REGIONAL COPPER-NICKEL STUDY:

AQUATIC MACROPHYTES IN STREAMS

MINNESOTA ENVIRONMENTAL QUALITY BOARD
REGIONAL COPPER-NICKEL STUDY

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INTRODUCTION TO THE REGIONAL COPPER-NICKEL STUDY

The Regional Copper-Nickel Environmental Impact Study is a comprehensive examination of the potential cumulative environmental, social, and economic impacts of copper-nickel mineral development in northeastern Minnesota. This study is being conducted for the Minnesota Legislature and state Executive Branch agencies, under the direction of the Minnesota Environmental Quality Board (MEQB) and with the funding, review, and concurrence of the Legislative Commission on Minnesota Resources.

A region along the surface contact of the Duluth Complex in St. Louis and Lake counties in northeastern Minnesota contains a major domestic resource of copper-nickel sulfide mineralization. This region has been explored by several mineral resource development companies for more than twenty years, and recently two firms, AMAX and International Nickel Company, have considered commercial operations. These exploration and mine planning activities indicate the potential establishment of a new mining and processing industry in Minnesota. In addition, these activities indicate the need for a comprehensive environmental, social, and economic analysis by the state in order to consider the cumulative regional implications of this new industry and to provide adequate information for future state policy review and development. In January, 1976, the MEQB organized and initiated the Regional Copper-Nickel Study.

The major objectives of the Regional Copper-Nickel Study are: 1) to characterize the region in its pre-copper-nickel development state; 2) to identify and describe the probable technologies which may be used to exploit the mineral resource and to convert it into salable commodities; 3) to identify and assess the impacts of primary copper-nickel development and secondary regional growth; 4) to conceptualize alternative degrees of regional copper-nickel development; and 5) to assess the cumulative environmental, social, and economic impacts of such hypothetical developments. The Regional Study is a scientific information gathering and analysis effort and will not present subjective social judgements on whether, where, when, or how copper-nickel development should or should not proceed. In addition, the Study will not make or propose state policy pertaining to copper-nickel development.

The Minnesota Environmental Quality Board is a state agency responsible for the implementation of the Minnesota Environmental Policy Act and promotes cooperation between state agencies on environmental matters. The Regional Copper-Nickel Study is an ad hoc effort of the MEQB and future regulatory and site specific environmental impact studies will most likely be the responsibility of the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency.

ABSTRACT

Stream macrophytes were surveyed at primary and secondary sampling stations in 1976. Fontinalis sp. and Sparganium spp. were the most commonly collected taxa. Nuphar variegatum is another commonly occurring species in the Regional Copper-Nickel Study Area (Study Area) which was rarely collected during this survey.

Aquatic macrophytes are scattered through Study Area streams and do not appear to be of major importance to the stream ecosystems within the Study Area. When present, they provide cover to forage and young game fishes, food for waterfowl and moose, an attachment surface for fish and invertebrate eggs and habitat for invertebrates.

INTRODUCTION

Aquatic macrophytes have been found to provide a direct and indirect food source to fish, invertebrates, and wildlife and increased substrate for periphyton and invertebrate colonization (EPA 1972). These macrophytes grow in three ways: attached to objects in the stream, rooted in the substrate, and free-floating. Attached macrophytes are found in areas of high stream velocity with a variety of substrates from rubble to boulder. This group is comprised of species of mosses, liverworts, lichens, and some angiosperms. Rooted plants, which are primarily angiosperms, are confined to areas where roots can penetrate the substrate, usually in areas of lower stream velocity than where attached plants are found. No rooted plants are specifically adapted for flowing water, although individuals found in flowing water may differ morphologically from the same species found in lakes (Hynes 1970). These morphological adaptations allow a species to survive in flowing water. Free-floating plants are rarely found in northern streams except in pools or impounded areas where duckweed (Lema minor or L. trisulca) can be found.

Climate generally determines which plants are found in a region, although factors such as springs and human influence may alter the temperature regime of a stream and the species composition therein (Westlake 1973). Current velocity is the most important factor determining the distribution of macrophytes in streams (Westlake 1973). Other factors include light availability and substrate composition.

Headwater streams (first and second order) are characterized by low macrophyte productivity because of shading and the low nutrient content of the water. As one moves downstream (third and fourth order stream), macrophyte productivity increases as shading affects lessen and nutrients increase. The increased flow stability as one moves downstream tends to enhance macrophyte growth. In very large (fifth and higher order streams), deep rivers, macrophyte productivity is reduced as turbidity increases and penetration of light into the water is reduced (Cummins 1975).

The contribution of macrophytes to the energy flow within a stream ecosystem is poorly understood. From one to thirty percent (ten percent average) of stream productivity may result from macrophytes (Fisher and Carpenter 1976). Little is known about the utilization of macrophyte tissues as a direct food source. Macrophytes contribute to the detritus supply in streams, but the importance of this material as a food source may be limited since aquatic macrophytes decompose more rapidly in streams than terrestrial vegetation and are available for a shorter time (Fisher and Carpenter 1976).

Aquatic macrophytes have been suggested as indicator species of lake types (Seddon 1972) and pollution (Sculthorpe 1967). Macrophytes also have been used as biomonitors of heavy metal pollution because they concentrate heavy metals at levels significantly higher than the surrounding environment (Mayes and McIntosh 1976, Ray and White 1976). The literature concerning heavy metal accumulation by macrophytes has been reviewed (Regional Copper-Nickel Study 1976). Little data is available regarding the relationship between heavy metal accumulation and toxicity in aquatic macrophytes.

A survey of stream aquatic macrophytes was undertaken in 1976 by the Aquatic Biology Team to determine: 1) the species present in the Study Area; 2) where aquatic macrophytes are found in Study Area streams; 3) the levels of heavy metals in macrophyte tissue; and 4) the metal concentration factors for macrophytes. Because the role of macrophytes in the stream ecosystem is poorly understood, the 1976 survey was assigned a low priority within the Aquatic Biology Study. In 1977 emphasis was shifted to examine the heavy metal levels in the yellow water lily (Nuphar variegatum) to determine the feasibility of using this species as a heavy metal monitor. This report deals with the macrophyte distributional data while a separate report on metal pathways contains data on the metal levels in macrophytes and the concentration factors (Regional Copper-Nickel Study 1978).

METHODS

Study Area

The Study Area includes 2130 sq mi in Lake and St. Louis counties in northeastern Minnesota (Figure 1). This area is divided into two major watersheds by the Laurentian Divide. Water north of the Laurentian Divide flows north to Hudson Bay and water south flows to Lake Superior. The streams in this area are generally low-gradient, soft water systems. The streams consist of long stretches of slow water connected by short riffles.

The streams sampled were located in the portion of the Study Area in the vicinity of the mineral potential zone. Macrophytes were sampled at the primary and secondary aquatic biology stations (see Regional Copper-Nickel Study: Operations Manual-Aquatic Biology, 1977 for a complete description of these stations). Figure 1 indicates the location of these sites. Each of these sites was located at a riffle with adjacent slack water areas.

Sampling Techniques

Qualitative methods were employed to collect macrophytes in July and August, 1976. At each station, individual plant species were pulled from the bottom and placed in separate plastic bags. Pool and riffle sections were sampled until all species of aquatic plants at the station had been collected.

At the field laboratory each sample was split. The first half was shipped to the University of Minnesota for analysis of heavy metal levels in plant tissue. The remainder of each sample was retained at the field laboratory for identification.

RESULTS AND DISCUSSION

Species collected during the survey are listed in Table 1. *Fontinalis* sp., a moss, was the most commonly observed species in the region. *Fontinalis* sp. was found growing attached to boulders in riffles at 14 of the 17 sites. *Sparganium* sp. was the next most commonly collected species. *Sparganium* sp. inhabited slow, shallow riffles with a gravel to small cobble (up to 15 cm diameter) substrate. Other plant species were scattered among the stations. *Nuphar variegatum*, the yellow water lily, was only collected at K-8 and F-1, but was observed in nearly every slow-moving stream section in the Study Area.

The species list included in Table 1 is not complete for the Study Area because of the limited survey. Table 2 presents a list of macrophytes identified during earlier Minnesota Department of Natural Resources (MDNR) stream surveys. As in the present survey, no quantitative macrophyte samples were collected during the MDNR surveys. This survey data probably represents a more complete list of macrophyte species for the Study Area since these surveys covered a greater portion of each stream. The intensity of the MDNR surveys is probably the reason that a larger number of macrophyte species were reported in Burntside, Shagawa, and Little Isabella rivers compared to the other streams listed in Table 2. Nuphar variegatum and Sparganium spp. were the most commonly observed plants during the MDNR surveys. The frequency of Nuphar variegatum collections by the MDNR is probably the result of sampling slower water than was sampled during the 1976 survey.

Most macrophytes in the Study Area are found in pools, beaver impoundments, and long, flat areas, since these areas provide a relatively stable environment during most of the year. Macrophyte development is inhibited in the Study Area by two factors: 1) the dark brown color of the water limits light penetration; and 2) relatively low nutrient levels in most Study Area streams. With the exception of Fontinalis sp. and Sparganium spp., there is little macrophyte production in riffles. Under ideal conditions heavy growths of these plants can be found in isolated beds. In 1976 this was a rare occurrence because riffles were subjected to extreme fluctuations in flow. Macrophyte observations during two years of sampling indicated that macrophyte growth in the Study Area can become heavy under ideal conditions in certain locations, but this growth is now widespread.

Stream macrophytes are utilized in the region as: food for waterfowl and moose, cover for fish, substrate for invertebrates, and an attachment surface for invertebrate and fish eggs. There is probably little energy input from macrophytes into the most of the region's streams compared with allochtonous inputs and autochtonous periphyton production.

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Table 1. Aquatic macrophyte species collected from primary and secondary aquatic biology stations in July, 1976.

Species \ Stations	K-1	K-2	K-5	K-8	SL-1	SL-3	SR-1	SR-3	P-1	P-2	P-5	E-1	F-1	BB-1	KC-1	BI-1	D-1
Fontinalis sp.	X		X	X	X	X	X	X	X		X	X	X	X		X	X
Equisetum fluviatile	X			X		X											
Typha latifolia			X						X							X	
Sparganium sp.			X	X	X	X	X	X			X	X	X		X	X	X
Potamogeton sp.				X					X								
Potamogeton epihyelrus			X						X								
Sagittaria sp.		X				X		X	X			X				X	X
Alisma sp.																	
Elodea nuttali		X															
Gramineae spp.			X						X				X			X	
Glyceria grandis						X											
Cyperaceae			X														
Eleocharis sp.	X				X	X											
Scirpus sp.		X	X														
Scirpus cf. *americanus*					X				X				X				
Carex sp.	X			X							X			X	X		
Carex cf. *comosa*					X	X											
Acorus calamus				X													
Calla palustris		X															
Juncus sp.			X														
Ceratophyllum demersum													X				
Nyphaea									X								
Nuphar sp.				X													
Nuphar variegatum				X									X				
Callitriche palustris				X								X					
Myriophyllum sp.									X								
Sium suave			X			X										X	
Lysimachia sp.	X																

Table 2. Compilation of macrophyte species observed during MDNR stream surveys conducted in the Regional Copper-Nickel Study Area.

SPECIES \ STREAM	August Creek (MDNR, 1968a)	Bald Eagle Creek (MDNR, 1968b)	Bear Island River (MDNR, 1968c)	Beaver River (MDNR, 1968d)	Burntside River (MDNR, 1967a)	Denley Creek (MDNR, 1968e)	Homestead Creek (MDNR, 1968f)	Jackpot Creek (MDNR, 1968g)	Johnson Creek (MDNR, 1968h)	Keeley Creek (MDNR, 1968i)	Little Isabella R. (Sec.1-4) (MDNR, 1967b)	Robin Creek (MDNR, 1968j)	Sand River (MDNR, 1968k)	Shagawa River (MDNR, 1967c)	Snake Creek (MDNR, 1967c)	Snake River (MDNR, 1968m)
Acorus calamus	X				X						X					
Calla palustris														X		
Callatrichia palustris												X			X	X
Carex spp.				X	X						X					
Ceratophyllum demersum			X							X			X			
Dulichium arundinaceum					X											
Eleocharis palustris					X						X					
Equisetum fluviatile											X					
Glyceria borealis											X					
Hippuris vulgaris	X							X								
Myriophyllum exalbesceus		X									X					
Nuphar microphyllum					X						X					
N. variegatum	X	X	X	X	X	X	X		X	X	X		X	X		
Nymphea tuberosa				X	X					X	X			X		
Polygonum amphibia	X															
Potamogeton amplifolius											X					
Perihydrus					X									X		
P. gramineus											X					
P. natans											X					
P. praelongus														X		
P. Richardsonii														X		
P. zosteriformis														X		
Saggitaria latifolia					X								X	X		
Scirpus acutus											X					
S. fluviatilis											X		X			
S. validus					X											
Sparganium sp.	X				X						X					
S. fluctuans		X	X	X			X			X		X			X	X
Typha latifolia					X						X	X	X	X		
Utricularia sp.	X	X			X											
U. vulgaris														X		
Vallisneria americana																
Zizania aquatica					X											