CATTAIL STAND DEVELOPMENT ON BASE METAL TAILINGS AREAS

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ABSTRACT

Cattails are frequently one of the principal indigenous plants which colonize wet areas of tailings, whether on extremely alkaline surfaces or in highly acidic conditions. However the stands are often small and their expansion is limited to small sections of the tailings beach or only pockets of cattail stands on drier areas on the sites. The objective of the present work was to address expansion of existing cattail populations currently growing in these two contrasting pH environments associated with tailings areas.

Experiments were implemented to ascertain some of the factor(s) which controls cattail plant growth on the tailings areas belonging to Inco Ltd., Sudbury, Ontario, which were partially covered with pyrrhotite and partially with alkaline mine slimes. Other experiments investigated cattail stand expansion as well as methods of introducing cattails into areas where they were not currently growing.

A useful indicator of the potential for cattail stand to expand is the ratio of the number of juvenile individuals to the number of mature individuals around the stand perimeter. In cattail stands where rhizomes were deep and the waste material compacted, the ratio was about 0.2; in a stand where the rhizomes were shallow and overlying wastes were not compacted, the ratio was 0.5.

It was hypothesized that young growing juvenile shoots could not penetrate the hard, compacted layers of overlying wastes. A series of cultivation experiments were set up in August 1985 to test this hypothesis.

Mature cattail plants were successfully transplanted to 'vacant' areas on alkaline and acidic areas of the site. The parent transplants produced numerous juvenile plants such that the ratio of juvenile shoots to mature plants was 1.5, indicating a vigorous stand expansion potential in the alkaline areas. In acidic areas the cattail rhizome-root stocks were introduced hydroponically. The root crowns were anchored in the acidic creek (pH 2.5) and they produced shoots within 4 weeks. The plants overwintered both planted hydroponically and in the transplanted area. The transplanted populations doubled in the following growing season, whereas the hydroponics survived poorly.

Experiments with young cattail seedlings which had germinated in close proximity to the cattail stands, indicated that the majority of the seedlings perished before the end of the summer. However a combination of mulching and fertilizer treatments enabled seedlings to persist into the fall.

INTRODUCTION

Cattails are one of the principal indigenous plants colonizing tailings sites. The stands are however frequently limited to small areas, particularly on base metal tailings (Kalin, 1984). Under natural conditions cattail stand development is mainly controlled by hydrological factors. The hydrological conditions along tailings beaches do not differ drastically, although cattail stands are growing in patches. The objective of the work was to address growth controlling factors of cattails in two contrasting pH environments on a tailings site in the Sudbury area.

Site Description

The tailings are situated in a basin which is generally typical of many in the Canadian Shield. These basins are characterized by forested, undulating terrain with shallow soils overlying Precambrian bedrock, with numerous bedrock outcrops. The basin experiences the typical climate for the entire northern Ontario region, with mild summers and cold winters. The climate is generally humid with approximately 950 mm of precipitation each year. Winters are characterized by extensive snow cover, which results in considerable runoff each spring. The average annual evaporation is approximately 500 mm, leaving a net water surplus of 450 mm. This surplus either runs off or infiltrates into the groundwater.

The tailings area is 45 ha and is ringed by four containment dams. The surface of the tailings slopes along a line of one percent. Farther down the tailings surface, the slope is reduced to approximately 0.2%. Such slopes are common in tailings areas. The surface characteristics are of several types. Moist alkaline areas covering a large fan extend all the way to the shores of a mine water retention pond. Hard pyrrhotite cover and loose pyritic tailings are presently being revegetated.

Indigenous cattail stands have developed on the shores of the mine water retention pond and sparse pockets of stands are distributed in the alkaline mine slimes and along the edges of the acid surface creeks on the pyrrhotite. Water enters the tailings area naturally through incident precipitation and runoff from the surroundings. Milling and therefore tailings discharge has ceased for some time on that site and presently only the mine water is discharged to the tailings area, forming a waterlogged fan covering pyrrhotite with mine slimes.

MATERIALS AND METHODS

Cattail Stand Expansion

The perimeters of the stands were excavated in two manners. In the first method a total of about 15 cm of sediment was sequentially skimmed off in layers without disturbing the underlying sediments. In the second method, a 30 cm deep trench (=1 spade depth) was dug around the perimeter of the stand. The sediments were broken up and the trenches were either completely backfilled or backfilled to within 15 cm of the surface. The sediments around the perimeter of control stands remained untouched.

Three square plots (approximately 4m x 4m) in the centre of a large stand were treated in different ways. One plot was flush-cut and raked free of cut cattails and debris. The entire plot was cultivated by hand with a spade to a depth of 30-40 cm. If rhizomes were brought to the surface they were dug into the loosened sediments. Two adjacent plots of similar dimensions served as controls: one was flush-cut and the cattails were raked off, the other received no treatment. The numbers of new shoots emerging from the 3 plots will be compared.

Transplanting Method

Mature cattails (vegetative and those bearing fruit stalks) were dug at random from cattail stands and planted in 6 groups of 10 plants. Each group was a circular to elliptical array, 3-5 m in diameter. Four of the stands were transplanted in early July and two stands in late July 1985.

Hydroponic Method

Cattails were dug from the bed of nearly 100% vegetative cattails in a cove of the mine water retention pond. The entire aerial (leafy) portion was cut off leaving the root crown, roots and any rhizomes, i.e. the underground stems which give rise to new juvenile plants. Eighteen cattail explants were placed about 0.3 m apart on a 6 m long, polyethylene net (2" mesh size) and laced into place with polyethylene line. Four such nets of explants were prepared. Two of them were installed along the shoreline of the minewater retention pond. A third array was placed across the mine slimes, recently accumulated behind a dam where mine slimes had accumulated covering pyrrhotite. The fourth array was anchored in a pool containing water of pH 2.5.

pH Determinations Around Cattail Roots

At three randomly selected cattail roots, mine-slimes-lime profiles were excavated from the root rhizome zone. 60 mL of sediments were placed in a beaker to which distilled water was added to a volume of 220 mL. The slime-water slurry was stirred with a glass rod while the pH and conductivity were determined.

Elemental Concentrations in Leaves

Cattail leaves and/or leaf tips were collected in September from the following locations on the tailings site: (1) an alkaline cattail stand (pH 9); (2) an acid cattail stand pH 2.5; (3) a nearly 100% vegetative stand and an adjacent fertile stand both alkaline; (4) was a collection made in a stand with high nickel concentrations and (5) a control site a natural stand, a quarter mile off Hwy 144 on a side road #65 leading to Rudder, Ontario.

Vegetative leaves from non-fruit producing cattails and leaves growing around the inflorescence peduncle (fruit stalk) were collected. In addition, apical tips of leaves from the acid and alkaline stand were also harvested. The top 5-15 cm of the former was black; the leaf termini were brown coloured in the latter stand.

The leaf collections were dried at room temperature and then in an oven ($150^{\circ}C$) for 30-60 min. They were ground in a Wiley mill to 20 mesh. ICP analyses for 18 metals and phosphorus were conducted after wet oxidation. Total C and total N (micro-kjeldahl) was determined from subsmaples of the dried material.

RESULTS AND DISCUSSION

Cattail Stand Expansion

With regard to cattail stand expansion, we observed that a few of the cattail stands had a large number of juvenile plants, i.e. ranging in size from those which had barely pierced the sediment surface to plants < 30 cm tall. The majority of large and small stands, however, had comparatively few juveniles.

Regardless of the proximity of the cattail stands to the shorelines of the mine water pond the stands were not expanding. Only few juvenile shoots were being produced. Thus, it seemed reasonable to develop an empirical method whereby the bed expansion potential could be evaluated, that is, a measurement of the number of new plants divided by the number of mature ones.

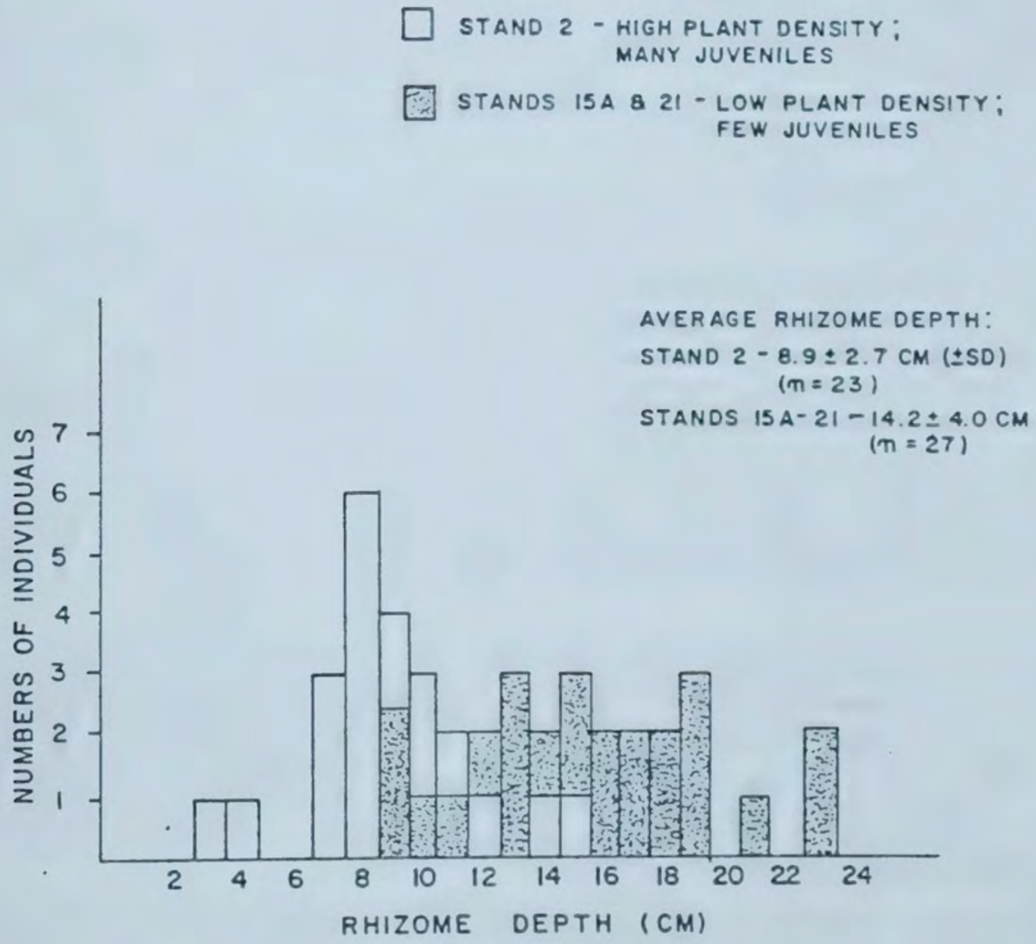
Juvenile-to-mature plant ratios were computed for 7 small cattail stands. The ratios are computed on the basis of all individuals in the stand resulting in an average of 0.2 or about 1 juvenile to 5 mature plants. The same ratio, counting just those individuals around the perimeter of the bed, is higher with 0.3 or 1 juvenile for every three adult plants.

It seemed obvious that in order for existing cattail stands to expand, the mature individuals had to be producing juvenile shoots. While juvenile shoots emerged some distance (10 to < 50 cm) from the parent plant in some stands new shoots frequently came up "cheek to jowl" along side the parent other stands.

These latter observations lead to the comparative study of rhizome depth and juvenile shoot production. The data are shown in the bar graph in Figure 1. The high juvenile-to-mature plant ratio exhibited a shallower rhizome depth and the lower ratio, a corresponding shift in rhizome position toward a greater depth. The average rhizome depth in stand 2 was 8.9 + 2.7 cm (SD) while that in 15A and 21 was 14.2 + 4.0 cm (SD).

During excavations to determine rhizome depths, we observed that layers of very compacted slimes and lime were encountered which gave a noticeable "resistance" to the spade and hand trowel. In many cases, we noted that the cattail rhizome with aborted shoot primordia lay just underneath the compacted sediment layers. By analogy, we concluded that if we encountered resistance while digging downward from the surface, surely young cattail shoots

Figure 1: Apparent Cattail Stand Expansion Potential and Rhizome Depth in Cattail Stands on Mine Slimes. (Stand 2 with many juvenile shoots has a high expansion potential and more shallow depth of rhizomes).



would be encountering similar resistance while trying to grow up toward the sediment surface through this compacted layer.

On excavating around the mature cattails in the latter stands, root-rhizome pH measurements were carried out. Table 1 gives the pH's of the mine slimes-limes around the roots and rhizomes of the cattails. They range from 8.5 to 9.9 with an average of 9.2. Of particular interest was a case in which the pH of the mine slimes in the vicinity of the parent plant was 8.5, while the pH, just 30 cm away, around the roots issuing from the rhizome of the parent was 4.6. The latter roots were actually growing into some fine pyrrhotite granules.

The results of the flushcut experiments and the expansions after over wintering were not encouraging. The marking of the perimeters did not survive the run-off and sedimentation of mine slimes sufficiently well to derive reliable numbers. The flushcut and excavation plots on the other hand yielded similar densities to those of the controls with 150 to 200 plants in all plots in September 1986.

Transplanting

A total of 6 new stands of cattails were started by transplanting plants from established beds (10 plants per new stand). In September, nearly 60 days after transplanting, only one of the initial 60 plants was dead and left behind no juvenile shoots. Table 2 gives the record of juvenile shoot production in each bed. The average ratio of juveniles to parent (irrespective of whether the parent was still alive in September) was 1.4. This ratio of almost one and a half juveniles per adult, is considerably higher than the juvenile-to-parent ratio reported from any of the established stands where ratios ranged from 0.2 to 0.5.

Although the high ratio may, in fact, be related to the physical act of disturbing the cattail plants and therefore may be considered as a result of a physiological "defense" mechanism which triggers accelerated rhizome growth and juvenile shoot production, the fact remains that the cattail tranplanting experiment was successful. It does appear that transplanting cattails produced stands with a reasonable stand expansion potential and good survival rates.

The origin of the cattail pockets on the tailings areas might be related to cattail seedling survival. In July two small plots of young cattails were fertilized with regular garden fertilizer. Adjacent plots received no fertilizer treatment. No evidence of a positive benefit of the fertilizer could be visually detected after 33 days. However, after 60 days, young stands in the treated plots showed good green colour and ranged in height from 2.5 to 15 cm. In adjacent control plots, all the plants were dead.

Hydroponic Cattails

Hydroponic cattails did take root and new shoots were

Table 1: pH and Conductivity on Mine Slimes in the Root Zone

Cattail Stand #	Root-Rhizome Depth (cm)	pH	Conductivity mhos/cm^2
4	26	9.9	500
11	18 (23)	9.3 (9.7)	500
19	27	8.5	550
		4.6*	800

* The rhizome from one parent root crown had its own root penetrating a layer of pyrrhotite. The latter roots wer aobut 30 cm from the parent plant.

Table 2: New Juvenile Shoots (<30 cm) in Transplanted Cattail Stands in September 1985 and % Increase in September 1986.

Cattail Stand #	No. of Mature	Juveniles	Ratio	No. Over-wintered	% Increase
6	10	8	0.8	8	238
7	10	15	1.5	9	200
8	10	13	1.3	8	162
10	10	11	1.1	7	200
16	9	14	1.6	6	m.1

m.1 marking lost on plants

produced by September 1985. However the survival after overwintering was very poor. Only two shoots continued to survive in the acid creek and none of the mine slime transplants. The nets were exposed due to extreme water level changes and hence no conclusion of the effectiveness of the method can be drawn.

The vast majority of young seedlings on the tailings had perished by the end of the summer. There were, however, notable exceptions. Isolated pockets of seedlings, well removed from established cattail stands, were healthy into September and were marked for observation in 1986. All seedling pockets, where the marking survived, grew in the following year. These observations indicate that potentially the origin of the cattail pockets are seedling populations which encountered conditions such that they could survive the initial critical establishment phase.

Metal Analysis of Cattail Leaves

Table 3 shows the metal content (ppm; mg/kg) for cattail leaves and cattail leaf tips. There are 5 paired leaf samples, i.e. leaves collected from plants in cattail stands from different locations, comparing the vegetative leaves (without the stalked "cattail" present) and leaves collected from the stalk bearing the brown cattail fruit.

Two collections of vegetative leaves were made from the stand of the mine water retention pond. One was from a population of exceedingly tall (about 2 m) cattails in which there were few fruit-bearing individuals. The second was from an adjacent population of short plants (<1.5m) with numerous fruit-bearing individuals.

Metal analyses on the cattail leaves were carried out to determine toxicity problems and nutrient limitations. Observation of leaves in the acidic stands suggested that the tips of cattail leaves (terminal 3-5 cm) were black. Frequently the outer border (1-2 mm) of either one or both edges of the leaves were also black. For cattails growing on the alkaline mine slimes, the tips were brown and occasionally there were brown edges to the leaves as well. Both colours, black and brown, indicated leaf cell death, but the "severity" of the toxicity problem appeared at least qualitatively greater in the acid-grown cattail leaves.

The quantitative mineral analyses (Table 3) indicate that substantial quantities of metals are absorbed by the cattails in the acidic stand. Especially significant are levels of Fe and S, when concentrations of these elements are compared with concentrations in the control leaves, i.e. acid creek is about 10 x the control value for Fe and 2.5 x the control value for S. The Fe content of the leaf tips of the acid creek cattails have 5 x the level contained in the entire leaf (on a dry weight basis).

It should be noted that on a dry weight basis, the tips concentrate many of the elements including Ni (91 ppm) and Mn (2,000 ppm). The tips of the alkaline (mine slime) cattails do as well, but to a much lesser extent, e.g. for Fe, 2 x the content of the entire leaf. Taylor and Crowder (1983a) mentioned similar able 3. CONCENTRATIONS OF SELECTED ELEMENTS IN CATTAIL LEAVES

ATTAIL CATEGORY/ EAF TYPE	ELEMENT[1] CONTENT (mg.kg^{-1} dry wt) AL	B	CA	FE	MG	MN	P	S	CU	NI	ZN
ontrol stand											
egetative	41.8	5.9	10339	80.5	3871	861	1666	1613	7.8	2.6	11.1
ruit stalk	54.4	6.4	13165	70.5	3958	1726	1618	1309	1.9	<4.8	13.0
lkaline water stand											
egetative	92.5	6.8	9407	352	972	163	1828	3612	13.9	24.8	11.5
ruit stalk	91.0	8.6	11063	338	899	171	1532	4309	14.0	32.7	10.7
igh Ni stand											
egetative	34.6	6.3	3419	73	1471	279	1993	2168	5.1	69.1	11.4
ruit stalk	45.5	8.9	6976	113	1384	717	2591	3510	3.9	74.5	9.9
cidic creek stand											
egetative	37.3	9.5	9350	632	905	941	1315	3938	16.8	40.3	8.4
ruit stalk	52.8	12.4	10669	575	986	1287	960	3065	2.9	35.9	7.6
eaf tips[2]	126.0	54.2	7681	3008	1155	2026	1230	5952	9.6	91.0	15.9
lkaline mine slimes stand											
egetative	<19.0	5.5	12506	54.2	377	729	1253	1649	3.6	10.8	8.7
ruit stalk	25.6	10.1	14036	64.7	190	762	814	1150	2.9	5.2	10.5
eaf tips[2]	40.4	55.7	11928	172	646	2958	1570	2039	9.1	<8.1	18.5
ine water stand											
egetative all plants	<13.6	3.2	8944	63	566	385	1775	2703	7.3	13.3	12.2
egetative hort plants	<16.2	14.7	10663	70.2	505	113	1432	2266	5.8	10.1	11.7

. - Elements concentrations below detection by ICP: As, Cd, Co, Pb, Se, and Te;

: - Collected from both vegetative and fruit stalk leaves leaf tip accumulation phenomena in their cattail studies.

As anticipated, the alkaline cattails growing on the mine slimes and those growing in mine water retention pond, had rather similar elemental concentration, e.g. Ni and Fe, but the former leaves had about twice the Ni content but little more than half the S content of the latter leaves. The high pH reduces the solubility of most of the metals, and they are, therefore, not "available" for absorption by the cattail roots. Generally, there were no consistent differences in trends in a comparison of the element content of vegetative versus fruit stalk leaves.

The dense stand of cattails in the mine water pond was exceedingly tall and healthy looking and the stand contained few fruit-bearing individuals. These cattails were as tall as those of the high Nickel stand, the alkaline water stand and the control stand. Boyd and Hess (1970) concluded from their study of cattail "standing crop" , i.e. the biomass of weight of plants per m^2, that of all the nutrients in the hydrosoils and water where the cattails were growing, only the P concentration was strongly correlated with biomass production. It is well known that mine tailings are very low in soluble P, particularly at alkaline pH's. It is of particular interest to note that the P content of the cattail leaves from this tall stand in the alkaline mine water pond is as high (or even higher than) as the P content from the other three locations.

In Table 4 selected elemental content of the acid creek water and the high Ni stand are compared to the elemental content of the leaves of its resident population of cattails. Because the uptake of elements by plants occurs via the roots, and the cattails are rooted in the sediments in the creek, it is not entirely justified to use elemental analysis of the creek water in the comparison with the elemental content of the cattail leaves. Such a comparison should be made using interstitial sediment water analysis (=pore water) which is present in the sediments because these are the concentrations of elements to which the plants are actually exposed. However it is assumed that the concentrations in the creek reflect closely the pore water concentration.

As opposed to the acidic creek stand all elements in the "High Ni" leaves are above the concentration of the element in associated water. Nickel concentrations in the leaves are highest, hence the name for the stand. The concentration factors for the acidic cattails (pH 2.5) are with the exception of Cu and P clearly lower than in the high Ni stand, with a more moderate pH value of 4.0. Although the concentration factors are negative for the acid creek population i.e. they indicate lower concentrations in the leaves than in the water, the absolute concentrations in the leaves are generally higher for those elements with negative concentration factors. Therefore it is suggested, that even under extreme acidic conditions, cattails are removing a fraction of the elements from the water to the biomass.

Bayley and O'Neil (1972) have reported that many elements show seasonal variations in their concentrations in cattails leaves. For example, Mg content has a midsummer peak. Such

Table 4: Comparison of the Concentrations of Selected Elements the Acidic and High Ni Location and its Leaves

	Concentration		Conc. in leaves[1]		CF[2]	
Element	Acid Creek (ppm)	High Ni	Acid Creek (ppm)	High Ni	Acid Creek	High Ni
Al	20.0	12.0	23.3	25.0	¬0	+ 2.1
Cu	0.6	0.45	4.7	2.3	+ 7.8	+ 5.8
Fe	1232.0	3.3	312.9	48.1	- 3.9	+ 14.6
Mg	114.0	32.3	490.0	740.0	- 4.3	+ 23.0
Mn	8.0	2.1	577.0	258.0	+70	+122.9
Ni	26.0	0.45	19.7	37.2	- 1.3	+ 82.7
P	0.1	< 0.05	589.6	118.8	+5896	
$SO_4^{=}$	5292	539	1814	1471	- 2.9	+ 2.7
Zn	0.6	3.3	4.1	5.5	+ 6.8	+ 1.7

1 Elemental data averaged for vegetative and fruit stalk leaves in Table 4; moisture content of 66% for cattail leaves as adapted from Kalin (1984) values for whole plants

2 CF = concentration factor or relationship between elemental concentrations in the water and leaves; (+) leaves > water; (- water > leaves

seasonal dynamics of mineral nutrients are found in all perennial plants, but those were not addressed in this study.

Carbon and Nitrogen Status of Cattail Leaves

The carbon and nitrogen content (C and N as % dry weight) for the samples of cattail leaves from a number of sites is given in Table 5. It is immediately evident that the leaves in all stands have essentially similar carbon contents, i.e. 47-48%. The C content of the vegetative and fruit stalk leaves is also essentially similar.

There is a rather wide range in nitrogen values: from 1.0 for the fruit stalk leaves of the controls to 2.5% for the vegetative "short" plants from mine water stand. Grouping the vegetative leaf N values according to the qualitative distinction of whether the plants are tall with long leaves or short with short leaves, i.e. the control, the alkaline water stand and mine water stand "tall" plants versus the remaining 3 locations, respectively, there is no separation of % N values. In both groups the values range between 1.5 and 2.0 (2.5)% N.

The carbon to nitrogen ratio of plant organic matter is only a useful index if it can be empirically determined that there is a consistent relationship between the numerical value of the ratio and some biological or ecological factor. In the present case, we have grouped the cattail sites into those showing a vigorous plant growth (tall plants; long leaves) and stunted plant growth (short plants; short leaves). The C:N ratios are shown in Table 5 and it may be noted that, as with the %N (and %C), the two groupings of plants cannot be related to a similar grouping of C:N ratios. For the tall plant category, the C:N ratios ranged from 21 to 28; for the short plants, from 16 to 32.

On the basis of the comparative N analyses, it does not appear that cattail growth on the alkaline mine slimes, in the acid creek or in the mine water stand (short plants), are limited by N. It is interesting to note that the %N in the tall and short plant populations is essentially similar, with the latter only slightly higher than the former. There is a considerable difference in the C:N ratios because the C content in the short plants is 5% lower than in the tall plants. Carbon metabolism in plants is dependent on "high energy" phosphorus. In Table 2 the P content of the mine water stand, i.e. short plants (1,432 ppm) is lower than that in tall plants (1775 ppm).

The %C cannot be correlated with plants grouped according to their stature, but the P content of vegetative leaves can be related to the tall vs. short plant groupings (see Table 2). While the foregoing considers nutrient limitations, especially P, as the element which may be limiting growth of cattail, it is also possible that cattail growth is inhibited by an interaction of heavy metals and, in the case of the acidic creek the lower pH of the water as well.

Table 5: Carbon and Organic Nitrogen Analysis of Cattail Leaves

	Carbon and Nitrogen as % Dry Weight		
	% Carbon	% Nitrogen	C:N Ratio
Control Stand			
Vegetative	42.0	1.5	28.0
Fruit Stalk	46.8	1.0	46.8
Alkaline Water Stand			
Vegetative	48.1	1.7	28.3
Fruit Stalk	48.0	1.5	32.0
High Ni Stand			
Vegetative	48.3	2.0	24.2
Fruit Stalk	49.0	2.2	22.3
Acidic Stand			
Vegetative	47.4	1.8	26.3
Fruit Stalk	47.5	1.3	36.5
Leaf Tips*	48.9	2.0	24.5
Alkaline Mine Slimes Stand			
Vegetative	48.3	1.5	32.3
Fruit Stalk	47.0	1.0	47.0
Leaf Tips*	47.2	2.5	18.9
Mine Water Stand			
Vegetative Tall Plants	45.2	2.1	21.5
Vegetative Short Plants	40.1	2.5	16.1

* collected from both vegetative and fruit stalk leaves

SUMMARY

The expansion of mature cattail stands growing alkaline mine slimes appears to be inhibited in those areas where there has been accumulation and packing of layers of mine slimes and lime (Figure 1) reflected in the differing rhizome depths. Mature cattails growing on mine slimes were successfully transplanted to areas of the mine slimes which were devoid of cattails. Frequently the leafy portion died, but new shoots arose from the subterranean rhizome.

Metal analyses of cattail leaves showed that plants growing in the acid creek accumulated a considerable level of Fe and S. The "tall" population of cattails in the mine water stand had a higher P content than all other populations investigated. None of the cattail stands seem to be deficient in N. However, phosphorus content of the cattail leaves suggests that the acid creek and alkaline cattails are P-limited in comparison with the "tall" stand of cattails in the mine water pond.

ACKNOWLEDGEMENT

This work was supported by Inco Ltd. Sudbury Operations and a grant to Inco by CANMET/RATS DDS contract # 23 SQ 23440-S-9119. Boojum Research Ltd. acknowledges in particular the assistance of J. Smith, B. Dreisinger and D. Bolton (Inco) and the dedication of M. Olaveson, R. Chan and M. P. Smith (Boojum) to the overall project.

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ISSN 0705-5927

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FOREWORD

The British Columbia Chapter of the Canadian Land Reclamation Association was formed in 1985 to provide a local public forum for the exchange of information and experience in land rehabilitation. Comprised of professionals from a wide range of backgrounds and interests, this organization pulled together quickly to host the 1986 Annual Meeting. The diverse membership in the B.C. Chapter was realized in a program that expanded the scope of the conference to include many fields that have not been represented in past programs. The quality of presentations and range of topics kept audience participation at a spirited level. It is our hope that we have initiated a trend to widen the scope of the annual meetings so as to not focus on traditional mining or energy development issues.

I wish to thank all speakers and attendees for making this first formal function of the B.C. Chapter a success. The enthusiastic support of chapter members in the planning and administration of the conference demonstrated a strong desire for a quality meeting. This drive bodes well for the future of our chapter.

A great deal of effort went into the publication of the proceedings of the 1986 Annual Meeting. Care was taken to accurately reproducce all papers, however minor errors may have escaped the review process. We hope that this will not detract from the information presented by the authors.

May the CLRA and all local chapters continue to grow and function as a focal point for land rehabilitation.