The Distribution of Nutrients and Organic Matter in Native Mountain Grasslands and Reclaimed Areas in Southeastern B.C.

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ABSTRACT

This is an interim report on a study examining the plant community nutrient cycles of reclaimed mined lands. The study's purpose is to assess the nutrient self-sufficiency of five-year-old reclaimed areas in montane and subalpine environments. Adjacent, undisturbed native grasslands were also studied for comparative purposes.

Paired plots were established on the four community types and shoot, root, detritus and soil levels of nitrogen, phosphorus and potassium were monitored over the course of a year. Organic matter distribution among shoot, root and detritus compartments are presented from August, 1976 to June, 1977. Shoot, root, detritus and soil levels of nutrients in August and October, 1976 are also presented.

Shoot, root and detritus levels were highest on the montane native grassland with the subalpine native area following. While the reclaimed areas were occasionally higher in shoot mass, root and detritus levels were far below those on the native areas. Root mass was higher on the montane than in the subalpine reclaimed area.

Higher nutrient levels in most compartments were found in the native areas indicating greater nutrient accumulation and storage, though exchange rates have not been calculated yet. Though the overburden materials on the reclaimed areas are poor in some nutrients the reclaimed areas contain more nitrogen and phosphorus than has been added artificially. This indicates that at least some overburden shales and coal contain significant levels of these nutrients.

INTRODUCTION

Reclamation practices in southeastern British Columbia usually include resloping, seeding with agronomic grasses and legumes and annual maintenence fertilization, usually of 200 kg (13-16-10) ha^{-1}. Many areas thus treated appear quite vigorous five years after initial treatment. We have, however, virtually no idea how near these reclamation plant communities are to nutrient self-sufficiency.

Reclamation is often defined implicitly or explicitly as a process that leads to the establishment of a self-sustaining vegetation cover on disturbed lands. The definition begs two questions: What is self-sustaining vegetation cover and how can we tell when vegetation is self-sufficient? Such a plant community must contain species able to complete their life-cycles on a given site.

It must also be able to capture and recycle nutrients and energy at a rate capable of maintaining production at acceptable levels. Observations of seedling production and survival as well as mature plant mortality should indicate whether the community is restocking itself at an adequate rate. However, the question of nutrient stability is more difficult to answer.

Nutrient dynamics in ecosystems has been the subject of considerable study by plant ecologists. Many such studies were reviewed by Rodin and Basilevich (1965). Ideally, these studies dissect the plant community into discrete compartments through which nutrient flow or tie-up can be measured. A grassland might be divided into shoot, root, detritus and soil compartments for the sake of simplicity. Given these parameters of interest, such a study should quantify both the standing crops (mass per unit area) and exchange rates (change per unit area per unit time) among compartments. Thus, nutrient cycling studies not only indicate the nutrient pool upon which the plant can draw and its location, but the rate at which exchange processes (plant uptake, decomposition and mineralization) occur. Naturally, if nutrient capital is high but exchange rates low, production will also be low.

This study was designed to answer questions concerning nutrient self-sufficiency of reclaimed areas. Consequently, the nutrient cycles of both reclaimed and undisturbed native grasslands at montane (1600 m el) and subalpine (2200 m el) environments were studied. It should indicate whether the native areas are more nutrient stable than the reclaimed areas and whether montane areas are more stable than the subalpine areas. Sampling began in August, 1976 and will be completed by October, 1977. The experiment is being conducted on Kaiser Resources Ltd. property near Sparwood, B.C. Thus, midway through the experiment, these data are preliminary and will be discussed only in terms of standing crop as exchange rates will only be calculated at the end of the experiment.

METHODS

In August, 1976 highly productive reclaimed areas at montane (1600 m el) and subalpine (2100 m el) locations were selected along with adjacent undisturbed native grasslands. Paired plots 30.5 m x 7.6 m separated by a 4.5 m buffer strip were established on each of four areas. Sampling within plots consisted of fifteen 30 cm x 15 cm rectangles in which detritus and shoot material were clipped. Thirty root samples per plot were obtained by cores which were separated in the laboratory. Three soil samples consisting of clusters of four were taken on each plot and analyzed separately. Each shoot, detritus and root sample was weighed to obtain an estimate of standing crop within each compartment. Composite samples of each compartment were analyzed for major nutrients. All soil and plant analyses were conducted by Dr. L.M. Lavkulich's lab in UBC's Soil Science Department. Thus far samples have been taken in August and October, 1976 and in May and June, 1977.

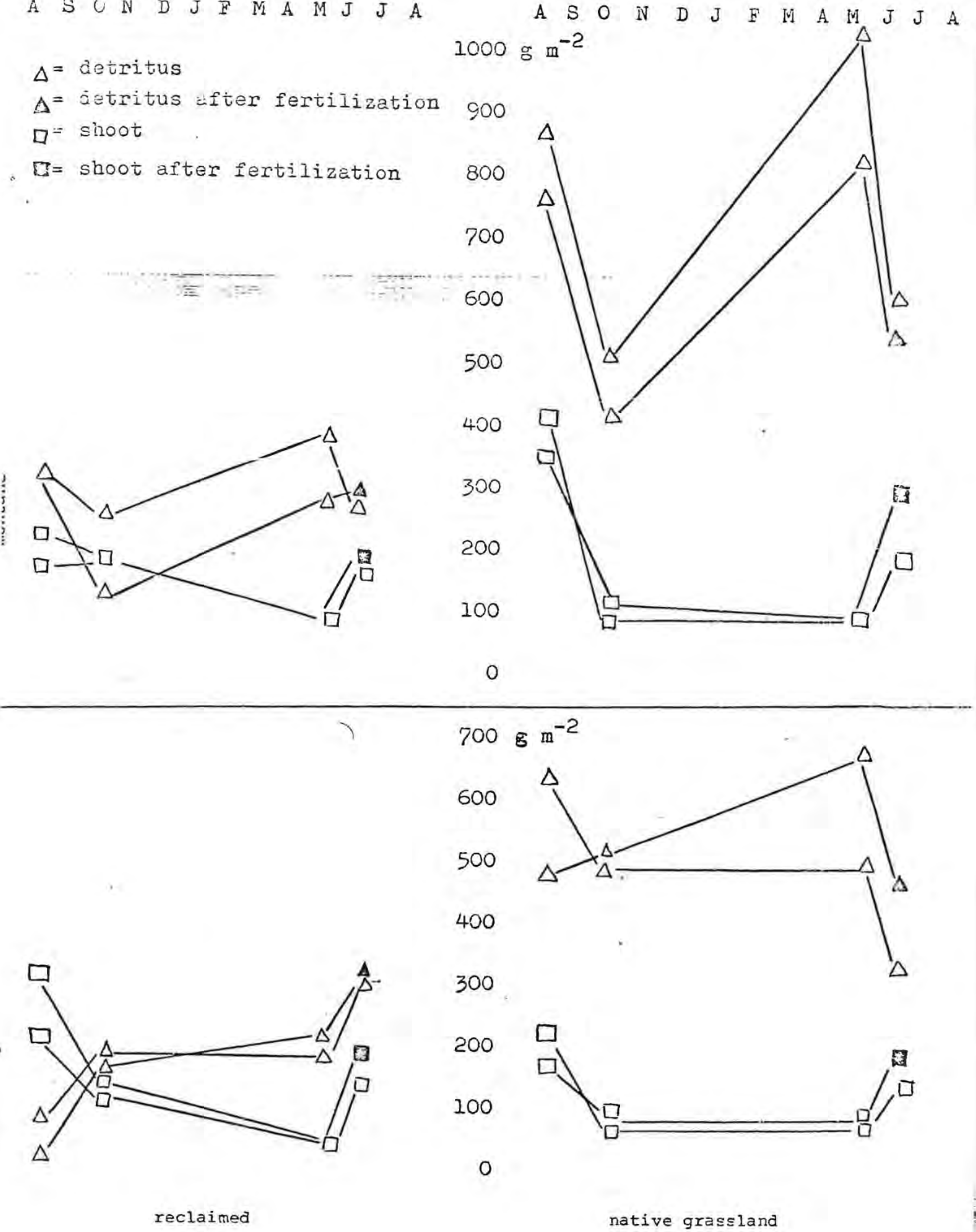
On June 3, 1977 one of the paired plots in each of the four test areas was treated with 1000 kg (13-16-10) ha^{-1} fertilizer while the other of the pair remained unfertilized. Monitoring of the plots should continue until October, 1977 on a roughly monthly schedule.

RESULTS AND DISCUSSION

Thus far, organic matter data are available from August, 1976 to June, 1977 (Figure 1). In both montane and subalpine native grasslands, shoot mass reaches a yearly minimum in October which continues until May. Rapid growth, appraching August levels, occurred by late June. In both montane and subalpine native grasslands fertilization resulted in higher shoot yields; in the montane area yield was doubled over the unfertilized paired plot. The montane native area, while only slightly more productive in October and May than the subalpine area, was nearly twice as productive in August and June than the subalpine native grassland.

Shoot levels on both montane and subalpine reclaimed areas decreased from August to October. However, rather than remaining constant until May like the native areas, the reclaimed areas both lost a further 50% of their shoot mass by late spring. This data suggests that the reclamation species were somewhat out of phase with the local climate, entering the winter period with more shoot mass than could be supported. Many of the species were still flowering

Figure 1. The distribution of oven dry organic matter (g m^{-2}) in shoot and detritus compartments, the data represent levels in paired plots. Where the lines join to form one character the values for paired plots are the same. The darkened characters represent the fertilized plot after fertilization.


A S O N D J F M A M J J A
A S O N D J F M A M J J A
Δ= detritus
Δ= detritus after fertilization
□= shoot
□= shoot after fertilization
1000 g m-2
900
800
700
600
500
400
300
200
100
0
700 g m-2
600
500
400
300
200
100
0
reclaimed
native grassland

in October and some showed frost damage. Nonetheless, both fertilized and non-fertilized reclaimed areas returned to near their previous August levels by late June although the fertilized plots were more productive in both montane and subalpine reclaimed areas.

Detritus levels on the montane native area decreased from nearly 800 gm^{-2} in August to 475 gm^{-2} in October. This drop, coinciding with drops in shoot mass over the same period suggests an interval of very rapid decomposition. Surprisingly, by May detritus levels had increased to near August levels. This may in part be explained by the great number of elk pellets found on the site in May. Since the area is very heavily used as winter range these pellets may constitute a significant import into the system. Nonetheless, with the onset of the growing season mineralization again proceeds at a higher rate than detritus accumulation resulting in a sharp drop in detritus levels from May to June. Though detrital standing crop values were lower in the subalpine native area, the pattern appeared similar to that in the montane native grassland. Also, fertilization appears to have had no consistent effect on detritus levels.

Detritus levels on the montane reclaimed area, like the native areas, declined from August to October, rose by late May and in the unfertilized plot dropped as substantial shoot growth began. The fertilized plot showed no such decrease from May to June. In contrast, detritus levels in the subalpine reclaimed area were very low in August, increased toward October, remained nearly constant over winter and rose sharply with the onset of substantial plant growth. This seeming anomaly may be the result of death of early plant growth in spring where frost and drought could damage species that weren't fully adapted to these conditions. The low detritus levels in August, 1976 were due to the very low production on the site in 1975. Thus, interpretation of these data must acknowledge the highly dynamic nature of these young systems.

As with shoot mass, root mass was highest at the beginning of the study on the montane native grassland at 1600 gm^{-2}. The subalpine native area at 1200 gm^{-2} was second with the montane and subalpine reclaimed areas at 500 and 100 gm^{-2} respectively. Except for the subalpine reclaimed areas, all root masses dropped from August to October. The montane native grassland remained at the same root level till May then rose sharply to 3200 gm^{-2} by June. The subalpine native grassland root mass increased by May to about 2200 gm^{-2} and continued to increase to 3400 gm^{-2} by June. The montane reclaimed area dropped to 100 gm^{-2} by October and by May rose to about 400 gm^{-2}. This rose to

600 gm^{-2} in June. The subalpine reclaimed area root mass rose from August to October and remained at about 200 gm^{-2} until May. By late June root mass increased to about 300 gm^{-2}.

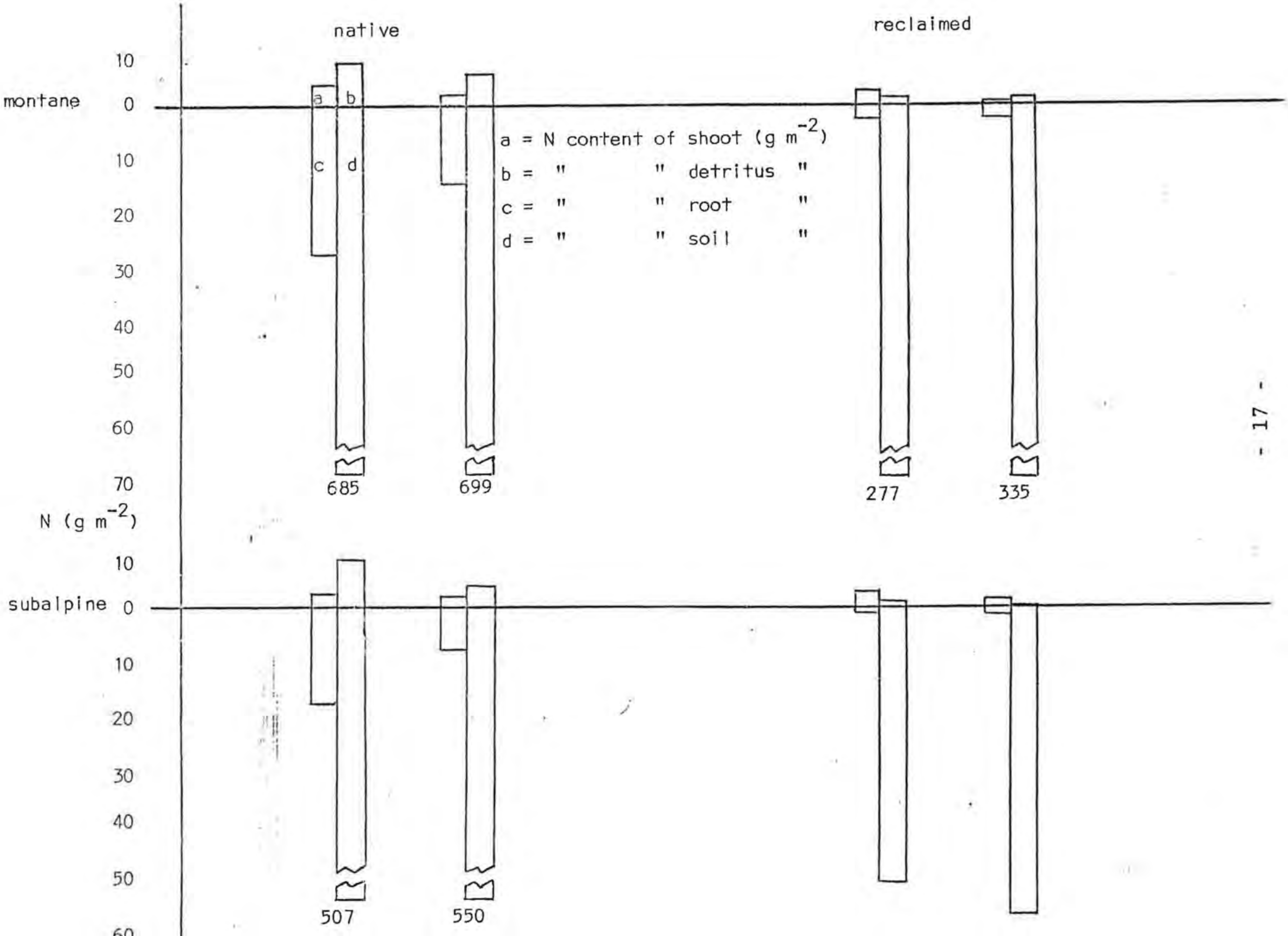
The large difference between native and reclaimed root masses is significant in that the root mass represents a large carbohydrate and nutrient reserve which is to some extent available for translocation to the shoot mass in early spring. Obviously, a greater storage facility of this sort is available to the native communities. Care must be taken in interpreting the data as the reclaimed areas, as young communities, are probably still in the process of developing a root system. The continuous rise in the root mass of the subalpine reclaimed area, resulting from absence of all die-off is probably due to the youth of the root system. The data will indicate by October, 1977 whether the reclaimed areas are showing a net increase or decrease over the course of a year.

Thus far fertilization or the absence of fertilization had no effect on the root masses of any of the studied plant communities.

Thus far chemical analysis data are available only for the August and October, 1976 samples. However, the data indicate system totals and distribution of nutrients within shoot, root, detritus and soil compartments. From this type of data exchange rates, accumulations and losses will be calculated for the compartments of each treatment. This should suggest whether, for example, nitrogen mineralization and intake proceeds at a rate sufficient to maintain an acceptable shoot cover on the reclaimed areas without annual fertilization. Shoot, root detritus and soil samples have been analysed for N, P, K, Ca and Mg. Except for nitrogen, soil data represent available nutrients. For the sake of brevity, only N, P and K data are presented in this paper. Also, only the left paired plot is shown for each site.

In both native and reclaimed areas the bulk of system nitrogen is in the soil compartments (Figure 2). However, the rapidly cycling portion of the nitrogen pool is more likely in the shoot, root, detritus and only a fraction of the soil compartment. The montane native community had the greatest pool of nitrogen with most in the soil followed by a large root pool, a smaller detritus pool and lastly a relatively small shoot pool. This pattern was consistent in both montane and subalpine native areas in August and October, although over this period the organic pools decreased while the soil pool increased. The reclaimed areas differed in having lower levels in all compartments except shoot in August.

Figure 2. The distribution of nitrogen in shoot, detritus, root and soil compartments of montane and subalpine native grasslands and reclaimed areas, soil nitrogen is represented as the Kjeldahl-derived total.


native
reclaimed
montane
subalpine
N (g m^{-2})
10
0
10
20
30
40
50
60
70
a
b
c
d
a = N content of shoot (g m^{-2})
b = " " detritus "
c = " " root "
d = " " soil "
685
699
277
335
507
550

Phosphorus levels were again highest in the montane native area (Figure 3). Also, like nitrogen, most phosphorus available to the plant community was in the soil, followed by root, detritus and finally shoot. Though total levels are lower in the subalpine native area the same distribution pattern is evident both in August and October. Phosphorus capital was lower in both reclaimed areas. Though its significance is as yet unknown, the distribution of phosphorus in the montane reclaimed area approximates that in the native communities.

System potassium levels, like those of nitrogen and phosphorus, were highest in the most productive site: the montane native grassland (Figure 4). The subalpine native area followed in potassium capital with both reclaimed areas at comparitively low levels. As with the two macronutrients previously mentioned, most of the systems's potassium was found in the soil. The low soil values for available potassium in the reclaimed areas may be due to low cation exchange capacity as well as low initial content in the overburden. The distribution of potassium is different from that of nitrogen and phosphorus in that the shoots constitute a larger pool of potassium than either root or detritus.

Figure 3. The distribution of phosphorus in shoot, detritus, root and soil compartments of montane and subalpine native grasslands and reclaimed areas, the soil phosphorus levels represent available phosphorus.

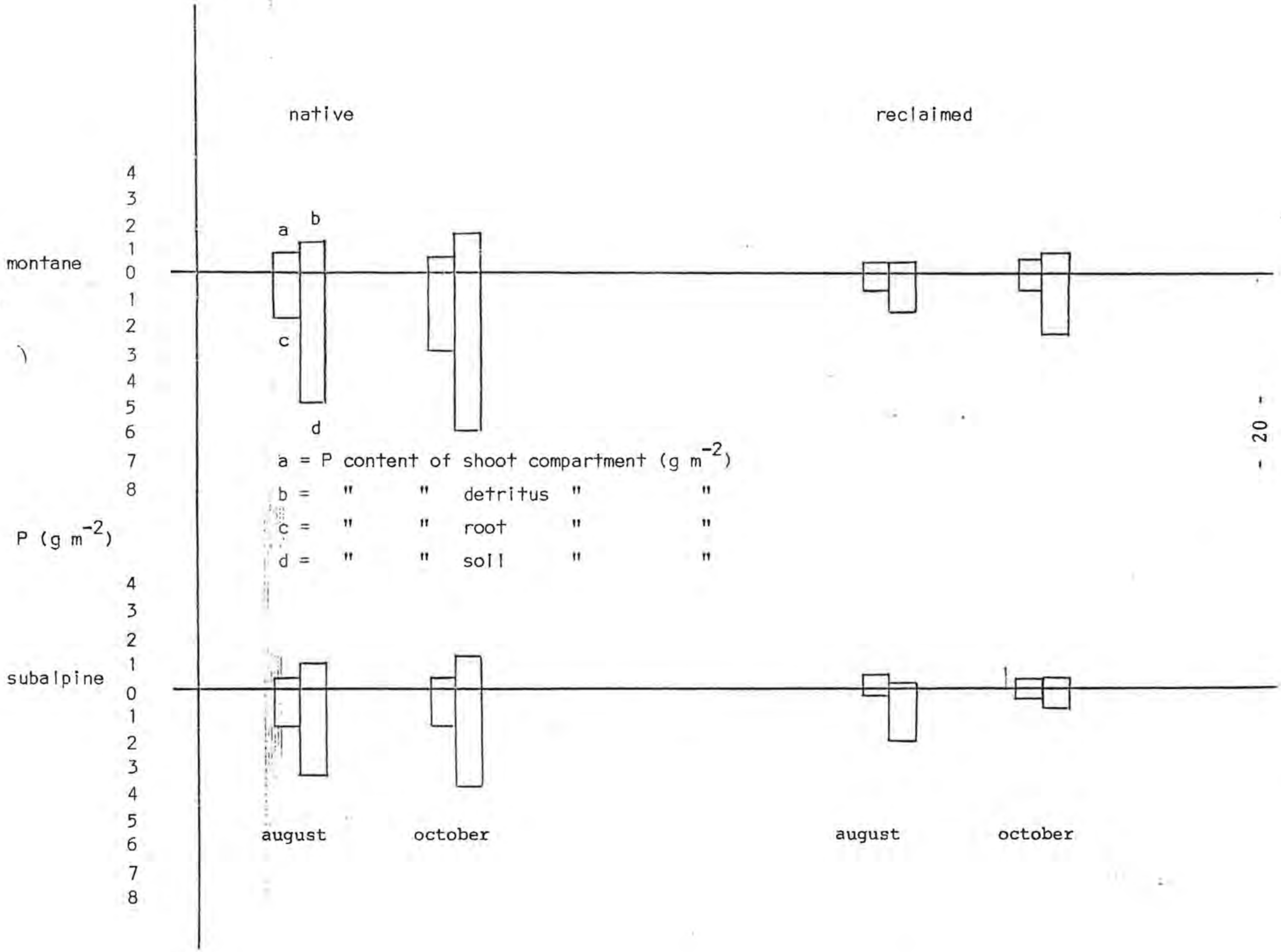
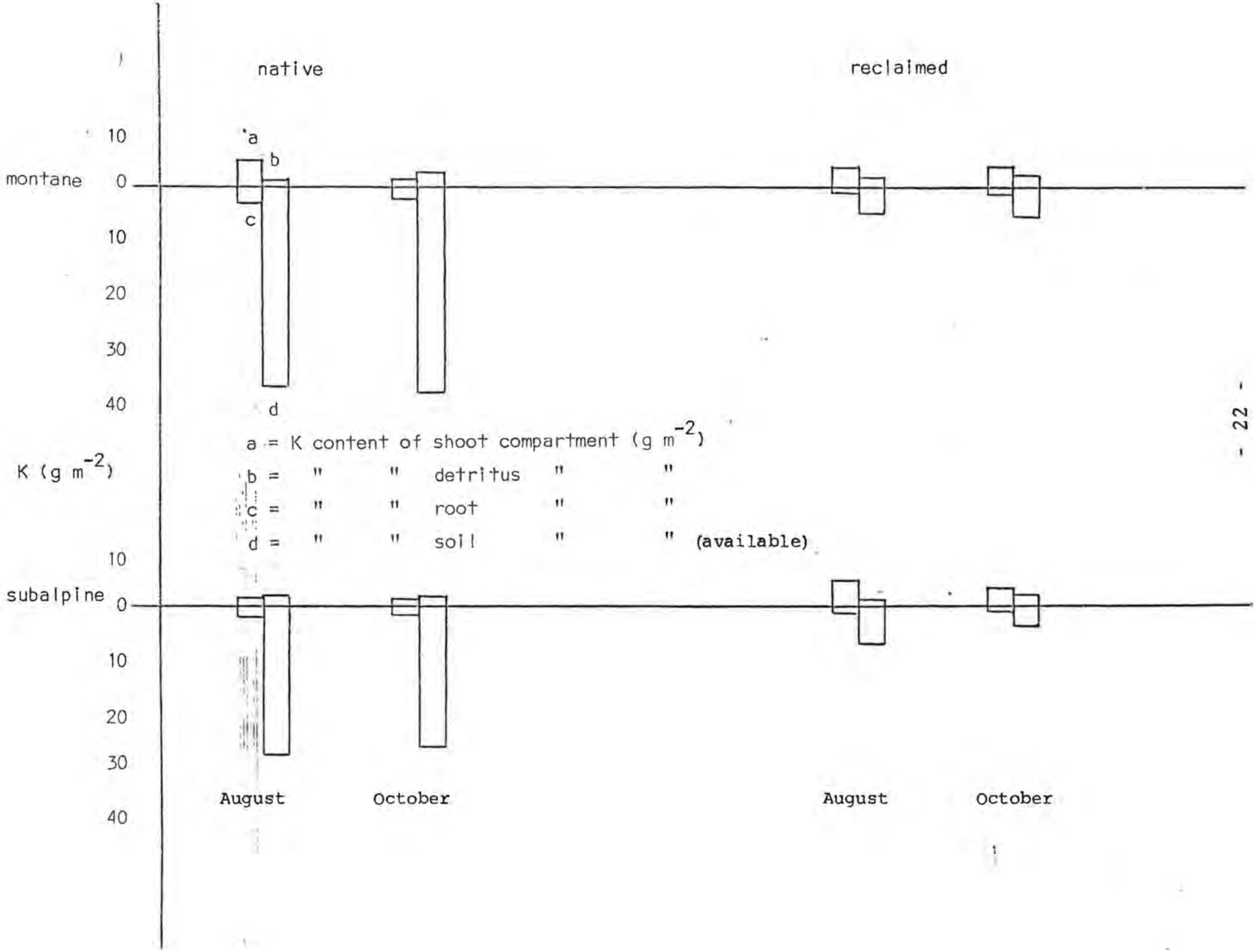

native
reclaimed
montane
subalpine
P (g m-2)
4
3
2
1
0
1
2
3
4
5
6
7
8
a
b
c
d
a = P content of shoot compartment (g m-2)
b = " " detritus " "
c = " " root " "
d = " " soil " "
august
october
august
october

Figure 4. The distribution of potassium in shoot, detritus, root and soil compartments of montane and subalpine native grasslands and reclaimed areas, soil potassium levels represent exchangeable potassium.


native
reclaimed
montane
subalpine
K (g m^{-2})
10
0
10
20
30
40
a
b
c
d
a = K content of shoot compartment (g m^{-2})
b = " " detritus " "
c = " " root " "
d = " " soil " " (available)
August
October
August
October

CONCLUSIONS

Conclusions drawn in an interim report require a great deal of circumspection. Consequently, I'll keep my conclusions in this paper to a minimum.

In terms of shoot, root and detritus, the montane native grasslands are by far the most productive. The subalpine native grasslands are next with the montane and subalpine reclaimed areas following. This order coincides with shoot, root, detritus and soil levels of N, P and K. While fertilized plots in all areas were higher in shoot production one month after treatment no such effect on root production or detritus levels was evident.

As insufficient chemical data is as yet available it is not possible to assess the different plant communities in terms of rate of nutrient release and uptake. However, the data indicate higher levels of N, P and K in most compartments in the native areas indicating greater accumulation and storage of nutrients in these areas. Again it must be noted that the reclaimed areas are young and were initiated on nutrient-poor overburden shales and coal. Though these overburden materials are poor in nutrients, both nitrogen and phosphorus levels in reclaimed areas were higher than the total fertilizer inputs over their five-year lifespan. However, potassium levels in reclaimed areas approximate artificial input levels. This indicates considerable nitrogen and phosphorus levels in at least some of the overburden materials, though their availability and release rates are not known.

REFERENCES CITED

Rodin, L.E. and N.I. Bazilevich. 1965. Production and mineral cycling in terrestrial vegetation. Trans. to English by G.E. Fogg. 1967. Oliver and Boyd, Edinburgh, U.K. 288pp.

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.