (1) the survey of the morphological, physical and chemical properties of the spoils and (2) the correlation of these spoil characteristics with the spoil age and with the species composition, the cover and the productivity of the associated vegetation.

The sites discussed in this report were selected on the basis of their geographic locations, the age of the spoils, the types of vegetation present and method of mining. They were all situated within the Aspen Parkland belt of central Alberta on spoils from the Dodds, Black Nugget, Ryalta, Burnstad, Pleasure Island (Camrose Collieries) and Forestburg mines, Figure 1.

The spoils evaluated during this study have been treated essentially as soils. The older spoils display many symptoms of incipient soil formation such as the downward mobilization of salts and their accumulation deeper in the profile, and also the accumulation montreal engineering company, limited



LEGEND

1 Black Nugget and Dodds
2 Burnstad
3 Pleasure Island (Camrose Collierie

● Sampling Location

FIGURE 1

LOCATION MAP OF STUDY ARE

of organic matter in the surface layers. In other senses as well, the spoils resemble soils; they have significant cation exchange capacity, they are mostly biologically active and they provide mechanical support for whatever is growing in them. Finally, it is true to say that given time these spoils will in any case develop into soils with the same or similar characteristics to any of those found in adjacent areas.

II MATERIALS AND METHODS

The study areas were visited, and interviews held with the individuals familiar with the mining history and procedures. On the basis of this information five mine locations were selected representing different spoil types and methods of mining. Within these spoil locations 44 sites were selected which represented spoils and vegetation conditions on spoils of different age groupings and topographical positions.

The test pits were excavated to a depth of 120-180 cm (4-6 ft) with a tractor-mounted backhoe. Detailed notes were taken on the morphological features of the spoils including texture, consistency, compaction and permeability as well as root penetration and distribution with depth. The descriptions were based on the standards of "The System of Soil Classification for Canada" while colours were described according to the "Revised Standard Soil Colour Chart System" (Oyama and Takehara 1967). The vegetative sampling consisted of three phases designed to obtain an in-depth appreciation of the vegetative community which had developed on each site. The three phases were: (1) an estimate of species composition and cover, (2) an estimate, or where possible a measurement, of site productivity and (3) a photographic record. The nomenclature was based on Moss (1959) in all cases.

Soil analyses were conducted by Chemex Laboratories Ltd. of Calgary using standard soil analytical techniques. The parameters identified were, particle size distribution, cation exchange capacity, pH, electrical conductivity, soluble cations (Na, Ca and Mg) , plant nutrients (available N, P and exchangeable K) and carbonates.

The sodium absorption ratio was calculated from the results of the soluble cation analyses.

III RESULTS

1. Particle Size Distribution (Texture)

The particle size distribution of the spoils was mainly related to the material(s) from which they were derived. The sampled spoils were mixtures of till, shale, sand/siltstone, coal remains and portions of the original soils. Some samples consisted almost entirely of one or two of these constituents but the majority consisted of more. The reported results, thus, represented the average textures of the "homogenized samples" after mixing and sieving in the laboratory.

The greatest proportion of the sites had sandy loam textures reflecting the predominantly sandy nature of the underlying Edmonton formation. Finer textures probably represented different admixtures of shale with the sandstones.

Certain anomalies in the distribution of textural classes can be associated with the mining techniques that were used. At the Burnstad, Pleasure Island, Dodds - Black Nugget and Ryalta sites heavy earth moving equipment such as scrapers and bulldozers removed the over burden layer by layer and redeposited it in the reverse order to that in which it was originally encountered. The continual passage of the machinery tended to compact each layer as it was deposited.

At the Burnstad and Pleasure Island sites the material lying directly over the coal and in the partings was a saline bentonitic shale. This was the last to be removed and was deposited over most of the surface. It was reflected in the high incidence of moderately fine textures (38% finer than sandy clay loam) on the surface and the lack of plant growth. At the Dodds and Black Nugget sites a thin sand/siltstone layer lying immediately over the bentonitic layer appears to have been mixed with it during the mining, thereby ameliorating it.

The dragline mining method used at Forestburg resulted in a very different distribution of materials from that observed where scrapers were used. The majority of samples (81%) were sandy loams while the remainder (19%) were loams. The surface materials are also dominantly (71%) sandy loams while the remainder (29%) are loams. It is thus evident that the dragline method resulted in a more thorough mixing of the spoils. However, the till and bedrock at this site likely also consisted initially of coarser materials than occurred elsewhere. This is borne out by the observation that the shales at Forestburg have a sandy clay loam texture, while those at Burnstad have a clay loam texture.

2. Reaction (pH)

The spoils were generally mildly alkaline, reflecting the calcareous nature of the bedrock formations and of the tills formed from them. Strongly alkaline conditions were recorded at the Dodds and Black Nugget sites and moderately alkaline conditions in the sub-surface materials of all other sites. Only at Burnstad, however, were moderately alkaline conditions encountered at the surface.

No strongly alkaline conditions were encountered in the surface spoils and with the exception of the Burnstad site, most would provide a suitable plant root environment from the pH standpoint. The few strongly acid samples, all of which were from the Burnstad site, probably represent leached Ae horizons of the Angus Ridge loam which originally occupied the surface.

3 Salinity

The spoils conditions ranging from non-saline to moderately saline were encountered but weakly saline conditions were predominant (49% of samples). A large proportion (44%) of spoils were non-saline, only a few (8%) moderately saline and none strongly saline.

The surface samples are mostly non-saline but a significant proportion (36%) displayed weakly saline characteristics.

Some of the salinity data is presented in graphic form in Figures 2 and 3. Inspection of this material makes it possible to identify some trends in the relationship between salinity, time, composition and depth of spoils.

1. In every case salinity increased with depth and also tended to be highest in those layers containing the largest proportion of shale.
2. Many of the older, mainly-till spoils were non-saline throughout the entire depth of the potential rooting zone of 120 cm (4 ft).
3. Younger spoils show a more even distribution of salts within this zone.
4. The shale-rich spoils show a much slower rate of leaching than the coarser till materials (see graphs of Burnstad and Dodds sites).

This evidence of salt movement suggests that under the prevailing climatic conditions salts will tend to move down the profile, especially in coarser, better drained situations. Exceptionally high levels of soluble salts were, however, encountered in the surface layers of some sites. This was attributed to the combined effects of the fine textures and a very high degree of compaction resulting in low permeability. Upward capillary action had thus tended to predominate in place of downward leaching and the situation was worsened by

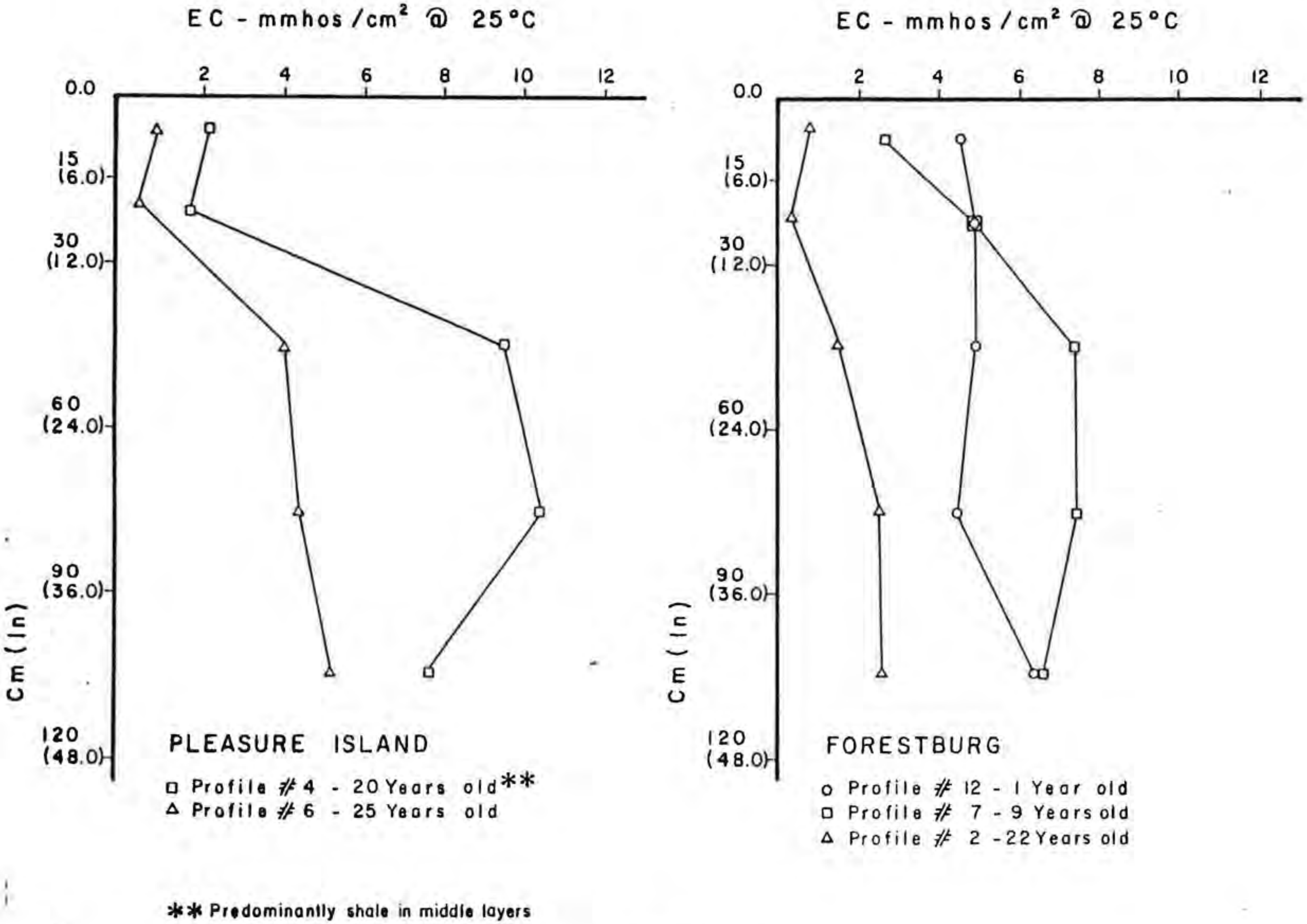


FIGURE 2

SALINITY PROFILES OF
SELECTED SPOILS SAMPLES OF VARIOUS AGES

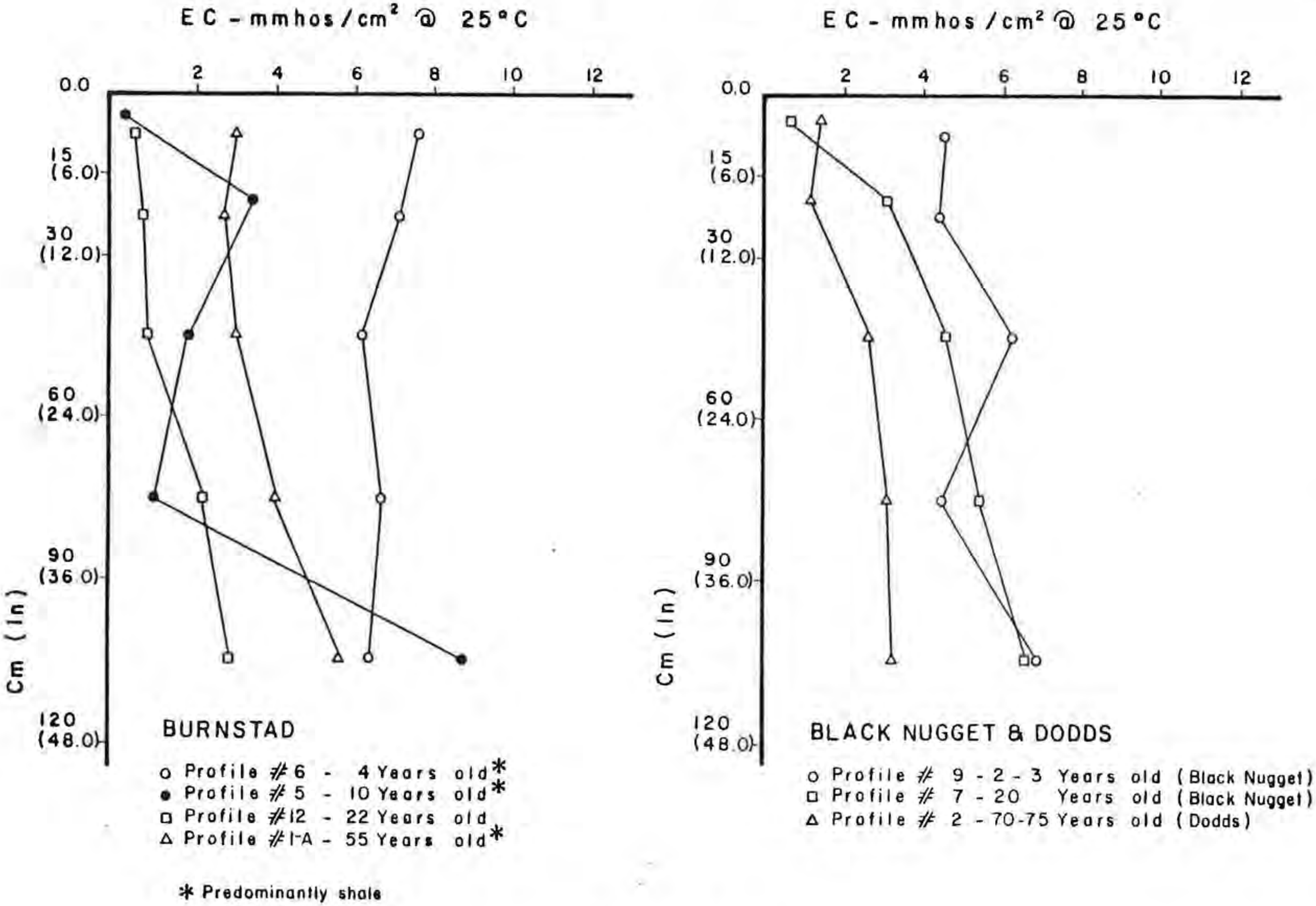


FIGURE 3

SALINITY PROFILES OF
SELECTED SPOILS SAMPLES OF VARIOUS AGES

a lack of surface vegetation. At the Forestburg site, the salinity was attributed to the fact that it was located in a sparsely vegetated depression. Run-off and sub-surface flows accumulated here tending to concentrate salts as the excess water is evaporated off.

4. Sodium

The most seriously sodium-affected spoils were at the Burnstad, Black Nugget-Dodds and Pleasure Island sites. However, only at Burnstad did these conditions prevail on the surface. Slightly less serious, but still potentially toxic conditions (SAR >18) were encountered in a few samples from every location but the Ryalta mine. Low and medium sodium levels (SAR <18) were encountered sporadically throughout all sites. These levels are generally not detrimental to plant growth, but towards the upper end of the range the sodium might reduce the amount of water available to plants under droughty conditions.

The relationship between the SAR and the total soluble salts was considered for each of the sites and for three age groupings of the spoils. These data reflect all the error introduced by the selection of the sites because of the special characteristics which required studying. They, however, gave an indication of some of the dynamics that occur in the spoils and involve those major parameters associated with salinity. There was a highly significant correlation between these two parameters in every site suggesting at very least the common origins of the salts and the sodium. With the exception of the Forestburg sites ($r^2 = 0.77$), the degree of variance in the SAR values was not more than 37%, explicable by the variance in the total salinity. This may be explained by the fact that the levels of both are more a function of texture and of the presence of shales. At the Forestburg sites, however, the textures are all loam or sandy loam which would leach rapidly. The salts and the sodium are thus more mobile in the profile and appear to be more closely related to one another.

5 Carbonates

Most of the component materials of the spoils contain alkaline earth carbonates derived mainly from the till, and the shale and from the horizons of secondary lime accumulation (Ca or Csaca) of the original solonetzic and chernozemic soils.

There was no identifiable correlation between the $CaCO_3$ content and the age and depth of the spoils. This suggests that the carbonates were much less mobile than the other soluble salts and that it would take a very long time (possibly centuries) for the formation of a layer of lime accumulation similar to that found in the original soils.

6 Cation Exchange Capacity (CEC)

47 percent of all samples ranged in CEC from 50 to 96 Meq/100 g. These relatively high CECs coincide with finer textures related mainly to higher amounts of shale, and also possibly to a higher content of illitic and montmorillonitic clays in the colloidal fraction of these samples.

The CEC data suggest that the spoils of all five study areas contain sufficient amounts of colloids to adsorb and supply the basic nutritional elements to most plant species.

7 Fertility

The highest concentrations of both available N and P in all the samples are much lower than the suggested deficiency levels of these elements for both cereal and legume crops in central Alberta. The reported concentrations of exchangeable K are sufficient, however, to meet the minimum requirements of such crops.

8 Morphological Characteristics

Some of the older vegetated spoils exhibit a noticeable increase in organic matter content, accompanied by a relatively darker colour and a somewhat granular structure in their surface layers. It was often difficult, however, to precisely differentiate between organic matter build-up as a result of root growth and biological activity, and that which resulted from the disintegration of the fine coal residue.

There was no visible evidence of the formation of genetic horizons within the spoils apart from slight changes in the granulation and colour of the surface of some profiles which might be identified as Ahj horizons. The structure was that of a compacted mass with no development of identifiable structural units (peds), as is the case in normal soils. A thin but firm crust was observed on the surface of the spoils which lacked or had a sparse vegetative cover. This resulted from the dispersion of the spoil particles under the direct impact of rainfall, and from repeated wetting and drying.

Compaction was greatest in the spoils which contained higher amounts of shale and in the areas where heavy tractors and scrapers were used in mining. In these areas, the effect of high compaction by this type of machinery combined with relatively fine textures was reflected in a shallower depth of penetration of the finer roots.

It was noted, however, that the presence of a visible quantity of coal residue in these spoils was accompanied by a deeper root system. Furthermore, the roots appeared healthier and well rounded. This may be attributed to the improvement in spoil/water/air relationships associated with the creation of larger pores and considerable decrease in the effect of compaction. Plentiful fine and medium roots were also observed growing in almost "pure" coarse fragmental coal layers.

9 Natural Revegetation

Within the mine areas studied, a characteristic sequence of vegetative plant succession was observed consisting of a number of discrete and identifiable vegetative stages. (Table I). Each stage was associated with certain characteristic species assemblages and appeared to occur within an approximate time span.

TABLE I

Stage of Revegetation

Vegetative Stage	Time Frame
Forb stage	1 - 4 years
Early grassland-weed stage	5 - 20 years
Early grassland stage	20 - 30 years
Grassland stage	30 - 50 years
Early aspen parkland stage	50+ years

Those naturally reclaimed areas which had suffered cattle grazing provided the best examples of each of these vegetative stages but it is likely that most mine sites pass through a similar progression. However, the development can be altered or even halted at any stage by adverse factors, the most prevalent of which are extremely adverse soil conditions and extensive grazing and overgrazing by cattle.

10. Description of Vegetative Stages

During the first stage most raw spoils were invaded by a variety of forbs, especially sweet clover. Few other species were present, apart from occasional individuals of brome or other grasses and foxtail barley in saline areas.

After a period of growth lasting approximately three to four years the sweet clover died back to be generally replaced by foxtail barley and numerous weedy species. With the collapse of the sweet clover the site productivity fell to very low levels and a stage began in which the site slowly developed into a grassland. The salt-tolerant foxtail barley was replaced by brome grass which eventually became the predominant grass species. The proportion of grasses slowly increased with time at the expense of the weeds. This initial grassland stage appeared to last for 15-20 years during which time the productivity of the site also slowly increased (Table 2).

About 20 years after mining, the first aspen trees, or willows in more moist sites, began to invade. The initial pioneers slowly spread by vegetative propagation to become the nuclei of the aspen groves found later. By about 30 years after mining, fairly large clumps of aspen had formed and the site took the outward appearance of the aspen parkland which originally dominated the area (Table 3).

The species composition of both the aspen groves and the grasslands were initially quite different from the original stands. The predominantly brome grassland may however be seen to be invaded and replaced by blue grasses and wheat grass which at the Black Nugget was being replaced by rough fescue. The original clumps appeared to be very stunted but some of the newer stands displayed better growth probably in response to improvements in the root zone. Undergrowth of the aspen at first was consisting mostly of roses, but more species seem to have invaded with the development of a richer assemblage. The most striking changes occurring were:

1. the increase in the grass cover with time along with a concomitant decrease in herbs,
2. the increase in the number of species present from 14 after 2 years to 50 after 31 years,

TABLE 2

Number of Species Present Related to Spoil Age

Age of Spoil	Numbers of Species Present				Total Species Present	Productivity	
	Grass	Herbs	Shrubs	Trees			
yrs						g/m^2	lbs/a
2	4	10	-	-	14	438.2	3,910
19	6	11	2	1	20	302.5	2,907
31	7	35	6	2	50	445.5	3,966

TABLE 3

Cover of Grassland Areas on Spoil Piles*

Age of Spoil	Percent Cover		
	Grass	Herbs	Bare Ground
yrs	%	%	%
2	5.3	79.1	15.6
19	39.4	49.4	11.2
31	67.4	36.9	-

*Total cover is over 100% due to formation of strata.

3. the high productivity related to the initial growth of sweet clover, its subsequent decline during the early grassland-weed stage and a build-up as the grassland stage progressed.

The vegetation of the regenerating aspen groves at the Black Nugget Park, a 30 year old site, were compared with that of ungrazed groves found in the vicinity. Of the 26 species re-established in the groves, 19 were common with at least one of the comparative sites. The remainder were mostly foreign to aspen grove vegetation (e.g. sweet clover, sage, thistles) and were expected to die out with time.

A total cover within groves declined with increasing dryness of the sites and as would be expected the lowest total cover occurred on the spoil sites. The percentage cover of trees, small and medium shrubs, herbs and grasses was comparable with at least one other site. Only the percentage of tall shrubs was lower on the spoil site than on any natural site surveyed.

IV CONCLUSIONS

The composition of the surface 1-2 m (3-6 ft) is probably the most important feature of the spoils with respect to the successful introduction of plants. The initial composition of this layer is both a reflection of the strata present and the mining method used. The layer by layer removal and re-deposition of spoils by heavy equipment such as bulldozers and tractor-drawn scrapers or even by horse-drawn scrapers has resulted in the formation of a poor growth medium in many of the older sites, with the exception of Black Nugget. The strata were replaced in the reverse order to that in which they originally occurred and the most problematic materials such as the saline shale layers left on the surface. The continuous passage of machines or even animals has also caused severe compaction and deterioration of the physical characteristics of the potential rooting zones. In contrast, a dragline cutting vertically through the strata tends to mix the overburden materials more thoroughly and results in more heterogeneous spoils with less compaction.

Free surface drainage and lack of compaction allows the rapid removal of potentially harmful salts by leaching, and easy penetration by plant roots. This situation can only be maintained provided there are loams or coarser materials throughout the potential root zone and preferably deeper. Materials as coarse as loamy sand and sand should, however, be avoided because of their low moisture holding capacity and infertility. The introduction of coal dust and fine particles into potentially problematic materials such as shales appears to greatly improve their physical characteristics and also the quality of the vegetation cover. Roots of plants growing where coal fragments are abundant are more plentiful and appear to be healthy and well-rounded. These observations bear out conclusions made by Fairbourn (1974) on the effect of using small coal fragments as a mulch.

Salinity is one of the major limiting factors to plant establishment, especially when combined with fine textured materials or occurring in poorly drained situations. Variations of salt levels down the profile are associated with textural variations. It was observed that salinity tends to be highest in layers having the highest proportion of shales. In addition, the levels of salts in high shale material decreases only slowly with time. The slow rate of leaching is related to the relative impermeability of the shales, especially when compacted and dispersed because of high sodium levels. Leaching, demonstrated by a general increase of salinity with depth, was observed to occur in most profiles inspected. In some of the older spoils composed predominantly of till materials the entire rooting zone (1.2 m or 4 ft) was non-saline. Conversely the younger, more saline profiles tend to have salts more evenly distributed throughout the profile but with high concentrations corresponding to the shaley layers.

There is a close correlation between the total soluble salts and the SAR. Both parameters generally increase with depth, especially in the older spoils, and both are higher in spoils with higher proportions of shales. The two factors are not, however, always directly attributable to one another since many soluble salts are relatively mobile. Much of the sodium is adsorbed onto the exchange complex.

There is good evidence from such sites as Dodds and Forestburg, that, provided the materials deposited at the surface are of suitable texture and have not been overly compacted, they will in time develop into productive plant growth media. It is concluded from this that the addition of topsoil is not an absolute necessity and could be foregone in some instances. This is especially so where the original topsoil is impoverished and where there are no inherent problems associated with the underlying till or bedrock. The major benefit of adding topsoil appears to be that derived from the presence of organic matter, the levels of which would otherise take many years of careful husbandry to develop to an acceptable level. The organic matter would significantly increase the cation exchange capacity and probably improve the availability of nitrogen and phosphorus both of which were markedly deficient in the spoils surveyed.

The spoils have a similar cation exchange capacity to most of the normal soils of the study areas and, therefore, the potential to adsorb and supply nutritional elements to plants.

A number of distinct successional stages were recognized in the vegetation recolonizing the spoil sites. The initial stages are simple with very few species managing to establish themselves. Predominant amongst the early colonizers is sweet clover which dies out after a few years, leaving a much less dense vegetative stand. As the succession proceeds, the developing plant community becomes more diverse. In the final stage the vegetation likely resembles the climax of the region. This was not observed to have been completely achieved, although in Dodds an early aspen parkland vegetative stage has been reached. This vegetative succession can be halted or considerably slowed at any stage as a result of adverse spoil conditions, such as compaction or the presence of saline (or alkali or saline/alkali) conditions. Disturbances such as overgrazing also cause severe limitation to the development of a plant cover.

In the benign spoils (those without significant levels of plant toxins) the productivity appears to be mainly related to the age of the spoils and the stage of succession of the vegetation. This is probably due to the gradual build up of the organic system in the spoil and emphasizes the importance of maximizing the level of organic matter as rapidly as possible on land to be used for sustained agricultural production. In these same benign spoils there appears to be evidence that their productivity will, with time, equal or exceed that of the native prairie vegetation, even without any reclamation inputs.

In the later stages of succession, spoils make good wildlife habitat, especially where levelling has been kept to a minimum and where a tree cover has been re-established. Numerous species of birds and mammals are attracted by the varied topography and micro-climates that thrive in the spoil habitat. Furthermore, ponds such as those at Black Nugget provide adequate habitat for beaver, muskrat, introduced fish and waterfowl. These in turn attract recreational use of the areas, thus providing an important outlet for the adjoining urban areas.

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PROCEEDINGS

OF

THE SECOND ANNUAL GENERAL MEETING

OF THE

CANADIAN LAND RECLAMATION ASSOCIATION

August 17, 18, 19 & 20 —1977 Edmonton, Alberta

(Sponsored by the Faculty of Extension, University of Alberta)

P R O G R A M

Canadian Land Reclamation Association

Second Annual General Meeting

August 17, 18, 19, 20, 1977

Edmonton, Alberta

Wednesday, August 17 (Optional Field Trips)

Field Trip No. 1 (Athabasca Tar Sands)

Leader: Philip Lulman (Syncrude Canada Ltd.)

Fee: $100.00 (covers bus and air transportation, lunch, and field trip information pamphlets)

Schedule: 7:30 am.- delegates board bus at Parking Lot T, located immediately south of the Lister Hall Student Residence complex. Air transportation from Edmonton Industrial Airport to Fort McMurray and return. Guided bus tour of surface mining and reclamation operations on Syncrude Canada Ltd. and Great Canadian Oil Sands Ltd. leases. 6:30 p.m.- delegates arrive back at Parking Lot T, University of Alberta campus.

Field Trip No. 2 (Aspen Parkland; Forestburg Coal Mine Reclamation)

Leader: George Robbins (Luscar Ltd.)

Fee: $25.00 (covers bus transportation, lunch, and field trip information pamphlets)

Schedule: 8:00 a.m. - delegates board bus at Parking Lot T, located immediately south of the Lister Hall student residence complex. Guided bus tour southeast of Edmonton, stopping at various points of interest (oil spill reclamation field plots; Black Nugget Park [abandoned minesite]; trench plots on Dodds-Roundhill Coal Field; solonetzic soil deep ploughing site) on the way to the Luscar Ltd. Coal Mine at Forestburg.
6:30 p.m. - delegates arrive back at Parking Lot T, University of Alberta campus.

Thursday, August 18

Events:	Opening of Formal Meeting; Presentation of Papers
Location:	Multi-Media Room, located on second floor of Education Building, University of Alberta.
8:00 a.m.	Authors of papers being presented on August 18 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching)
9:00 a.m.	Meeting Opened by Dr. Jack Winch (President of the C.L.R.A.; Head of the Department of Crop Science, University of Guelph). Comments by Dr. Winch.
9:15 a.m.	Welcome to delegates on behalf of the Government of Alberta by the Hon. Mr. Dallas Schmidt, (Associate Minister Responsible for Lands, Alberta Department of Energy and Natural Resources)
9:25 a.m.	Commencement of Paper Presentations. Morning session chaired by Mr. Henry Thiessen (Chairman of the Land Surface Conservation and Reclamation Council and Assistant Deputy Minister, Alberta Department of Environment).
9:30 a.m.	Paper 1. Combined Overburden Revegetation and Wastewater Disposal in the Southern Alberta Foothills by H.F. Thimm, G.J. Clark and G. Baker (presented by Harald Thimm of Chemex Reclamation and Sump Disposal Services Ltd., Calgary, Alberta).
10:00 a.m.	Paper 2. Brine Spillage in the Oil Industry; The Natural Recovery of an Area Affected by a Salt Water Spill near Swan Hills, Alberta by M.J. Rowell and J.M. Crepin (presented by Michael Rowell of Norwest Soils Research Ltd., Edmonton, Alberta)
10:30 a.m.	Coffee Recess
11:00 a.m.	Paper 3. The Interaction of Groundwater and Surface Materials in Mine Reclamation by Philip L. Hall of Groundwater Consultants Group Ltd., Edmonton, Alberta.
11:30 a.m.	Paper 4. Subsurface Water Chemistry in Mined Land Reclamation; Key to Development of a Productive Post-Mining Landscape by S.R. Moran and J.A. Cherry (presented by Stephen Moran of the Research Council of Alberta, Edmonton, Alberta).
12:00 noon	Lunch Recess

1:25 p.m.	Continuation of Paper Presentations. Afternoon session chaired by Mr. Philip Lulman (member of C.L.R.A. executive; reclamation research ecologist with Syncrude Canada Ltd.).
1:30 p.m.	Paper 5. Coal Mine Spoils and Their Revegetation Patterns in Central Alberta by A.E.A. Schumacher, R. Hermesh and A.L. Bedwany (presented by Alex Schumacher of Montreal Engineering Company Ltd., Calgary, Alberta).
2:00 p.m.	Paper 6. Surface Reclamation Situations and Practices on Coal Exploration and Surface Mine Sites at Sparwood, B.C. by R.J. Berdusco and A.W. Milligan (presented by Roger Berdusco of Kaiser Resources Ltd., Sparwood, B.C.).
2:30 p.m.	Paper 7. Agronomic Properties and Reclamation Possibilities for Surface Materials on Syncrude Lease #17 by H.M. Etter and G.L. Lesko (presented by Harold Etter of Thurber Consultants Ltd., Victoria, B.C.).
3:00 p.m.	Paper 8. The Use of Peat, Fertilizers and Mine Overburden to Stabilize Steep Tailings Sand Slopes by Michael J. Rowell of Norwest Soils Research Ltd., Edmonton, Alberta.
3:30 p.m.	Coffee Recess
4:00 p.m.	Paper 9. Oil Sands Tailings; Integrated Planning to Provide Long-Term Stabilization by David W. Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta.
4:30 p.m.	Paper 10. Bioengineering. The Use of Plant Biomass to Stabilize and Reclaim Highly Disturbed Sites by H. Schiechtel and K. (Nick) Horstmann (presented by Margit Kuttler).
5:00 p.m.	End of August 18 Sessions.

Friday, August 19

Events: Presentation of Papers; C.L.R.A. Annual General Business Meeting; C.L.R.A. Annual Dinner.

Locations: Paper presentations and C.L.R.A. Annual General Business Meeting in Multi-Media Room, located on second floor of Education Building, University of Alberta.
- Annual Dinner held in Banquet Room located on second floor of Lister Hall.

8:00 a.m. Authors of Papers being presented on August 19 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching).

8:30 a.m. Showing of Film Rye on the Rocks. This film depicts reclamation situations at Copper Cliff, Ontario and is being shown for the purpose of introducing delegates to the site of the 1978 C.L.R.A. meeting (Sudbury, Ontario).

8:55 a.m. Continuation of Paper Presentations. Morning session chaired by Dr. J.V. Thirgood (Vice-President of C.L.R.A.; member of Forestry Faculty, University of British Columbia).

9:00 a.m. Paper 11. Reclamation of Coal Refuse Material on an Abandoned Mine Site at Staunton, Illinois by M.L. Wilkey and S.D. Zellmer (presented by Michael Wilkey of the Argonne National Laboratory, Argonne, Illinois).

9:30 a.m. Paper 12. A Case Study of Materials and Techniques Used in the Rehabilitation of a Pit and a Quarry in Southern Ontario by Sherry E. Yundt of the Ontario Ministry of Natural Resources, Toronto, Ontario).

10:00 a.m. Coffee Recess.

10:30 a.m. Paper 13. Amelioration and Revegetation of Smelter-Contaminated Soils in the Coeur D'Alene Mining District of Northern Idaho by D.B. Carter, H. Loewenstein and F.H. Pitkin (presented by Daniel Carter of Technicolor Graphic Services Inc., Sioux Falls, South Dakota).

11:00 a.m. Paper 14. The Influence of Uranium Mine Tailings on Tree Growth at Elliot Lake, Ontario by David R. Murray of the Elliot Lake Laboratory, Elliot Lake, Ontario.

11:30 a.m.	Paper 15. Weathering Coal Mine Waste. Assessing Potential Side Effects at Luscar, Alberta by D.W. Devenny and D.E. Ryder (presented by David Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta).
12:00 noon	Lunch Recess.
1:25 p.m.	Continuation of Paper Presentations. Afternoon session chaired by Dr. John Railton, (Manager, Environmental Planning, Calgary Power Ltd., Calgary, Alberta).
1:30 p.m.	Paper 16. The Distribution of Nutrients and Organic Matter in Native Mountain Grasslands and Reclaimed Coalmined Areas in Southeastern B.C. by Paul F. Ziemkiewicz of the Faculty of Forestry, University of B.C., Vancouver, British Columbia.
2:00 p.m.	Paper 17. Systems Inventory of Surficial Disturbance, Peace River Coal Block, B.C. by D.M. (Murray) Galbraith of the British Columbia Ministry of Mines and Petroleum Resources, Victoria, British Columbia.
2:30 p.m.	Paper 18. The Selection and Utilization of Native Grasses for Reclamation in the Rocky Mountains of Alberta by D. Walker, R.S. Sadasivaiah and J. Weijer (presented by David Walker of the Department of Genetics, University of Alberta, Edmonton, Alberta).
3:00 p.m.	Coffee Recess; Distribution of Proceedings.
3:30 p.m.	Commencement of 1977 General Business Meeting of the Canadian Land Reclamation Association. Meeting chaired by Dr. J.V. Winch, C.L.R.A. President.
7:30 p.m.	Commencement of C.L.R.A. Annual Dinner in Banquet Room, second floor of Lister Hall.

Guest Speaker:	William T. Plass, Principal Plant Ecologist, U.S.D.A. Forest Service, Northeastern Forest Experiment Station, Princeton, West Virginia.
Topic of Speech:	Challenges in Co-operative Reclamation Research.

Note: Following the Annual Dinner and Mr. Plass's speech, delegates may retire to the adjacent Gold Room. A bartender will be on service until midnight.