Long-term Ecological Behaviour of Abandoned Uranium Mill Tailings

2. Growth Patterns of Indigenous Vegetation on Terrestrial and Semi-aquatic Areas

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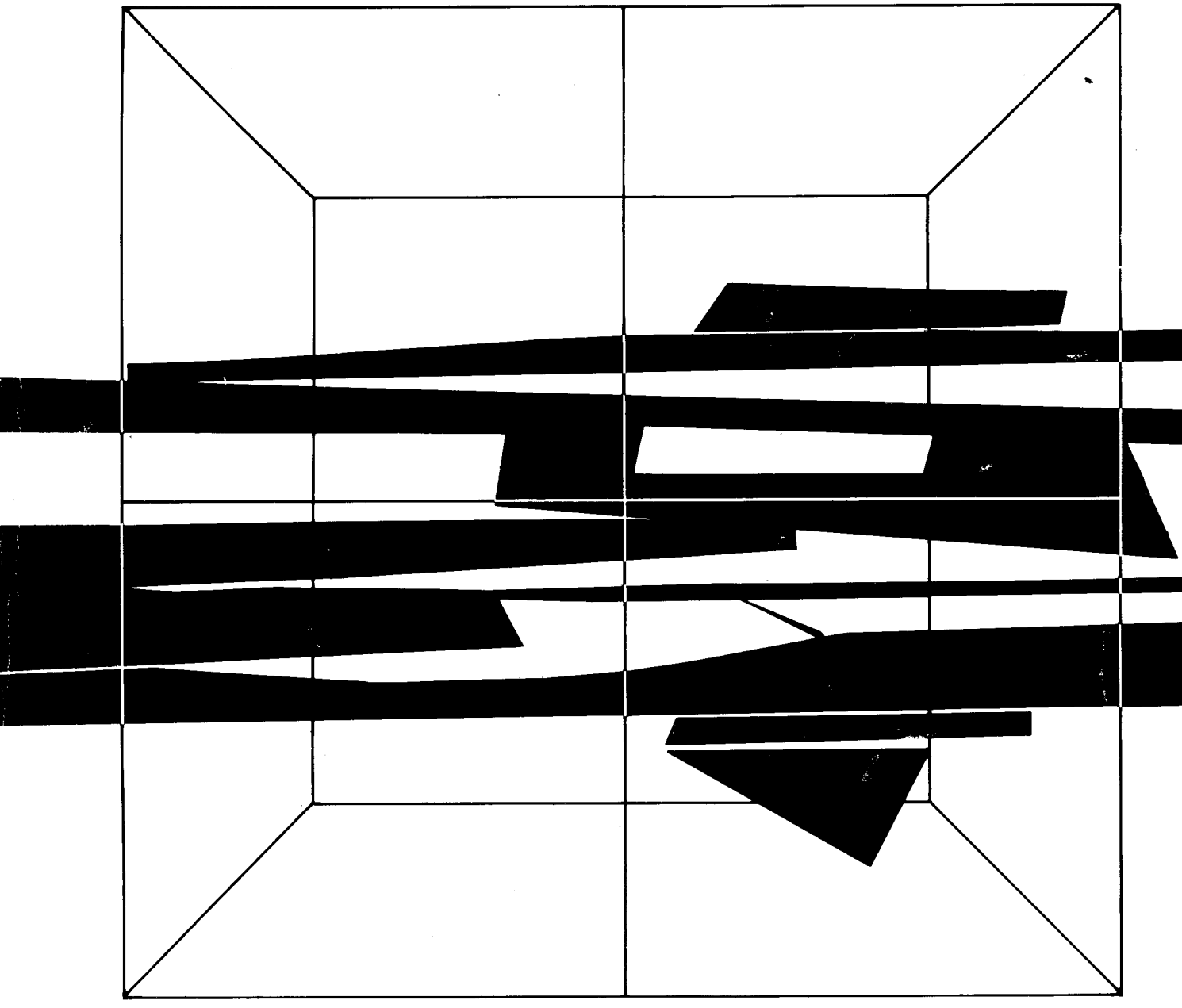

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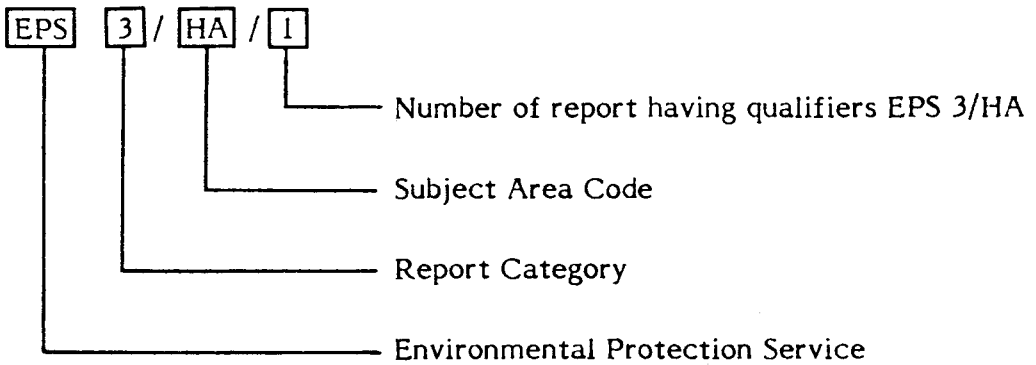

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LONG-TERM ECOLOGICAL BEHAVIOUR OF ABANDONED URANIUM MILL TAILINGS

2. GROWTH PATTERNS OF INDIGENOUS VEGETATION ON TERRESTRIAL AND SEMI-AQUATIC AREAS

by

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for
Environment Canada,
Atomic Energy Control Board
Energy, Mines & Resources Canada

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ABSTRACT

Semi-aquatic and terrestrial areas on abandoned or inactive uranium mill tailings in Ontario were studied in order to identify the growth characteristics of the naturally invading species dominating these areas. Semi-aquatic areas of tailings sites have been invaded by cattails. These species formed wetland communities which varied in size, but all were essentially monocultures of *Typha latifolia*, *T. angustifolia*, or of the hybrids *T. glauca*. Sedges, *Scripus cyperinus* (wool-grass) and *Phragmites australis* (reed-grass), were found in transition zones between the cattail stand and the dry section of the tailings site. The expansion of the cattail stands appeared to be controlled by the hydrological conditions on the site, rather than the chemical characteristics of the tailings.

RÉSUMÉ

Les parties semi-aquatiques et terrestres de terrains abandonnés ou inutilisés de dépôt de résidus provenant du traitement de minerais d'uranium en Ontario ont été étudiées afin de déterminer les caractéristiques de croissance des espèces naturellement envahissantes, dominantes. Les terrains semi-aquatiques étaient envahis par les quenouilles. Celles-ci formaient des communautés plus ou moins grandes, constituées essentiellement d'une seule espèce: *Typha latifolia*, *T. angustifolia* ou l'hybride *T. glauca*. Le scirpe souchet, *Scripus cyperinus*, et le roseau *Phragmites australis* étaient présents dans les zones de transition entre le peuplement de quenouilles et la partie sèche du terrain. L'expansion des peuplements de quenouilles semble régie par les conditions hydrologiques plutôt que par les caractéristiques chimiques des résidus.

FOREWORD

Natural vegetation is invading the inactive/abandoned uranium mill tailings in Northern Ontario. A multi-year study was initiated in 1980 with the main objective to survey and identify the biota on the tailings in Bancroft and Elliot Lake areas of Ontario (Phase I) (EPS 4-ES-83-1). It was found that cattails (*Typhaceae*) stands colonized the semi-aquatic areas whereas trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) were the dominant tree species on the terrestrial portions of the tailings. The objectives of the present investigation (Phase II) were to study the growth conditions and to assess the survival status of the ingressed vegetation under the prevailing ecological conditions. The project will eventually provide information of radionuclides transfer from tailings into the environment, and the data base will be used for future forecasting of potential environmental impacts. Again, it is hoped that the results of this study will be helpful to those involved in the management/regulatory aspects of the uranium mill tailings.

The research work was carried out under contract by Margarete Kalin of the University of Toronto. Funding for the project was jointly provided by the Atomic Energy Control Board, Environment Canada, and Energy, Mines and Resources Canada.

Waste Management Branch
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I am especially grateful for the technical expertise of Guntis Brumelis and Norm Chudzinski who collected the data in Bancroft and completed all the work in the laboratory. Furthermore, I wish to acknowledge Norm's photographic expertise.

Special thanks are due to Katherine Frerot who prepared the report. I am indebted to Martin Smith for preparing maps and graphs as well as for reading drafts of the report. Caroline Caza deserves a special mention for many of her challenging questions which contributed throughout the years to the project. I am thankful for the encouragement I received during difficult periods of the project from J. Howieson and J. Coady. I also wish to thank A. Baweja who acted as Scientific Authority, and J. Wallach who provided editorial comments. In the final analysis, however, this report would never have been completed without the support of J.L. Yen.

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SUMMARY

Parameters of cattail growth such as density in the stand, height growth, reproductive development, and vegetative growth of the plants were studied in 13 cattail stands on the tailings over a two-year period. Data obtained were compared to five stands growing in non-tailings environments. The results led to the conclusion that cattails grow equally well in either environment, despite the extremely harsh growing conditions present on the uranium tailings. The only indication of stress on the plants was the higher number of fruits on the acidic tailings sites in the Elliot Lake area. The root zone of the cattails stands on the Elliot Lake and Bancroft tailings, however, were found to be respectively less acidic and more acidic than the surface region. These observations suggest that the roots have some control over the pH of their immediate environment.

Annual above-ground biomass production reflected the reproductive state of the cattail stands. In vegetative stands there were more leaves, whereas in reproductive stands, there were more stems and fruits. The biomass quantities of the cattails stands on tailings were in the same range as those of the control stands and were related in all cases to the stand density. Decomposition coefficients, determined after one year of biomass left to decay to litter, were found to be comparable to those in the control stands and to those reported in the literature. The total amount of litter in the tailings wetlands was determined from litter collections. Calculations concerning the anticipated quantity of litter in a cattail stand were based on a model. Decomposition coefficients and annual biomass input for the stands on the tailings were used to derive long-term litter accumulation values. These values were compared to the measured quantity of litter in each stand. Approximately half of the cattail stands have reached a 'steady state' on the tailings, where annual biomass input and decomposition are in equilibrium. The study of semi-aquatic areas on uranium mill tailings lead to the conclusion that the wetland communities are stable and growth will continue as long as the existing hydrological conditions prevail.

The basic growth characteristics of trembling aspen and white birch on uranium mill tailings were determined from the present study. The terrestrial areas of uranium mill tailings, where trembling aspens *(Populus tremuloides)* and white birch *(Betula papyrifera)* have colonized sections of inactive or abandoned tailings, exhibit diverse characteristics. Sites which have been revegetated with introduced grasses and legumes, such as Nordic in Elliot Lake and completely unamended sites in the Bancroft area (Auger and Bicroft Proper), both support tree stands. Trees have also colonized

uranium tailings both where the surface was only stabilized with limestone (Stanrock in Elliot Lake) and where sites were neutralized, fertilized and seeded once without further maintenance (Crotch in Elliot Lake). Regardless of the site condition and the time since amendment or abandonment, tree stands exhibited the same average height. Under all these site conditions, both trembling aspen and white birch grew and exhibited a net height increase per annum. Net growth occurred in all size classes of trees and ranged from 1 to 100 cm per year. The tree characteristics, however, reflected extremely poor site conditions, even on the sites which were fertilized annually. From the determinations of characteristics of selected stands in Bancroft and Elliot Lake it was inferred that the trees were stunted. Trees on non-tailings sites had attained the same height as the trees on the tailings, but in less time. The tree form (the relationship between height, trunk and crown diameter and number of branches), however, did not deviate from that expected in regenerating forests.

The establishment of tree populations on the tailings reflected ecological characteristics of the species. Trembling aspen root systems sometimes suckered, while white birches gave no such indication, suggesting that this tree population originated from seeds only. The height class composition of the tree stands differed between the two species because of this. White birch appeared to exhibit more stable, consistent growth than trembling aspen on the tailings, though both species were shallow rooted.

Investigations of the root region of trees indicated large pH differences within several centimetres of depth. In locations where alkaline and acidic layers were not clearly separated, establishment of both aspen and birch was low, compared to locations which had clearly separated pH strata.

Given the slow development of trees, the different establishment methods of new trees in stands, and the chemical characteristics of the root region on the tailings, development of these trees in the long-term cannot be determined.

The long-term development of semi-aquatic environments appeared considerably more stable as cattail growth was found to be extremely tolerant of the tailings conditions. The trees in the terrestrial environments, on the other hand, appeared to be growing at their limits of ecological tolerance. Thus, before the pathways of long-lived radionuclides in the terrestrial environment from the tailings can be delineated, further work is required.

INTRODUCTION

The movement of long-lived radionuclides from uranium mill tailings to surface waters and vegetation is governed largely by the ecological, chemical and physical characteristics of the tailings environment. During the operation of a mine, the tailings environment is maintained so that dispersal of radionuclides by air and/or through water is minimized. Any mining operation, however, has a finite life time which eventually renders the tailings sites unattended. The characteristics of the tailings environment gradually changes as colonization of indigenous vegetation progresses. Whicker and Shultz (1982) suggested that environments which support lush communities of high biomass generally contain a large fraction of radionuclides. The movement and accumulation of long-lived radionuclides and their partitioning between biotic and abiotic compartments of the ecosystem is affected by species diversity and community biomass. The pathways of radionuclides within the tailings environment and, in the long-term, the environment at large, is a reflection of the basic character of the colonizing communities.

In order to undertake pathways analysis for radionuclides migrating from uranium mill tailings to the environment, plant communities which are likely to colonize inactive tailings sites must be identified. Abandoned and inactive uranium mill tailings have already been investigated , where it was found that pioneering species are colonizing all of the waste sites to various degrees (Kalin, 1983). The establishment of some plant groups was shown to be particularly successful in dry areas of tailings sites and on tailings beaches (Kalin and Caza, 1982).

The objective of the present research was to determine whether these plant groups are forming stable habitats capable of long-term survival. More specifically, from May to August, 1981 and 1982 a study was made of the growth and development of indigenous primary colonizers in the semi-aquatic and the terrestrial environments of uranium mill tailings in Ontario.

1 SEMI-AQUATIC AREAS ON INACTIVE OR ABANDONED URANIUM MILL TAILINGS

1.1 Specific Objectives

The objective of the study of wet areas on tailings was to determine the growth dynamics of cattails and the species composition of the cattail stands on tailings sites in the areas of Elliot Lake and Bancroft. Above-ground biomass produced per year, the decomposition rate, and the litter accumulation were measured to indicate growth of the cattail population. These characteristics of the cattail stands on tailings were compared to characteristics of stands growing in undisturbed environments in both areas.

1.2 Methods and Materials

1.2.1 Description of Study Sites. In the past, uranium mill tailings were frequently deposited in natural depressions such as lakes or ponds, which were contained by dams at one or more of their boundaries. This process has often resulted in the retention of shallow water covering the surface of the tailings site. Similar shallow water bodies can be formed by surface water run-off collecting at low points. Tailings beaches are quite common on abandoned or inactive sites, often forming extensive stands (Plates 1a and 1b), or developing islands (Plate 2). In Table 1, information on the tailings sites and descriptions of the location of the cattail stands are summarized. The locations where cattails have established colonies have different characteristics. Some surface water input to the tailings appears to be present at all stands and water drains often result from surrounding slopes. The type of water input for each stand studied is described in Table 1.

Control stands were studied in order to compare the growth characteristics of cattails on the uranium mill tailings to cattail stands not associated with tailings. The control sites were located at least 200 m away from roadsides in order to prevent contamination by dust, although disturbance of the control stands by beavers and/or hunters could not be prevented. The locations of all study sites are shown in Map 1 for the Elliot Lake area and in Map 2 for the Bancroft area.

1.2.2 The Plants: Cattail Biology. Cattails, also referred to as reed mace, water torch, candlewick or flag tulex, are aquatic emergent macrophytes with erect annual herbage and a perennial creeping, stoloniferous rootstock. The cattail family, Typhaceae, consists of a single genus *Typha*, with an undetermined number of species in the world (Morton, 1975). In North America, about 15 morphologically similar species have been documented, and two major species, *Typha latifolia* and *Typha angustifolia*, are sympatric