MINNESOTA PEAT PROGRAM

LEGISLATIVE STATUS REPORT

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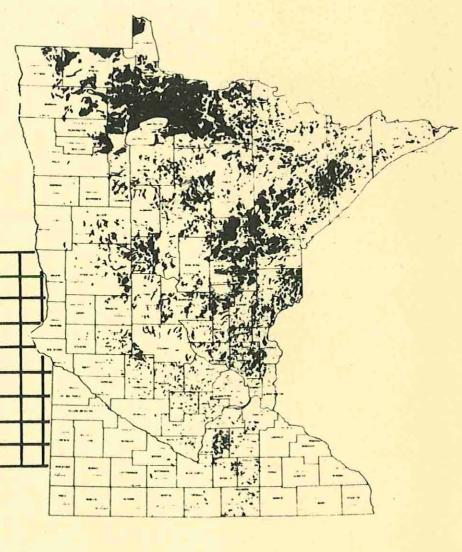

Minnesota Department of Natural Resources

PREPARED FOR THE MINNESOTA STATE LEGISLATURE

FOREWORD

The following status report is intended to provide a comprehensive summary of all research which has been and continues to be conducted under the auspices of the Minnesota Peat Program. Work for the program has been conducted in three major phases. The first and second phase were funded by the Upper Great Lakes Regional Commission; the third phase was funded by a legislative appropriation. The February, 1979 Status Report, presented in the following pages, summarizes studies funded primarily during the second and third phase of the program. It is a compilation of work carried out by staff of the Minnesota Department of Natural Resources (MDNR), private consultants and university personnel. Midwest Research Institute, the consulting firm responsible for Phase I of the program, has published a final report entitled "Peat Program: Phase I. Environmental Effects and Preliminary Technology Assessment." Staff personnel working with the MDNR have also prepared an executive summary of the Phase II work for presentation to the Upper Great Lakes Regional Commission.

In order to prepare this status report the staff borrowed liberally from final reports and progress reports prepared by participants involved in all aspects of the study. The following contractors participated in the second phase of the peat program:

- Dr. Kenneth Brooks - "Hydrological Factors of Peat Harvesting"
- Dr. Ronald Crawford - "Effects of Peat Utilization on Water Quality in Minnesota"
- Dr. Vilis Kurmis and Dr. Henry Hanson - "Vegetation Types, Species and Areas of Concern and Forest Resources Utilization of Northern Minnesota's Peatlands"
- Dr. William Marshall - "Terrestrial Wildlife of Minnesota Peatlands"

Environmental Research and Technology, Inc. - "The Potential Air Quality Impacts of Harvesting Peat In Northern Minnesota"

Dr. Wilbur Maki and Regional Development Commissions (RDC): Arrowhead RDC, Headwaters RDC, and Northwest RDC - "Economic Effects of Peatland Development"

Dr. Charles Fuchsman - "The Industrial Chemical Technology of Peat"

Dr. Rouse Farnham - "Status of Present Peatland Uses for Agricultural and Horticultural Peat Production"

Dr. William Fleischman - "Peatland Policy Study"

Bather, Ringrose, and Wolsfeld, Inc. - Peat Slide Show

Alice Rogers Pearce - Peat Slide Show Text

Participants in the third phase include:

Dr. Kenneth Brooks and Mr. Jack Clausen - "Water Resources of Peatlands"

Dr. Phillip Regal and Mr. Daryl Karns - "Relationship of Amphibians and Reptiles to Peatland Habitats in Minnesota"

Dr. John Tester and Ms. Pamela Pietz - "Utilization of Minnesota Peatland Habitats by Large Mammals and Birds"

Dr. Eville Gorham, Dr. Herbert Wright, Jr., Dr. Paul Glaser and Mr. Gerald Wheeler - "Ecological and Floristic Studies of the Peatland Vegetation of Northern Minnesota"

Dr. Dwain Warner - "Bird Populations and Habitat Use in Minnesota Peatlands"

Walter Butler Company - "Peat Utilization and the Red Lake Indian Reservation"

Dr. Rouse Farnham - "Agricultural Reclamation of Peatlands"

Dr. Edward White - "Forestry Reclamation of Peatlands in Northern Minnesota"

Dr. Charles Fuchsman - "Analysis of Minnesota Peat for Possible Industrial Chemical Use"

Other individuals and organizations that have contributed either directly or indirectly to the following report include:

Mr. Tom Malterer, Director, Minnesota Peat Inventory Project

Mr. Don Grubich, Iron Range Resources and Rehabilitation Board

Mr. Paul Rundell, Minnesota Department of Natural Resources, Bemidji

The Institute of Gas Technology

Ekono, Inc. - "Utilization of Peat for Direct Burning"

Midwest Research Institute

"Minnesota Peat Program - Phase I: Environmental Effects and Preliminary Technology Assessment"

"European Peat Technology"

The Peat Advisory Committee

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EXECUTIVE SUMMARY

The State of Minnesota is currently developing a management policy for its peatlands. Although its nearly seven million acres of peatlands are relatively undisturbed, pressure for their development is increasing. In order to properly manage the peat resources it is essential that the state gain an understanding of the environmental, social and economic implications of commercial peat development. Administered by the Minnesota Peat Program and funded through the Upper Great Lakes Regional Commission and state legislative appropriations, twenty-seven studies have been initiated to gather information about the peat resource and options for its utilization.

The studies in the following pages have been conducted during the past two years. They include work conducted under Phase II of the Minnesota Peat Program (a 16-month study funded by the Upper Great Lakes Regional Commission) and work conducted under legislative appropriations for the 1977-1979 biennium.

Research has focused primarily on the following four areas:
1) The natural environment of peatlands, including the peat resource, hydrology, plants, animals and air quality.
2) The regional socio-economics of the peatland area.
3) Utilization options for the peat resource; and
4) Reclamation studies of areas where peat has been extracted.

NATURAL ENVIRONMENT

A necessary prerequisite to formulating a peatland management policy is to conduct a complete inventory of the state's peat resource. Since the summer of 1976 the Peat Inventory Project has been compiling detailed information regarding the quantity, quality, type and depth of peat resources located throughout northern Minnesota. From inventory studies it is estimated that between 7 and 7.5 million acres of peatland are located within Minnesota. Thus, Minnesota contains the largest peat resource in the lower 48 states.

Averaging 6 to 7 feet in depth, nearly 85-90% of Minnesota's peat is the moderately decomposed reed-sedge or hemic peat. Generally, reed-sedge peat is considered the best peat for energy, chemical/industrial and agricultural uses, although it also has horticultural value. The remaining 10-15% of the peat is primarily the highly decomposed sapric peat. It appears that the least decomposed sphagnum or fibric peat contributes less than 2% of Minnesota's peat resources. Sphagnum moss is highly valued as a horticultural product.

Currently, the Peat Inventory Project is evaluating the peat resources in Aitkin, Koochiching, Lake of the Woods, northern Beltrami and southwestern St. Louis Counties. In addition, a report describing the nature, properties and locations of sphagnum peat resources in Minnesota is being compiled.

In addition to establishing the areal extent and physical properties of Minnesota's peatlands it is equally important to identify components that are important to the ecological development and maintenance of peatlands. The components that were studied include water resources, vegetation, wildlife and air quality.

During Phase II of the Minnesota Peat Program extensive literature reviews were conducted in order to provide a preliminary characterization of the peatlands natural environment. Perhaps the most important conclusion that arose from these reviews was the relative paucity of biological information available for Minnesota peatlands. For example, many of the Phase II studies had relied heavily upon data collected in other states as well as Canada. It was evident that the peatlands were a large undisturbed wilderness area that had received very little attention by researchers. Therefore, monies available from the legislative appropriation were used to fund the studies described below.

One of the major areas of concern and study is the hydrology of peatlands. The water that flows through the peat has a profound influence upon the lowland environment. Factors that govern the hydrology of peatlands were identified during Phase II. For example, an important influence governing peatland hydrology is the source of water. Lowlands that are isolated from the regional groundwater supply and receive water and nutrients primarily from precipitation are classified as ombrotrophic bogs. Water within bogs is characterized by its low pH (acidic), low mineral content and dark color. Minerotrophic fens, on the other hand, are an integral part of the regional groundwater system, receiving waters and nutrients both from precipitation and from groundwater inflow from the surrounding mineral soils. Fens generally contain water of a more neutral pH, lighter color and higher mineral content due to the groundwater influence.

Phase II studies also revealed the difficulties of assessing the hydrologic impacts of peat harvesting. Literature sources indicate that harvesting methods that require drainage may affect water quality by increasing the concentrations of nutrients, humic acids and particulate organic matter within the discharge water. Furthermore, some sources suggest that humic substances may be toxic to many of the plants and animals in receiving waters. Some studies have also indicated that peat may accumulate heavy metals such as mercury. This raises the possibility that if peatlands were harvested heavy metals may be released into the environment.

Because more information was needed on the possible hydrologic impacts of peat development, legislative monies were used to initiate research on the hydrology of northern Minnesota peatlands. The study was designed to assess the effects of peatland development on water quantity and quality. The Michigan Peat Company's horticultural operation located in Carlton County and the state's agricultural peat experiment station located at Wilderness Valley Farms in St. Louis County were selected for monitoring. Two additional peatlands that have not experienced any development were also monitored: the Toivola Bog within southwestern St. Louis County and the Tamarac River drainage within the Red Lake peatlands. Field research has included the regular monitoring of 30 water quality parameters at each site and the establishment of instrumentation that will enable researchers to analyze the water budget (i.e. inputs and outputs) at three of the four sites. Preliminary results indicate that the two disturbed peatlands yield water of darker color, higher suspended sediment, and higher nitrogen and phosphorus content that that from the undisturbed peatlands.

Floral and faunal communities are an important aspect of Minnesota peatlands. The literature reviews pointed out important areas of research, several of which were then funded with the legislative appropriation. Included in the research were detailed studies of: 1) plant communities, 2) small mammals, 3) gamebirds, 4) songbirds, and 5) reptiles and amphibians.

The vegetation study conducted during Phase II of the Peat Program provided a brief characterization of the peatlands plant communities, emphasizing the important influence of hydrology on the vegetation. Minerotrophic fens, for example, are dominated by grass-like plants, such as sedges and reeds. Ombrotrophic bogs are characterized by a dense low shrub layer with a tree overstory dominated by black spruce or tamarack. The lack of information on peatland flora, however, was evident and two additional studies were initiated.

The primary objective of the first study was to classify the plant communities and landscape features within the large patterned peatlands of northwestern Minnesota. Detailed information regarding the floral composition of all the major land forms within the Upper Red Lake peatland was collected. Because of the influence of water quality and quantity upon lowland vegetation, water samples were also collected and analyzed. Analysis resulted in the recognition of four major plant communities. These were: 1) forested areas of the ombrotrophic bogs, 2) open bog areas with only scattered dwarf trees, 3) open pools of water found within the water tracks of minerotrophic fens, and 4) the tear-drop shaped tamarack islands, also located within the water tracks of fens. Another characteristic landform within the patterned peatlands are the hummocks or raised ridges and strings. Rather than being characterized by a distinct association of plants, however, hummocks exhibit a mixture of fen and bog species.

During the botanical field research a total of 590 plants were collected as voucher specimens and preserved in the herbarium at the University of Minnesota. Within this collection are 16 species that are regarded as rare or endangered in Minnesota.

The primary objective of the second study was to develop a vegetation classification that can be used for aerial photo interpretation. The classification will be used to prepare vegetation cover-type maps for portions of the Upper Red Lake peatlands and Toivola Bog. An additional aspect of the mapping study is to provide color infrared coverage of approximately 35 miles of transects chosen to represent principal vegetation types, landform patterns, environmental gradients and disturbances.

During Phase II an extensive literature review of all faunal species known to inhabit peatlands was conducted. Again the need for additional studies was evident; much of the data reviewed was drawn from areas outside of Minnesota or was circumstantial in nature. Three major field studies were initiated: 1) a study of small mammal communities; 2) songbird populations; and 3) a study of large mammals and birds.

The study of small mammal communities was primarily designed to provide baseline information regarding the presence and abundance of small mammals in peatland habitats. The first phase of work involved a statewide survey designed to examine the geographic aspect of their distribution and abundance. A preliminary analysis of the data illustrates that regional differences in the composition of peatland small mammal communities do exist. The bog lemming, for example, was not found in Minnesota's southernmost peatlands, whereas the arctic shrew was captured in far greater numbers in southern peatlands. Such differences are primarily accounted for by differences in the physical structure of the peatland vegetation.

The second phase of the small study is a more intensive year-round study of small mammals in the peatlands of Koochiching County. Several peatland and non-peatland habitats will be monitored extensively throughout the year to determine the population structure, local distributions and habitat utilization of component species. Data collection for this aspect of research is still in progress. One conspicuous result thus far is the dramatic difference between the abundance of small mammals in different peatland habitats. Generally, wetter habitats with a lower diversity of plant species supported fewer small mammal species and individuals.

A field study of songbirds was designed to characterize the bird populations that utilize peatland habitats. Although much of the data has yet to be analyzed, several significant findings have already emerged. Among these is the demonstration that sharp-tailed grouse maintain well-defined display grounds in fen habitats throughout the spring. Earlier studies had suggested that this species utilized lowland habitats only during the winter. In addition, peatland habitats, particularly tamarack bogs, appear to be very important stopover points for migrating songbirds.

The third major field study was designed to investigate the utilization of peatland habitats by several large mammals and birds. Species chosen for study were the ruffed grouse, spruce grouse, white-tailed deer and snowshoe hare. This study was located in the smaller peatlands near Itasca State Park. Preliminary results indicate that white-tailed deer, ruffed grouse and snowshoe hare generally demonstrate a wide variety of utilization patterns. However, alder was the only habitat strongly selected by female grouse and hares demonstrated some degree of selection for wetland shrubs. Spruce grouse, on the other hand, demonstrated a distinct seasonal selection for black spruce-tamarack bogs during the spring and summer.

Legislative monies were also expended for a study of the peatland herptofauna (reptiles and amphibians) because of their importance in the food chains of wetlands and their value as sensitive indicators of various environmental parameters.

Similar to the studies described above, the field work was designed to document which species utilize the various peatland habitats. Laboratory tests are also being conducted to determine the tolerance of different stages of the amphibian life cycle (i.e. eggs, tadpoles and adults) to various water quality treatments.

Field data collected during the summer of 1978 indicate that amphibians are the dominant element of the peatland herptofauna. Of the seven amphibian and reptile species collected in the area of study the wood frog and American toad were by far the most numerous. In addition to this species information, overall habitat preferences and seasonal habitat preferences were also demonstrated. For example, the least attractive habitat to the peatland herptofauna was the white cedar/black spruce forest. The dense, cold and shady environment within this forest may be the principal reason for its low levels of herptofaunal populations.

A final aspect of the peatland environment that was studied during Phase II was air quality. The contracted study was designed primarily to make a preliminary evaluation of the potential air quality impacts that may result from development of the peat resource. An important part of this evaluation was a characterization of the current air quality within northern Minnesota. The locally intense development of taconite and paper industries within the area has resulted in the fact that the air quality near several of the major population centers ombrotrophic bogs, 2) open bog areas with only scattered dwarf trees, 3) open pools of water found within the water tracks of minerotrophic fens, and 4) the tear-drop shaped tamarack islands, also located within the water tracks of fens. Another characteristic landform within the patterned peatlands are the hummocks or raised ridges and strings. Rather than being characterized by a distinct association of plants, however, hummocks exhibit a mixture of fen and bog species.

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such as Duluth and International Falls, does not meet federal standards. Most of Minnesota's peat resources, however, are located in areas that are sparsely populated, lack industrial development, and have been officially designated as Class II. This classification refers to areas in which any air-quality deterioration that would normally accompany moderate well-controlled growth would not be considered significant.

Two major impacts to the regional air quality could result from development of peat. First, peat dust may be released by harvesting activities. This was the major concern addressed by the Phase II study. Second, stack emissions from industrial plants designed to utilize the harvested peat may degrade air quality. Because peat contains less sulfur than coal, sulfur dioxide emissions should be substantially reduced. At present, however, the potential impact of stack emissions has not been addressed.

Socio-Economics

The second major focus of the Minnesota Peat Program was the socio-economic climate of communities located near the resource. Two different studies were undertaken. One study was designed to estimate the potential regional socio-economic impacts of peat development. The second study addressed the special concerns of the Red Lake Indians, a tribe whose land holdings border many of the state's peatlands.

The socio-economic impact study proceeded by defining an eight-county study region consisting of seven northeast and north central counties (Arrowhead Region) in Minnesota and Douglas

County, Wisconsin. Next, a development scenario was constructed that would reflect a reasonable set of events that would ensue should the peat resource be developed. Five different options that were believed to be realistic large-scale means of utilizing peat were included in the scenario: 1) peatland agriculture, 2) peat mining, 3) synthetic gas production, 4) synthetic gas distribution, and 5) peat coke production. Each option was further developed by estimating the magnitude and timing of the projected development and evaluating the markets that would be available for peat-derived products. The scenario was constructed with the assumption that all five development options would commence simultaneously in 1985. Working with the additional assumption that all the synthetic natural gas is sold outside the study region, a computer simulation system (SIMLAB) was used to forecast the projected socio-economic impacts. SIMLAB predicted that by the year 2000 peatland development in the 8 county region will have created approximately 18,500 new jobs, increased the area's population by 30,500 and resulted in a gross output of $868,876,000 (1970 dollars). These figures include the direct impacts to the peat industries, the indirect impacts to other business firms that furnish goods and supplies to the peat industries and the induced effects of the household spending of peat industry payrolls.

A second scenario for peatland development was also constructed, differing from the first only in its marketing assumptions for the peat-derived synthetic natural gas. Scenario II assumed that some of the gas would be sold to customers within the study region. For several reasons, investigators found this alternative to be considerably more difficult to model. It is possible that a cutback in the natural gas supply would result in a cutback in the rate of business expansion which could offset some of the positive impacts of peatland development. Computer runs, however, were not able to demonstrate such impacts.

The second socio-economic study was of the Red Lake Indian Reservation. In addition to their large continuous land holdings surrounding the Upper and Lower Red Lakes, the tribe has numerous smaller holdings throughout north-central Minnesota. Any peatland development within the Red Lake areas would be very close to the tribe's holdings. Therefore, prior to development, it is important to address their special concerns.

The Red Lake tribe has a unique status among Indian reservations- it is a closed reservation. All social and economic concerns are managed directly by the tribe. Residents on the reservation are dependent primarily on the natural resources of their land. Commercial operations that support many residents include a fish-processing plant and a pulp mill. In addition, members of the tribe harvest much of the wild rice in the area for food and presently have plans for developing commercial operations. Residents are also dependent on the area's wildlife as a source of food. Should any aspect of peatland development have a negative impact upon the reservation's primary sources (fish, wild rice, timber, wildlife) it could result in severe consequences to the present socio-economic independence of the tribe.

Utilization Options

The third major focus of the Minnesota Peat Program was to gather information regarding the utilization options available for the state's peat resource. During the course of the investigation six major options were identified, 1) preservation; 2) timber production, 3) agriculture, 4) horticulture, 5) industrial chemicals, and 6) fuel. The first three options are considered non-consumptive; options that do not involve extraction of the peat deposits. The latter three are classified as consumptive options.

Minnesota's peatlands are among the last of the large undeveloped wilderness areas in the United States. Within these peatlands are areas that support unique flora and fauna, represent unusual peatland types or contain peat profiles that exhibit important palynological records. Because a management policy should include the preservation of unique features of peatlands, a special interest task force was formed to act as a technical advisory committee. Members will develop criteria for selecting peatlands of special interest and identify areas for preservation. To aid the group a statewide aerial photo inventory of twenty-two physical features of peatlands (e.g. raised bogs, string fens, ...) is underway. The inventory will help serve as a guide for developing criteria to identify areas of special interest. Two areas for preservation have already been identified by the National Natural Landmark Program. These are the Upper Red Lake Peatlands (137,900 acres) and the Lake Agassiz Peatlands (22,000 acres).

Peatlands are also a significant resource for Minnesota's timber industry. At least four of Minnesota's twelve pulp mills depend upon large volumes of black spruce, the most important peatland species in terms of acreage and volume harvested. In 1976, 24% of the pulpwood produced in Minnesota came from Minnesota's peatlands. Based upon 1976 stumpage prices, the black spruce and tamarack harvested in the peatlands of Koochiching County alone generated a return of over $5 million. Any significant loss of commercially productive peatlands could therefore be of critical concern. The potential value of utilizing reforestation techniques as a means of reclaiming mined peatlands, described below, is also an important consideration.

The production of agricultural crops is the third major option for the non-consumptive use of Minnesota's peatlands. Currently, approximately 8.7% of the state's peatlands are utilized for agricultural purposes. Nearly 520,000 acres of the 666,000 acres that are under cultivation are used for hay, pasture or forage crops. The cultivation of row crops ranks second in importance (89,284 acres) while the cultivation of wild rice ranks third (18,507 acres). The majority of this cultivated acreage lies in the southern two-thirds of the state where the peatlands are generally smaller and exposed to a longer growing season. Climate is one of many factors that must be taken into consideration when determining the suitability of crops to peatland agriculture. Farming peat is a specialized enterprise that requires different technology than farming mineral soils. Among the important management considerations are control of the water level and prevention of shrinkage.

Another consumptive utilization option is the production of such horticultural peat products as sphagnum peat moss, potting soil and growing mixes. Presently, less than 2% (1400 acres) of Minnesota's peatlands are harvested for horticultural uses. The largest commerical operation (840 acres) is located in Carlton County and is owned by the Michigan Peat Company. Other commercial operations are located in Aitkin, Itasca and St. Louis Counties. Because the United States currently imports nearly 60% of its horticultural products from Canada the prospects for the industry's expansion in the U. S. are very good.

Peat is also of interest as a source of industrial chemicals. In Europe, peat has long been used as a raw material for a wide variety of chemical products. Such products can be grouped into four major categories: 1) peat bitumens, 2) peat carbohydrates, 3) peat humic acids, and 4) peat coke. The major product of processed peat bitumens is wax. Peats that could be considered for commercial production should contain at least 5% wax, although wax contents of 2 to 5% may be of marginal interest. Peat carbohydrates, when suitability heated, yield a sugar-rich food on which yeast can be grown. The yeast culture can be optimized either for the production of alcohol or high quality protein supplements. For peats to be suitable for such processes their ash content should not exceed 5%. Peat humic acids also have an important use as industrial chemicals. Although their chemical nature is still not completely understood, several properties of humic acids have prompted their extensive use in agriculture. For example, they have the ability to promote nitrogen and magnesium uptake by crop plants and to improve a crop's resistance to pests. Finally, when peat is subjected to high processing temperatures a carbon residue called peat coke is generated. In recent years the principal use for peat coke has been the production of activated carbon. Because of its high absorptive capacity, activated carbon has been used to remove pollutants from industrial waste gases and water. To be successfully used for the production of activated carbon the peat must be at least 30% decomposed with not more than 6% ash.

As evidenced by the discussion above, the first requirement for assessing the feasibility of manufacturing industrial chemicals from Minnesota's peats is knowledge of their chemical composition. Therefore, monies from the legislative appropriation were used to fund a preliminary survey of the chemical characterization of Minnesota peatlands. Peat samples from five sites located across the northern lowlands are being analyzed for their ash, phosphorous and wax contents. The preliminary analysis suggests that only one of the 5 sites may be of marginal interest for commercial production.

The final consumptive option to be discussed is the utilization of peat deposits to provide fuel. In recent years the Soviet Union and several European countries have utilized their peat resources to generate electric power and to provide municipal heating. Although the combustion of peat for electric power and heating is efficient and economical, the conversion of peat to synthetic natural gas (SNG) is currently not commercially feasible. The technology for such conversion, however, is still in its infancy.

One major problem associated with utilizing peat for energy is the large volumes of peat that must be mined. Because of its lower heating value a substantially larger volume of peat must be used to provide the same amount of energy as a smaller volume of coal. In addition, because the average water content of field peat is nearly 94%, large volumes of water must be extracted prior to fuel production. Air or sun drying are sufficient for the smaller-scale technology that has developed in Europe. However, appropriate technology for water removal on a large scale currently does not exist. Until the time when such techniques are developed, the problem of water removal will remain a major obstacle for utilizing peat on a large scale for either gasification or direct combustion.

An important point to emphasize when contemplating utilizing peat as a source of fuel is that, from a practical standpoint, peat is a non-renewable resource. At best it can only have a short-term effect on our energy needs, and even that effect may be marginal. Because of the many potential uses for peat, large-scale energy extraction should not be given undue preference until priorities for the use of Minnesota peatlands have been established.

RECLAMATION STUDIES

The fourth major focus of the Minnesota Peat Program was reclamation studies of areas where peat has been extracted. Since the reclamation of all state-owned peatlands leased for development will be required, an understanding of the problems and potential of reclaiming these areas is of prime importance. Although European reclamation efforts provide some useful information, their applicability to Minnesota's peatland is limited. As a result, field studies were initiated in both forestry and agricultural reclamation at Wilderness Valley Farms. Because the long term nature of these studies only preliminary results are available.

To date, the main emphasis of the forest reclamation studies has been testing the effectiveness of eight different fertilizer treatments on the survival of five tree species (white spruce, black spruce, scots pine, Norway spruce, and hybrid poplar) planted on unmined peatland. Because of complications that were encountered in extracting the peat, mined treatment plots are not available until the 1979 field season. Of the five species selected, hybrid poplar exhibited the greatest mortality. However, overall survival was acceptable. Additional analysis will include collecting leaf samples, in order to assess nutrient uptake by the trees, in addition to annual measurements of height and diameter growth.

Other aspects of the forestry study are in the early stages. The natural succession of vegetation on peatland mined in the last 5 to 40 years is currently being studied to determine the feasibility of utilizing secondary plant succession as a means of natural reclamation. Also, preliminary plans have been developed to install a greenhouse for testing the effects of drainage and fertilization on early growth and survival of several tree species. Peat samples from the surface and from one foot above the mineral substrate will be used as the planting medium.

The first major aspect of the agricultural reclamation study was to establish ten vegetable and six field crops in unmined peat. As in the forestry study described above, complications were encountered in the attempt to prepare the mined treatment plots. The plots however, will be ready for planting by spring 1979. Nevertheless, work conducted this past summer has prompted the following preliminary conclusions regarding the feasibility of peatland agricultural reclamation: 1) field preparation, including optimum drainage, uniform surface contouring and raised planting beds, is of utmost importance; 2) an early start in planting, preferably mid to late May, is important; and 3) it is necessary to test the suitability of several varieties among each crop.

The second major aspect of the agricultural study was to test the growth response of two plants, tomatoes and mums, to different soil mediums. The soil samples included surface, subsurface and mineral substrate material from Wilderness Valley Farms in addition to other samples representing the major peat types across Minnesota. Results from greenhouse growth trials conducted at the University of Minnesota indicate that the less acidic sapric and hemic peats are the most favorable growth mediums. Studies that are continuing include a physical-chemical analysis of peat samples collected at Wilderness Valley and experiments to test the suitability of various nutrient applications to crops grown in peatland soils.

In light of the studies briefly summarized above and described in greater detail in the following pages, Minnesota has begun to develop an appropriate management and policy framework for the future utilization of its peat resource. One study conducted during Phase II was directed toward reviewing current policies and practices related to peatland management in other states. It was hoped that familiarity with other policies might help to provide useful direction when reviewing and possibly revising current policies in Minnesota. However, from the results of the study it was apparent that management policies for peatlands are not well-developed. A well-defined framework that links regulatory procedures with the goals and objectives of peatland management has yet to be developed. Minnesota, therefore, has the unique opportunity to carefully outline a management policy for peat prior to any extensive development. The peatland policy that has been developed during the course of the Minnesota Peat Program is described in detail in a separate report titled "Policy Report".

CONCLUSIONS AND RECOMMENDATIONS

Increasing pressure to develop Minnesota's peatlands has brought to attention the need to critically review both the extent and value of the state's peat deposits. The findings presented in this summary report are an initial attempt to address many of the questions and issues pertaining to peatland development. In particular, the studies funded by Phase II of the Minnesota Peat Program were designed primarily as in-depth reviews of literature currently available regarding the nature of the peatland environment, the possible options for utilizing peat and the potential impacts of development. With the help of this comprehensive review a legislative appropriation for the 1977-1979 biennium was used to initiate several field research studies. The majority of these studies focused upon gathering first-hand information regarding the natural environment of peatlands; the paucity of available biological information had been all too evident from the Phase II studies. A comprehensive understanding of the natural environment is essential for the development of a realistic management and protection policy.

Although this report does not directly address the issues pertaining to management policy, several investigators involved with various aspects of the program made the following management recommendations based upon their research:

1. Preservation of rare, endangered and other species of special interest in areas of sufficient size to adequately protect them.
2. Preservation of examples of unique and representative peatlands for the enjoyment of future generations.

3. Because of the complex hydrology of peatlands, large areas should not be harvested by drainage methods.

4. Until the water quality impacts from harvesting are understood the water discharge from harvested areas into receiving waters should be minimized.

5. The water that is extracted from peat during drying operations should be discharged into the harvest pond or peatland rather than into ditches or receiving waters.

6. The state should insist that industries that propose to utilize peat as a fuel source provide detailed plans for waste treatment facilities. Proposed treatment processes should then be reviewed by competent, outside scientific experts.

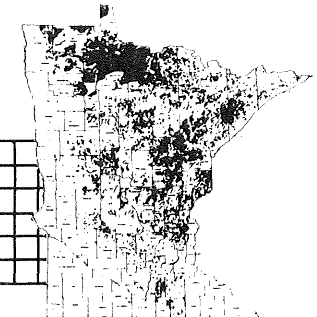
7. Because commercially productive peatlands currently make a significant contribution to the regional timber industry it was recommended that, to the extent any acreage of production spruce forest is destroyed, they should be reforested to black spruce to maintain at least the present level of growth of that important species. To further offset the loss of growth of peatland timber species it was also recommended that more intensive forestry practices be applied, including the conversion of some presently unproductive swamp shrub areas to black spruce.

8. Small-scale consumption and development (such as horticultural development or industrial chemical operations) may be more appropriate to introduce into the poor, sparsely-populated rural areas of northern Minnesota than large-scale development. Locally-owned labor-intensive operations providing employment and income for young people, with minimal threat to existing social patterns, comprise a set of characteristics which may be attractive to rural peatland communities.

Concluding Remarks

The studies summarized in this status report are helping to describe the natural environment of peatlands, regional socio-economics and the options available for utilizing the peat resource. This information has proved invaluable in establishing a framework for management policy. Nevertheless, our knowledge of peatlands is still far from complete. The complex hydrology of peatlands, for example, is still poorly understood; hydrological factors however, have a profound influence upon the peatland environment. Until we gain a more complete understanding of Minnesota's vast resource it is recommended that development proceed slowly and be limited in extent.

1 INTRODUCTION



The peatlands of Minnesota are recognized as a valuable, non-renewable resource and, as such, deserve careful study if they are to be used in a rational and well-planned manner. The opportunity to plan for the management of an important resource prior to development provides a rare, yet challenging task to resource managers. In preparation, the Department of Natural Resources has designed and initiated a comprehensive program to study the peatlands of Minnesota. The primary objective of the Minnesota Peat Program is to present to the legislature, for its consideration, policy alternatives for peatland management.

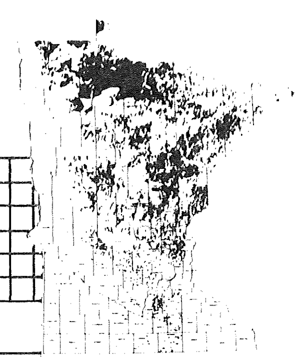
The development of a reasonable management policy requires the collection of pertinent information about the peat resource. Information regarding the natural environment of peatlands and the socioeconomic conditions of local communities is important to characterize the area of potential development and to identify its unique natural features and social concerns. Information regarding the options available for either utilizing of not utilizing the resource is equally important to properly assess both the appropriateness and feasibility of peatland development. The intent of this report is to summarize the status of research which has been designed to provide such information.

The research summarized in the following pages has been conducted primarily between the years 1977-1979. Within this period two different appropriations were used to fund pertinent studies. The first was a federal appropriation granted by the Upper Great

Lakes Regional Commission. Designated Phase II of the Minnesota Peat Program, the grant funded a 16-month study designed to review all available information on the natural environment of peatlands, the socio-economic characteristics of local communities and the potential alternatives for utilizing the peat resource. Phase II was a continuation of an effort initiated during Phase I of the Minnesota Peat Program, a study which was also funded by the Upper Great Lakes Regional Commission between 1975-1977. Both Phase I and Phase II are complimentary to studies that have been funded by a special legislative appropriation and by the Legislative Committee on Minnesota Resources. Constituting the third major phase of the Peat Program these studies are designed to gather first-hand information about Minnesota's peatlands. Research efforts have focused primarily on the informational needs identified during Phase I and Phase II.

2 PEATLAND ENVIRONMENT

PEAT INVENTORY
WATER RESOURCES
VEGETATION
WILDLIFE
AIR QUALITY



Peatlands are the product of a complex interaction among plants, topography, water, time and a cool climate. Within the wetland communities formed in the shallow beds of large glacial lakes, or atop former glacial outwash plains, plants grew, died and accumulated layer upon layer in a cool, wet environment. Several factors, the principal being cool temperatures and stagnant waters, served to inhibit the decomposition of these plants. Unlike the litter that rapidly accumulates and decomposes annually in upland communities, the litter in wetland communities decomposes only to a limited extent, accumulating in the form of compacted organic matter familiar to biologists as peat.

A priority in the study of Minnesota's peatlands is an assessment of the nature of our peat resource. Information as to the quantity, quality and depth of Minnesota's peat deposits is essential for the development of an appropriate management policy. Another priority is an evaluation of factors that are important to the ecological development and maintenance of the unique features of the natural environment of peatlands. Factors that have been chosen for study include water resources, vegetation, wildlife and air quality.

PEAT INVENTORY

Prudent use of Minnesota peatlands requires that an inventory be made of the types, depths, extent and potentials of all the peat resources in the state. As a result, the Peat Inventory Project (PIP) was initiated in 1977 for the purpose of identifying and evaluating the major peatlands in northern Minnesota. Funded through various legislative appropriations the project has three major objectives: 1) to outline the dimensions of major peat areas in northern Minnesota and to determine the quantity, quality, type, and depth of peat deposits in these areas; 2) to provide the state legislature with information that will enable it to make short-term and long-term policy decisions regarding development; and 3) to evaluate and/or designate areas that have the potential for certain types of development. The progress that has been made toward achieving these objectives is summarized below.

The PIP estimates that the State of Minnesota contains between 7 and 7.5 million acres of peatlands averaging 6 to 7 feet in depth. Their areal extent represents approximately 14% of the state's total land surface. By far the greatest concentration of peat deposits lie in the north central and northeastern one-third of the state. Compared to the large expansive tracts of peatlands found through such northern counties as Koochiching and Beltrami, peatlands in southern Minnesota are a less common sight and are considerably smaller in extent. Approximately half of all Minnesota peatlands are either owned or administered by the state.

The PIP's identification and classification of all sphagnum deposits in Minnesota that are commercially valuable for the production of horticultural products is near completion. Spahgnum or moss peat is considered to be of prime horticultural value although reed-sedge peat is also used in horticultural products. Such peat has decomposed to a limited extent; more than 2/3 of the organic portion consists of recognizable plant fibers while the remaining 1/3 is decomposed beyond recognition. Preliminary indications are that less than 2% of the state's peat resources is sphagnum.

A final report describing the nature and properties of sphagnum peats, methods of identification and a thematic map showing their location should be available by July 1, 1979.

The greatest majority (85-90%) of Minnesota's peat is the moderately decomposed reed-sedge or hemic peat. Characterized by its dark reddish-brown color, about 1/3 to 2/3 of the organic material consists of recognizable plant fibers. The peat is derived from sedges, rushes, reeds and woody plants. Current small scale use of hemic peat includes the production of wild rice, vegetables, and sod. Hemic peat is generally considered the best for energy and agricultural uses.

Highly decomposed or sapric peats represent 10-15% of the peatlands in Minnesota. Some sapric peats are derived from plants that accumulate at the bottom of shallow lakes, while others develop from more completely decayed fibric or hemic peats. Sapric peats commonly form a thin layer at the base of peat deposits, but occasionally are found up to five feet in thickness.

Evaluations of the total peat resources in Aitkin, Koochiching, Lake of the Woods, northern Beltrami and southwestern St. Louis counties are now in various stages of completion. Progress can be cummarized as follows:

1. Southwest St. Louis County

A surficial geology map for field reconnaissance was prepared and the subsequent field work and laboratory analysis has been completed. Cartographic work is currently being done by the Department of Natural Resources, Bureau of Engineering. The final report should be completed by July 1, 1979.

2. Aitkin County

A surficial geology map for field reconnaissance was prepared by the Minnesota Geological Survey and a limited amount of field work has been conducted in northeastern Aitkin county.

3. Koochiching County

A reconnaissance level surficial geology map has been prepared and work has been completed in central portions of the county.

4. Lake of the Woods County

A surficial geology map for field reconnaissance has been prepared for two-thirds of the county. In addition, field work has been completed in the northern and northeastern sectors.

5. Northern Beltrami County

The surficial geology map is still being prepared; only a limited amount of field work has been completed.

In summary, inventory work on the horticultural peat deposits of Minnesota and the total peat resource of southwest St. Louis County will be published early in 1979. However, more time is necessary for completing inventory work in Aitkin, Koochiching, Lake of the Woods and northern Beltrami counties. Although reconnaissance in nature, inventory efforts help to provide a sound basis by which future management decisions can be made. The basic resource suitabilities for development, preservation, or other uses can be weighed with respect to social, economic and environmental considerations. Also, the effect of utilizing a given area and amount of peat in relation to the total resource can be determined.

WATER RESOURCES

Water resource studies conducted during Phase II of the Minnesota Peat Program attempted to identify and evaluate factors and processes that govern the hydrology of peatlands. An understanding of these natural processes was then used to evaluate the possible impacts of peat harvesting on water quantity and quality. In addition, a preliminary attempt was made to design a model capable of estimating the hydrologic response of peatlands to habitat alterations.

Participants in the Phase II studies included Dr. R. L. Crawford, from the Freshwater Biological Institute, University of Minnesota and Dr. K. N. Brooks and Dr. S. K. Predmore, from the College of Forestry, University of Minnesota. Dr. Crawford's study was entitled "Effects of Peat Utilization on Water Quality in Minnesota"; Dr. Brooks and Dr. Predmore's study was entitled "Hydrological Factors of Peat Harvesting." A summary of their work is presented in the following two sections.

Phase II Characterization

Based on their source of water, peatlands are either classified as ombrotrophic bogs or minerotrophic fens. Ombrotrophic bogs are isolated from the regional groundwater supply and receive water and nutrients primarily from precipitation. Minerotrophic fens are an integral part of the regional groundwater system and receive water and nutrients both from precipitation and from the inflow of groundwater from the surrounding mineral soils.

Fens therefore, have a more dependable supply of water and fluctuate less than ombrotrophic bogs.

A major consideration in the study of peatland hydrology is an examination of the factors that govern the flow of water through and from peatlands. The most important factors are the physical and hydraulic properties of peat soils. Both the degree of decomposition and the density of the soil influence the rate of water movement and the amount of water that is retained within the soil. Because peat's density and degree of decomposition increase with depth, they create a gradient of increasingly slower water movement. Surface peats are less decomposed, more porous, and exhibit higher rates of water movement than peats located at greater depths. Minerotrophic fens consist of moderately to highly decomposed peat, compared to the more porous sphagnum peat found in the ombrotrophic bogs.

Runoff from peatlands is governed, in part, by these physical properties of peat. Another major factor however, is the level of the water table. Greater discharges occur at high water levels for several reasons. First, peatlands with high water tables are characterized by an increase in soil moisture and a decrease in their capacity to store water. Secondly, increased water levels may create greater hydraulic gradients which lead to increased flow. Finally, high water tables lie in the lease decomposed surface peats which exhibit greater hydraulic conductivities and more rapid water movement.

Contrary to popular belief, peatlands do not act as large reservoirs which store water during wet periods and release water during dry periods. However, short-term regulation of snowmelt and storm-flows takes place as runoff is delayed by the peatland's relatively flat topography and short-term retention storage.

The characteristics of peatland water are determined by the chemistry of the precipitation and groundwater that enters the system and by the chemistry of the peat material. Ombrotrophic bogs yield water of low pH (acidic), low mineral content, and dark color. The low mineral content occurs because the major source of water is from atmospheric precipitation. The low pH and dark color result from the water's contact with the organic soil. Due to the groundwater inflow minerotrophic fens yield water with a more neutral pH, lighter color and higher mineral content. Most peatland waters may be considered oligotrophic (nutrient-poor) with respect to their content of minerals, such as calcium, magnesium, potassium and sodium. However, water from ombrotrophic bogs may be eutrophic (nutrient-rich) with respect to its content of nitrogen and phosphorous.

Phase II Impact Analysis

The hydrological impacts associated with peat harvesting are difficult to predict because peatland hydrology is complex and, at present, inadequately researched. The design of computer programs that are capable of accurately modeling peatland hydrology would aid the biologist in assessing the potential impacts. Personnel at the University of Minnesota have taken the initial step by quantifying several of the processes that govern the hydrology of peatland watersheds.

Although such models have not been tested and perfected, it is possible to make a preliminary assessment of impacts. If development should occur, the combined effects of removing surface vegetation, draining the water and harvesting the peat could result in increasing the annual water yield and the maximum water discharges largely as a result of: 1) reduced evapotranspiration; 2) reduced interception of precipitation; 3) reduced water storage; 4) reduced water infiltration; 5) accelerated snowmelt; and 6) the accelerating effect of drainage ditches.

Drained harvesting methods may affect water quality by increasing the concentrations of nutrients, humic acids, and particulate organic matter within the discharge waters. The impact to surrounding natural (i.e. non-peatland) waters upon receipt of these discharges from peatlands could be varied and difficult to predict. Literature and preliminary studies indicate the possibility that humic substances within bog waters may be toxic to many plants and animals in the receiving waters. Studies have also indicated that algal growth in natural waters may be stimulated upon receipt of bog water presumably because of an influx of nitrogen and phosphorus.

The impacts of harvesting the peat without draining the water (e.g. hydraulic dredging), would depend upon the presence or absence of an outlet from the pond that is created by peat extraction. With no outlet, the impacts may be diminished.

Finally, a potential impact from both drained and undrained methods of peat harvesting could result from the apparent tendency of peat to adsorb such heavy metals as copper, nickel and mercury. Peatlands may be accumulating atmospherically-deposited (ash and/or precipitation) heavy metals such as mercury. As a result, the peatlands may serve a useful function by removing heavy metals and preventing their potential concentration within food webs. Such heavy metals could be released into the ecosystem if peatlands were disturbed.

Current Studies

Although impacts to water resources are a major environmental concern associated with large-scale peatland development, they are generally disputed and are basically unknown. Included among the issues that need to be addressed are: 1) Do the various methods of harvesting peatlands differentially affect water quality? 2) Do hydrologic impacts vary according to the characteristics of the peat and/or the location of harvesting within the peatland watershed? 3) What would be the effects of alternative reclamation schemes on water quality? In light of these issues, and the major role that hydrology plays in the naturel environment of peatlands, legislative appropriations were used to initiate hydrologic research in the peatlands of northern Minnesota.

Titled "Water Resources of Peatlands," the study is being conducted by Dr. K. Brooks of the University of Minnesota and Mr. J. Clausen of the Department of Natural Resources. The primary objective of their work is to evaluate the effects of peatland development on water quantity and quality. Field data collected during the course of the study will also be used to expand and refine the hydrologic model that was begun during the Phase II studies.

In order to properly evaluate the impacts of development it is important to monitor commercial peat development operations. Therefore, among the four areas chosen for study are two experimental areas where the peat deposits have been variously disturbed. Two undisturbed peatlands were also selected for study in order to establish a basis of comparison.

The Corona Bog, located near the town of Cromwell in Carlton County, was chosen as one of two experimental sites. Approximately 900 acres in size, the bog has been leased from the state since 1958. The peat deposit is currently harvested by the milled peat method, a method which operates by milling the upper surface of the peat to facilitate drying. Once the layer has been air-dried to approximately 55% moisture (peat originally contains about 90% water), it is gathered by vacuum harvesters, baled and then sold for horticultural purposes. The impact of these harvesting operations upon the quality and quantity of water at Corona is presently being monitored at two locations. During the 1979 field season a control plot immediately adjacent to the current operations will also be monitored. Because future development plans include the expansion of harvesting operations, the control plot could provide a valuable pre-development characterization of water resources.

The second experimental study area is located at Wilderness Valley Farms in southwest St. Louis County. Owned by the State of Minnesota, the Farms are currently operated by the Iron Range Resources and Rehabilitation Board. The farm includes approximately 900 acres of reed-sedge peat (fen peatland) upon which various agricultural crops have been raised during the past twenty years. At present, several new plots are being established for testing a variety of alternatives currently available for reclaiming mined peatlands. The resource study will interface with the reclamation study by monitoring various hydrological parameters on each plot. The reclamation study will be described in more detail in a later chapter. To date however, two forestry plots (treatment 1 - unmined, unfertilized; treatment 2 - unmined, fertilized) and one agricultural plot (unmined) have been established and their hydrology is being monitored. Approximately nine more plots will be established next summer, including two more forestry plots (mined), one more agricultural plot (mined), three sewage treatment plots and two retention ponds.

The Toivola Bog, also located in southwestern St. Louis County, was chosen for study for two reasons: 1) it is a small yet complete watershed (16 sq. miles) drained by Joula Creek; and 2) it provided an opportunity to characterize the hydrology of an undisturbed peatland.

The second undisturbed study site was a minerotrophic fen within the Red Lake Peatland in north central Minnesota. The specific area selected was the watershed of the Tamarac River, an area considered to be representative of peatland watersheds in the Red Lake region. This watershed also drains a portion of the 200,000 acres that the Minnesota Gas Company has requested to lease for the construction of a peat gasification plant. Monitored approximately 9 miles upstream from Upper Red Lake, data from the river will provide information regarding differences in hydrology and water quality between north central and northeastern Minnesota.

The field studies conducted at each study site include the monitoring of 30 different water quality parameters (Table 1). At Wilderness Valley Farms these parameters will eventually be monitored for each different reclamation treatment. Because the parameters vary on both a seasonal and storm-related basis, they are monitored regularly throughout the study period. Three of the four study areas are also instrumented for water budget analysis by measuring such parameters as precipitation, runoff, evapotranspiration and groundwater levels. A water budget analysis essentially provides information regarding water inputs, outputs, and rates of water movement within a watershed. The only study site where a complete water budget is not being developed is in the Red Lake area. Approximately 100 sq. mi. in size, the watershed is too large and complex to attempt a thorough analysis in this preliminary investigation. Finally, peat profiles and bulk densities will also be determined at each site in cooperation with the Peat Inventory Project.

TABLE 1. WATER QUALITY PARAMETERS THAT ARE BEING MONITORED AT FOUR PEATLAND STUDY SITES.

Temperature	Magnesium	Chromium
pH	Iron	Cadmium
Specific conductivity	Sodium	Cobalt
Dissolved oxygen	Manganese	Nitrate+Nitrite-N
Color	Zinc	Selenium
Acidity	Copper	Mercury
Alkalinity	Boron	Total nitrogen
Suspended sediment	Ammonia-N	Total phosphorus
Arsenic	Lead	Volatile solids
Calcium	Nickel	Aluminum

Table 2 summarizes some of the more important water quality values obtained to date. Water from the two fen areas, Red Lake and Wilderness Valley, has a higher pH and a higher conductivity than that from the two bogs, Corona and Toivola. These preliminary results also show that the two disturbed peatlands yield water of darker color, higher suspended sediment, and higher nitrogen and phosphorous than that from the undisturbed peatlands. Of additional interest are the preliminary results from heavy metal analysis shown in Table 3. Near detection limits, these values are considered very low.

TABLE 2. MEAN WATER QUALITY VALUES FOR SELECT PEATLANDS IN NORTHERN MINNESOTA.

Parameter	Corona	Toivola	Red Lake	Wilderness Valley
pH	5.1	5.9	7.0	6.5
Spec. cond. (umhos/cm)	67	47	113	207
Color (units)	390	250	190	540
Sus. Sediment (mg/l)	11.5	2.5	1.2	24.3
Total P (mg/l)	.12	.06	.05	.78
Total N (mg/l)	3.3	1.5	1.5	6.0

TABLE 3. RANGE IN VALUES FOR SELECTED METALS IN WATER LEAVING PEATLAND STUDY AREAS.

Parameter	Range in Value (ppb)
Mercury	1.3 - 2.2
Selenium	0 - 2.1
Arsenic	0 - 5.3

A preliminary analysis has also been made of the rainfall-runoff relationships for the disturbed and undisturbed bogs, Corona and Toivola. A one-inch rainfall on July 12, 1978 resulted in twice as much runoff from the undisturbed area (Toivola) as compared to the drained area (Corona). At Toivola the storm runoff started almost immediately after the precipitation began while at Corona the runoff began nearly 3.5 hours later. This single example supports the general conclusion found in the literature that the drainage of peatlands reduces peak flows resulting from spring snowmelt or summer rainstorms. Drainage however, may increase minimum flows over the rest of the year in addition to increasing the total annual flow.

A significant amount of analysis is still needed before any of the above conclusions become certain. However, as the data continues to be analyzed it will gradually become incorporated into the hydrologic model that eventually will become an important tool capable of predicting the hydrologic impacts of peatland development.

VEGETATION

The Phase II vegetation study conducted a review of previous investigations that had characterized the flora of peatland vegetation. Unique vegetational features and plant species of special concern were also identified. Investigators responsible for this aspect of the Phase II study were V. Kurmis, H. Hansen, J. Olson and A. Aho of the College of Forestry, University of Minnesota. Their study was entitled "Vegetation Types, Species, and Areas of Concern and Forest Resources Utilization of Northern Minnesota's Peatlands." Findings from the first half of their report ("Vegetation Types, Species and Areas of Concern") are summarized in the following two sections.

Phase II Characterization

The diversity of peatland vegetation directly reflects the diversity of complex interactions among the flow, level and chemistry of the peatland waters. Abrupt changes among these parameters are evidenced by markedly different vegetation types. Gradual change among the parameters is evidenced by a gradual change in vegetation types.

Although the influence of water resources upon peatland vegetation is varied, three major vegetation types are widely recognized. These include the ombrotrophic bogs and minerotrophic fens discussed earlier, along with a third major type designated as swamps. With respect to vegetation, bogs are characterized primarily by a dense low-shrub layer of ericaceous species such as leatherleaf, cranberries and bog rosemary. The tree layer, if present, consists mainly of black spruce or tamarack. Fens, on the other hand, are dominated by grass-like plants, such as sedges and reeds. A low to medium height shrub layer may also be present.

Swamps are defined as wooded wetlands where standing or gently flowing surface waters persist for long periods. The water in swamp peatlands is characteristically neutral to mildly acidic with relatively high concentrations of oxygen and mineral nutrients. Swamps are typically the most minerotrophic peatland type. While most swamps are dominated by trees, some are dominated by shrub thickets.

Further refinement of these categories has led to the following system for the classification of peatland vegetation:

1. Treeless bog
2. Wooded bog
3. Treeless fen
4. Wooded fen
5. String fen and bog
6. Swamp shrubs
7. Swamp hardwoods
8. Swamp conifers
    a. White cedar forest
    b. Tamarack forest
    c. Black spruce - older forest
    d. Black spruce - feather moss forest
    e. Black spruce - sphagnum forest

Plant lists have been used to characterize each of these vegetation categories.

The presence and abundance of unique, rare, or uncommon plant species within these vegetation communities is important. Ten peatland plant species of "special concern" were selected by the investigators. Their list includes species ranging in status from being officially recognized as endangered or threatened, to species whose occurrence in Minnesota is located near or at the limit of their natural range. The species are listed as:

Western Jacob's Ladder	Lingonberry
Ram's Head Lady's Slipper	Small Round-Leaved Orchid
Bog-Adder's Mouth	Calypso Orchid (Fairy Slipper)
Showy Lady's Slipper	Twig Rush (Water Bog Rush)
Swamp Pink Dragon's Mouth	Slender-Leaved Sundew

Typical peatland habitats were defined for these species and reported locations were mapped.

Phase II Impact Analysis

The primary impact of any resource development is the temporary or permanent loss and manipulation of habitat. In order to protect the unique species and vegetational features of the peatland environment, it is necessary to protect the areas in which these elements occur. Thirty-five areas of special concern have already been identified. Although their listing is not contained in this report, the areas include both existing and proposed Scientific and Natural Areas and National Natural Landmarks. Several proposed Critical Areas have also been identified.

Current Studies

A major recommendation of the Phase II vegetation study was to conduct a comprehensive investigation of Minnesota's peatland flora. In particular, the Phase II study revealed the need for collecting information on plant species that comprise the ground layer of vegetation, such as sedge and moss species. Because a thorough understanding of Minnesota's peatland vegetation is important for the future development of management policies, the initiation of such research was considered a priority by the peat program staff. Therefore a portion of the appropriations made available by the legislature was used to fund two major studies.

The first study is titled "Ecological and Floristic Studies of the Peatland Vegetation of Northern Minnesota." Dr. E. Gorham and Dr. H. Wright, Jr. of the Department of Ecology, University of Minnesota, are responsible for the investigation. Assisting them are Dr. P. Glaser and Mr. G. Wheeler of the Department of Botany. The primary objective of their research is to classify the plant communities and landscape features within the large patterned peatlands (i.e. peatlands comprised of tear-dropped shaped islands, stringed fens, etc.) in northwestern Minnesota. As a preliminary step to classification components of the flora, including both the ground vegetation and canopy vegetation (i.e. trees and shrubs) will be studied in detail. The resulting classification scheme will be an important tool for mapping Minnesota peatlands with the use of aerial photographs.

The second study is titled "Vegetation Analysis of Selected Beltrami, Koochiching and St. Louis County Peatlands by Remote Sensing Methods." Dr. M. Meyer and R. Hagen of the College of Forestry, University of Minnesota, are conducting the investigation.

Their primary objective is to prepare cover type maps of the Upper Red Lake Peatlands in Beltrami and Koochiching County and the Toivola Peatlands in St. Louis County.

1) Ecological and Floristic Study

The ecological and floristic study focused on the complex peatland north of Upper Red Lake. It is by far the largest and most distinctive peatland in Minnesota and in the entire northern United States (excluding Alaska). Fifty-seven sites, distributed among all the major landforms of the area, were chosen for detailed vegetation analysis. Relevés were the means of analysis and served as the basis for plant community classification. The relevé method involves compiling a complete list of all plant species found within the defined stand of vegetation. In addition a visual estimate is made of the cover (abundance) and sociability (dispersion) of each species. With this information, investigators are able to derive a classification scheme for all the sample sites that is based upon floristic composition. In the present study relevés were conducted in all 57 sampling sites.

In addition to conducting the relevés, field investigators collected plants, mosses and lichens from each sample site. Voucher specimens have been prepared from the collections so that the species composition of the peatland flora may be officially documented. The specimens are being deposited in the herbarium of the University of Minnesota. Water samples were also collected from each site and analyzed for their color, total ionic concentration and acidity. Finally, several peat cores were taken from representative sites in order to obtain information on the historical patterns of plant community succession. At present, the relevés and water samples have been analyzed and a brief summary of their results is presented below. The peat cores however, have yet to be examined.

Based upon their floristic composition and physical features investigators distinguished five major vegetation communities in the Upper Red Lake Peatland (Table 2). The communities separate into two distinct types based upon their diversity of plant species and correlated with differences in their water chemistry. These two types have been variously described earlier as the ombrotrophic bogs and minerotrophic fens. Floristically the bogs are characterized by their low plant species diversity while fens are characterized by their high plant species diversity.

With the use of the floristic data two major plant communities can be recognized within the ombrotrophic bogs (Table 2). The first is a community that occurs in non-forested openings such as the centers of ovoid-shaped islands. Investigators distinguish the community floristically by the presence of two Carex, or sedge species. Characteristic of non-forested openings,these two plants are not known to occur together in any other community. Forested bogs represent the second major plant community found within ombrotrophic bogs. As their name implies forested bogs contain a tree layer composed largely of stunted black spruce and, occasionally, tamarack. Floristically however, the tree canopy

TABLE 2. PLANT COMMUNITIES OF THE RED LAKE PEATLAND

Major Communities	Ombrotrophic Bog	Minerotrophic Fen
Characteristics	Low Plant Species Diversity	Higher Plant Species Diversity
	Low (acidic) pH	Higher (less acidic) pH
	Poor Supply of Dissolved Salts	Richer Supply of Dissolved Salts
	1. Non-Forested Openings Carex oligosperma* Carex pauciflora	1. Pools Triglochin maritima Scheuchzeria palustris Drosera intermedia Utricularia intermedia
	2. Forested Carex trisperma Vaccinium vitis-idaea Smilacina trifolia	2. Tear-Drop Islands A. Carex paupercula var. pallens Carex canescens Carex disperma Carex pseudo-cyperus Rubus pubescens Lonicera villosa var. solonis Rumex orbiculatus Aronia melanocarpa B. Water-filled pools Iris versicolor Typha latifolia Calla palustris
		3. Hummocks Not floristically unique

* Character Species

alone can not distinguish forested bogs from non-forested openings - even the latter may contain small scattered clumps of stunted black spruce. Instead, three plants growing in the ground layer of vegetation are considered the characteristic species of forested bogs (Table 2).

Within the fens of the Upper Red Lake Peatland the investigators encountered difficulty in their attempt to distinguish floristic association. The physical heterogeneity of the fen substrate is responsible for a great deal of variability in the vegetation. Because the vegetation types continuously intergrade with one another it is difficult to describe plant communities of the fen solely as discrete associations. Therefore, the minerotrophic vegetation was categorized according to the three major land-forms: pools, tear-drop shaped islands and hummocks.

The pool communities are open areas with approximately 6-20 centimeters of standing water. Floristically the community is distinguished by four plants (Table 2) including one member of the sundew family (Drosera intermedia). Restricted to wetlands, the sundews are among a limited number of plants that are carnivorous - they obtain nutrients by devouring insects. Although they are not restricted to the pool community, several sedge species are also commonly found in pools.

The second major landform, the tear-drop shaped island, has a complex structure consisting of several discrete strata of trees, saplings, shrubs and herbs. Variable in their size and floristic composition, these islands display the richest flora of any landform in the peatland. Despite their variability, the islands with well-developed stands of tamarack and black spruce have a distinct assemblage of eight characteristic species that are generally restricted to the community (Table 2). An additional assemblage of species was also found to be characteristic of the water-filled depressions that occur within the teardrop islands (Table 2).

Hummocks, the third major landform, could not be floristically distinguished by plants restricted to their substrate. The plants growing upon hummocks are also common in both the pools and islands. Although they may vary considerably in size and shape, hummocks are typically covered with a dense growth of moss. If they are well-developed they may also support small stunted tamarack trees.

As was mentioned above, representative specimens of all the vascular plants, mosses and lichens within the study area were collected. A total of 590 vascular plants were collected, identified and preserved as voucher specimens. Out of this total collection, 198 species were found representing 50 different plant families. Mosses and lichens are currently being identified by experts.

Of the plants collected, the aster, sedge, grass and orchid families are the largest and best represented. Sixteen vascular plants were also found which are considered rare or endangered in Minnesota. As Table 3 shows, nine of these are given limited legal

TABLE 3. RARE AND ENDANGERED VASCULAR PLANT SPECIES FOUND IN THE RED LAKE PEATLAND.

Cyperaceae (Sedge family)

Carex exilis [c]

Cladium mariscoides [a] (Twig-Rush, Water Bog Rush)

Rhynchospora fusca [a]

Droseraceae (Sundew family)

Drosera anglica [c]

Drosera linearis [a] (Slender-leaved Sundew)

Gentianaceae (Gentian family)

Gentiana rubricaulis [ab]

Juncaceae (Juncus family)

Juncus stygius var. *americanus* [a]

Orchidaceae (Orchid family)

Arethuisa bulbosa [ab] (Swamp Pink, Dragon Mouth)

Cypripedium acaule [ab] (Stemless Lady Slipper)

Habenaria lacera [ab] (Ragged fringed Orchid)

Liparis loeselli [ab]

Listera cordata [ab]

Malaxis unifolia [ab]

Pogonia ophioglossoides [ab]

Pogonia ophioglossoides forma *albiflora* [ab]

Xyridaceae

Xyris Montana [a] (Yellow-eyed grass)

[a]Morley's list of rare and endangered plants of Minnesota
[b]Minnesota Statute No. 17.23
[c]Plant taxonomists, University of Minnesota

protection under the Minnesota Wild Flower Conservation Law. Another 5 are included in Professor Thomas Morley's list of plants rare or endangered in Minnesota, but are not included in the Minnesota Wild Flower Conservation Law. Two are plants which have only recently been discovered in the state.

2) Remote Sensing Study

There are two major phases to the peatland mapping study. The first involves the preparation of vegetation cover type maps of portions of the Upper Red Lake Bog and portions of the Toivola Bogs. To prepare these maps the most recent black and white aerial photographs and color infrared photographs of the area are being utilized. Necessary field checking has already been completed and an appropriate classification scheme has been developed. Maps for portions of the Red Lake Bog should be completed early in 1979.

The second phase of the mapping study will provide color infrared coverage of approximately 35 miles of representative transects. Transect locations were chosen to demonstrate principal vegetation types, vegetation patterns, environmental gradients, effects of man-made disturbances (e.g. ditches, roads, logging and transmission line construction) and natural disturbances (e.g. dwarf mistletoe infections, fire scars and beaver flooding). The photography was completed in August and September of 1978.

WILDLIFE

The Phase II wildlife study was designed to review all ecological information available on wildlife species that are known to be wholly or partially dependent upon Minnesota's northern peatlands. Both game and nongame mammal and bird species were examined. Because detailed studies of peatland wildlife had not been conducted in Minnesota when this review was initiated, much of the available data were drawn from studies conducted in other states of the Great Lakes region and from studies conducted in Canada. Personnel responsible for the Phase II wildlife study were W. H. Marshall and D. G. Miquelle of the Department of Entomology, Fisheries and Wildlife, University of Minnesota. Their study was titled: "Terrestrial Wildlife of Minnesota Peatlands." Findings from their report are summarized in the following two sections discussing birds and mammals. Continuing studies that are being funded with the 1977-1979 legislative appropriation are also discussed under the appropriate headings.

BIRDS

Phase II Characterization

The Phase II study revealed that approximately fifty bird species, including several hawks, shorebirds, and songbirds, are known to utilize peatlands for breeding habitat. The species list, presented in Table 4 , was drawn from several studies conducted in bogs located in Itasca State Park and from an extensive study conducted in the Canadian peatlands.

TABLE 4. BIRDS OF PEATLANDS - A list compiled during Phase II of the Minnesota Peat Program.

Sedge Willow

Ring-necked Duck
Black Duck
Sharp-tailed Grouse (winter)
Common Snipe
Solitray Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Hawk Owl (feeding)
Short-eared Owl
Alder Flycatcher
Common Yellowthroat
Red-winged Blackbird
Common Grackle
Lincoln's Sparrow
Swamp Sparrow
Song Sparrow

Fens

Marsh Hawk
Sandhill Crane
Yellow Rail
Common Snipe
Solitary Sandpiper
Greater Yellowlegs
Least Sandpiper
Bonaparte's Gull
Short-billed Marsh Wren
Leconte's Sparrow
Sharp-tailed Sparrow

Tamarack: Tamarack/Black Spruce

Hawk Owl (nesting)
Great Gray Owl
Red-eyed Vireo
Tennessee Warbler
Nashville Warbler
Yellow-rumped Warbler
Cedar Waxwing
Palm Warbler
Connecticut Warbler
Common Yellowthroat
Dark-eyed Junco
Chipping Sparrow
White-throated Sparrow

Swamp Conifer/Black Spruce

Spruce Grouse
Northern 3-toed Woodpecker
Yellow-bellied Flycatcher
Canada Jay
Boreal Chickadee
Swinson's Thrush
Ruby-crowned Kinglet
Golden-crowned Kinglet
Solitary Vireo
Nashville Warbler
Magnolia Warbler
Cape May Warbler
Yellow-rumped Warbler
Bay-breased Warbler
Connecticut Warbler
Dark-eyed Junco
Chipping Sparrow
White-throated Sparrow

Muskeg

Sharp-tailed Grouse (winter)
Hermit Thrush
Yellow-rumped Warbler
Dark-eyed Junco
Chipping Sparrow
White-throated Sparrow

Several species listed in Table 4 deserve special recognition. Five game species for example, utilize peatlands in a major fashion: the ring-necked duck, spruce grouse, sharp-tailed grouse, common snipe and sandhill crane. Four of these species are dependent on some aspect of the peatland habitat for breeding purposes. Literature describing the habitat requirements of the fifth species, the sharp-tailed grouse, suggest that the bird is dependent on peatlands only during the winter, when the habitat provides important roosting cover. Recent field studies however (studies funded by the legislative appropriation), have demonstrated that the lowland habitats are important to the grouse year-round.

The sandhill crane has also been officially recognized by the Minnesota Department of Natural Resources (MDNR) as a threatened species. "Threatened", as defined by the MDNR, denotes a species which could become endangered in Minnesota in the foreseeable future but not necessarily throughout its entire natural range. Information collected by mail survey in 1976 indicates that approximately 70 to 85 pairs of sandhills currently summer and/or nest in 12 Minnesota counties. Because the state of Minnesota is also a major stopping point along the cranes' migration route, the bird is protected by the Migratory Bird Act of 1916.

Although a variety of birds utilize the northern peatlands for nesting habitat, many species that nest in other habitats are often observed in the bogs. This may be common where low lying peatlands are well interspersed with a variety of upland vegetation types. In these settings, peatlands may provide a valuable addition, such as a food source, and thereby increase the variety and density of birds found in the upland area.

Unlike the smaller peatlands in southern Minnesota, the peatlands in northeastern and north central Minnesota are extensive areas, often thousands of acres in size. As a result, the breeding density and diversity of their bird communities is relatively low compared with communities in more heterogeneous upland habitats. Canadian studies indicate that breeding densities may range from approximately 90 to 200 pairs per 100 acres. By comparison, upland habitats may average 200 to 400 pairs per 100 acres. Data indicates that one of the younger successional communities, muskegs, is perhaps the least productive habitat. Muskegs, which are characterized by the lowest breeding bird densities in the peatlands, contain a dense shrub cover, and ground cover, along with scattered black spruce and tamarack trees.

Phase II Impact Analysis

As the Phase II study revealed, the bird populations of Minnesota peatlands have not been well-studied, thereby making it difficult to identify the potential impacts of peatland development. Although the breeding density and diversity of bird communities suggests that peatlands are generally less productive than forests on mineral soils, the value of peatlands to birds should not be judged on these merits alone. Extensive development could have a significant negative impact upon the nesting and/or winter habitat provided by peatlands. Biologists agree, for example, that one of the most important conditions for the maintenance of a sandhill crane population is isolation. Because the population is already considered threatened, destruction of habitat could be detrimental.

Current Studies

Dr. Marshall's literature review of peatland bird populations revealed the paucity of data that was available from the peatlands of northern Minnesota. Data drawn from field studies conducted throughout northeastern North American can provide a fairly accurate list of the bird species breeding in the various bog types. Nevertheless, there is little data available, particularly quantitative data, that adequately describes the seasonal habitat utilization of peatland bird populations. In order to properly evaluate the ecological impacts of the development of Minnesota's peat resource, the collection of such information is a priority. As a result, two field studies were funded with monies from the legislative appropriation.

The first study is titled "Bird Population Structure and Seasonal Habitat Use as Indicators of Environmental Quality of Peatlands." The principal investigator is Dr. D. W. Warner, professor of Ecology and Behavioral Biology and curator of Birds at the Bell Museum of Natural History, University of Minnesota. Dr. Warner's primary objective is to obtain quantitative data on the population structure of bird species that utilize resources of the several vegetation types growing on major peat deposits in Minnesota. The second study is titled "Utilization of Minnesota Peatland Habitats by Large Mammals and Birds." Principal investigators for the study include Dr. J. R. Tester, professor of Ecology and Behavioral Biology, University of Minnesota and Ms. P. J. Pietz, research associate, University of Minnesota. Their study will incorporate the techniques of radiotelemetry to intensely monitor the peatland habitat preferences of two game bird species, the ruffed grouse and spruce grouse.

1) Population Structure and Seasonal Habitat Use

Stationed in Waskish, Minnesota, Dr. Warner and his staff have focused their studies primarily in the peatlands and adjacent uplands of Beltrami County. Their research has been designed to incorporate a variety of censusing techniques. During the 1978 summer field season three techniques were utilized. First, a series of walking transects were established in each of the vegetation cover types. Varying from 2500-6000 ft in length, a total of 27 transects were established in 13 different habitats. Birds observed while walking along the transect were categorized by their lateral distance from the observer, their species identification, sex and age (where possible). Such information allows investigators to calculate the density for each bird species that was sighted. Transects were censused a minimum of once a week from mid-May through early August.

The second censusing technique employed was mist-netting. Thirty-five to sixty, Japanese mist nets were set up in each of the following four habitats: 1) spruce island; 2) cedar; 3) tamarack; and 4) black spruce. Birds were netted in these areas from May through September. All birds caught were banded (some color-marked) and data regarding their age, weight, sex, breeding condition, molt and any other additional comments were recorded. This data will supplement the transect data by providing information on the following: 1) territory size and location of breeding pairs, 2) appearance and disappearance of individuals due to changing activity patterns, 3) breeding and molt condition, 4) age, and 5) weight of individuals.

A road census by car was the third censusing technique employed by Dr. Warner. Four routes, each ten miles in length, were established and censused during April and May. The routes were driven at dusk to census woodcock, snipe, grouse and owls and were driven in the morning to census grouse and snipe. Neither the transect or mist-netting techniques are designed to adequately census any of these larger species.

Various types of information were also collected to describe the peatland habitats where birds were censused. Included were: 1) qualitative descriptions of the plant species composition (releves) and percent cover, 2) tree, sapling and shrub densities, 3) estimates of canopy cover, and 4) quantitative estimates of the structure of the vegetation (foliage density and foliage height diversity). In addition, an entomologist working with Dr. Warner's staff collected quantitative information on the presence and abundance of insects within each habitat. Because the majority of songbirds are heavily dependent on insects for their summer diet it is hoped that such data will provide a valuable perspective on the availability of food resources.

Data on bird populations were also collected during the winter months. The major techniques utilized during the winter of 1978-1979 included a series of road census routes and four walking transects. Four hundred meters in length, the transects were established in the following habitats: 1) semi-open bog, 2) mature tamarack, 3) open bog, and 4) mature black spruce. Supplementary observations were also obtained by establishing feeding stations and observing the birds that used them.
Much of the data collected during these field studies remains to be analyzed. Nevertheless, several significant findings are obvious and deserve mention. First, sharp-tailed grouse that were observed in the bog habitats during the winter months maintained numerous well-defined leks (i.e. display grounds) in the ribbed fen and scrub fen habitats throughout the spring. As was mentioned above, earlier studies had suggested that the peatland habitats were not utilized by this grouse species during the breeding season. However, as of 10 June as many as 20 birds were still observed on one lek in the early spring.

The second major finding concerns the size and diversity of the peatland breeding bird populations. The two habitats for which breeding densities have been estimated (muskeg and black spruce) registered fewer than 50 breeding pairs per 100 acres. Not only are these density estimates considerably low but the diversity of species in these communities is also not very large. The muskeg habitat for example, registered only seven breeding species. The most diverse habitats appeared to be the swamp thicket and cedar-spruce forest, registering a total of 44 and 41 species respectively. However, for many habitats, the swamp spruce and cedar-spruce included, more than 50% of the species detected were listed as casual in their occurrence. A bird of a given species was assigned this status if it was observed on less than 25% of the censuses.

An additional finding relates to the periodic changes in the manner of birds caught with mist nets. Three major peaks were observed in the total captures between May 7 and September 6; these were particularly evident on the spruce island plot. The first peak occurred during late May and appeared to correspond to the time when birds were migrating through or arriving and establishing breeding territories. After the establishment of breeding territories there was a lull in activity through June while females were incubating and rearing hatchlings. The second peak in numbers occurred when the first broods fledged from the nests and were captured in the nets. In the spruce island plot this peak is actually made up of two successive peaks. The first occurred on July 3 when Nashville warblers comprised 43% of all captures that day. Later, on July 20, palm warblers comprised 62% of all captures.

These staggered peaks may indicate some degree of habitat partitioning between the two species, although another season of data would be necessary to confirm this. The third major peak in capture numbers began in late August, corresponding to the initiation of fall migration.

Finally, an important finding that is obvious from the analysis to date is the significance of the peatland habitats to migrating birds in the fall, particularly the tamarack lowland. Such incredible numbers of birds moved through the tamarack swamp in the fall that at times researchers could not process all the birds caught in a days' time. Although Nashville warblers far outnumbered the other species caught, significant numbers of yellow-rumped, Tennessee, black and white, and Connecticut warblers were also caught. Clearly the tamarack habitat must be an important molting and migratory stopover site.

Although the findings discussed above are preliminary in nature, they demonstrate that Minnesota's peatlands support a significant avifauna that merits further study. The peat resource is a necessary and integral part of the life cycles of many of the 119 species observed by Dr. Warner and his staff during the course of their studies. Future analysis will include a detailed investigation of the importance of this resource to members of the peatland bird community.

2) Utilization of Peatland Habitats by Large Birds

The peatlands of Hubbard County, Minnesota were chosen for intensive study by Dr. Tester and his staff. Located south of the Red Lake peatlands, the area consists largely of jack pine uplands interspersed with several types of lowland habitat, such as conifer bogs and sedge fens. The diversity of upland and lowland habitats permitted the researchers to focus their attention on an animal's selection for or against various types of peatland habitat.

Two game bird species have been chosen for intensive study: the spruce grouse and ruffed grouse. Individual birds are being trapped, radio-tagged and then released within the study area. The high frequency signals emitted by the animal's radio-collar allow the biologist to relocate individuals with the use of hand-held antennas or antennas mounted on towers. Once animals are released, an attempt is made to relocate them at least once every 48 hours. The time schedule for relocation is varied as much as possible in an attempt to obtain data from different periods of night and day. Direct observations of each animal are also used to supplement the data.

Additional sources of information on habitat use and selection include snow track surveys in periods of adequate snow cover, a pellet survey in the spring and road track censuses in the summer and early fall. Although surveys such as these do not involve direct observations of the animals they provide a rough index of habitat utilization.

Two assumptions are important to Dr. Tester's study. First, when analyzing the radio-telemetry data it is assumed that the distribution of radio locations in various habitats reflects the actual distribution of habitat utilization. Thus, if 10% of an animal's locations were in alder, it is assumed that the animal actually uses alder about 10% of the time. Secondly, it is assumed that the proportions of each habitat type within the study region are the proportions available to the animal. Patterns of habitat utilization are then interpreted as demonstrating active selection for or against particular habitats.

To date ten spruce grouse and six ruffed grouse have been radio-tagged. Although home range and movement data have yet to be examined, seasonal patterns of habitat selection for both male and female grouse have been summarized.

Radio-tagged spruce grouse were found exclusively in jackpine throughout the winter. However, by late March, the adult males apparently sought display territories in black spruce-tamarack bogs, and remained in these coniferous lowlands throughout the summer months. Prior to incubation the females also demonstrated a strong preference for conifer bogs. Nevertheless, in at least two cases their nesting and broodrearing activities were confined to the jack pine. After the young chicks had hatched jack pine habitats were still used extensively although considerable time was now spent in the black spruce-tamarack and alder habitats. By late fall, when snow again covered the ground, both male and females were back in jack pine uplands.

The snow track and pellet count surveys did not prove useful for obtaining information on spruce grouse. Incidental sightings of unmarked birds totaled 174, most of which were groups of birds seen in jack pine during the winter (116). During the snow-free months most of the sightings were in jack pine uplands (33) and in black spruce-tamarack bogs (22). Unfortunately, the difference in visibility between these two habitat types is very great; the probability of seeing a bird in jack pine is much higher than that of seeing one in coniferous bogs.

The habitat preferences of spruce grouse that are being demonstrated in this study differ considerably from earlier findings. However, previous studies were conducted in areas of Minnesota where upland conifers were apparently unavailable. As a result, all phases of grouse activity were restricted to various types of lowland. Nevertheless, with regards to the composition of the ground vegetation and the overall structure of the forest, the upland sites selected by spruce grouse in the current study show striking similarities to those used in the bog habitats of earlier studies. This would suggest that the degree of canopy cover and the types of shrub and herbaceous vegetation available for food are more important than the actual species of trees present in the overstory.

The radio-tagged ruffed grouse are demonstrating a wide variety of habitat preferences. The alder and jack pine habitats have been the only habitats that are used to any extent by all males and females. Female grouse have selected for only one habitat type:

alder. All other types have been used in proportion to their availability or somewhat less. Two males that were monitored demonstrated selection for alder throughout the year, while one showed selection for mixed upland. Another male favored mixed uplands only during the spring and summer, while another favored black spruce-tamarack during the spring and summer. Although no males showed strong selection for jack pine, three more than doubled their use of this type in the fall.

Incidental sightings of unmarked birds have been most common in jack pine (37) and mixed uplands (33), followed by alder (13) and black spruce-tamarack bog (9). Again, however, differences in visibility among these habitat types and differences in the amount of time spent in each type requires that these figures be viewed with some skepticism.

In the past, ruffed grouse have not commonly been regarded as members of Minnesota's peatland fauna. However, data demonstrating the importance of alder lowlands to the species are not entirely unprecedented. Researchers working in northern Michigan found 40 drumming logs, all of which were in lowland cover types. In addition, over 73% of the tall shrub stems growing near the logs were speckled alder. The study emphasized that such vegetation furnished the most important cover for male ruffed grouse.

Dr. Tester's research staff is continuing their work in the lowlands of Hubbard County. Future analysis will include a complete analysis of seasonal habitat preferences in addition to an analysis of movements within an animal's home range and diurnal patterns of habitat utilization.

MAMMALS

Phase II Characterization

The literature that was reviewed during the Phase II wildlife study indicates that eight large game and furbearing species, along with thirteen small mammal species, are inhabitants of Minnesota's peatlands (Table 5). However, the lack of detailed studies for many of these species suggested that the list should only be considered preliminary until future studies are conducted.

TABLE 5. MAMMALS OF PEATLANDS - A list compiled during Phase II of the Minnesota Peat Program.

Moose	Red Squirrel
White-tailed Deer	Northern Flying Squirrel
Eastern Timber Wolf	Red-backed Vole
Canada Lynx	Star-nosed Mole
Fisher	Least Chipmunk
Marten	White-footed Mouse
Beaver	Southern Bog Lemming
Snowshoe Hare	Northern Bog Lemming
Cinereus Shrew	Meadow Vole
Short-tailed Shrew	Meadow Jumping Mouse
Arctic Shrew	

The moose and white-tailed deer are the major game species associated with the peatland habitats. Of the two, the moose is more dependent on the resource. Although moose do not use most of the large, continuous peatlands, they do use the marginal habitats found at the boundary between peatlands and upland habitats. Plant species common to these areas, such as willow and bog birch, are important food items for moose. Deer are unlikely to be observed in any of the peatland habitats, especially large, uninterrupted tracks, during either the spring, summer or fall. However, a key to their winter survival in northern Minnesota is the presence of mature white cedar lowlands. The importance of these yarding areas to deer results both from the protection that the dense conifers provide against the chilling winds and cold temperatures and from the high nutritional value of white cedar as a winter food.

Although several recent habitat studies are available for the game species, little information is available for most of the furbearing mammals. Substantial data does exist, however, for the beaver and snowshoe hare.

Beavers were not originally found in peatlands. However, around 1915, an extensive drainage ditch system was dug to drain the peatlands for agricultural purposes. The mineral soil that had been dredged out of the ditches and deposited on the banks provided a good substrate for the establishment of aspen, willow, and balsam poplar; all favored beaver foods. By 1947, the beaver population in these ditches was estimated at 3.2 beaver per mile of ditch.

The snowshoe hare, on the other hand, is found in nearly all forested or brushy habitats when the number of individuals in the population is high. However, during the years of low hare densities they are found only in the swamp conifers (cedar-spruce and spruce), wetland shrubs and fens.

Among the larger furbearing mammals several species have been officially recognized by the MDNR as either threatened or of "changing or uncertain status." Like the greater sandhill crane, the pine marten has been classified as a threatened species and is legally protected within the state. The fisher, Canada lynx and eastern timber wolf have all been classified as species of "changing or uncertain states." Both the fisher and timber wolf are now legally protected within the state. The timber wolf, which has also been classified as threatened by the U. S. Fish and Wildlife service, is protected by the Endangered Species Act from any actions that may adversely affect habitat that is critical to the species survival. Although the degree to which these species depend upon the peatlands for food and cover is largely unknown, none of the species are solely dependent upon the habitats for survival.

Little is known about the habits and biology of many of the thirteen small mammals that may inhabit Minnesota's peatlands. This is particularly true of many of the shrew species that are considered to be typical of lowland habitats. Among the small mammals listed in Table 5, six are primarily dependent upon lowland habitats: the cinereus shrew, short-tailed shrew, arctic shrew, star-nosed mole, southern bog lemming and northern bog lemming. The seven remaining species are common inhabitants of upland communities.

Phase II Impact Analysis

The difficulty in predicting the impacts from peatland development to large and small mammal populations is similar to that encountered for birds. Pertinent information has been lacking for advancing such predictions. The available data suggests however, that none of the large game or furbearing mammals make extensive use of the large expansive peatlands. The moose and white-tailed deer are perhaps the only species that are dependent upon some aspect of lowland habitats for survival.

Among the small mammals dependent upon peatlands the destruction of habitat could be temporarily detrimental. However, because these animals are all short-lived, their populations may recover quickly if the habitat is reestablished.

Current Studies

Justification for utilizing monies from the legislative appropriation to fund mammalian field studies in Minnesota's peatlands is similar to the justification to fund the bird studies described earlier. The information that was reviewed and summarized during Phase II of the peat program was gathered from studies scattered throughout several north central and northeastern states. Very few field studies have actually been conducted within the large continuous peatlands of northern Minnesota. Until this area receives proper attention by field biologists, the state of Minnesota will be in a tenuous position to make informed decisions as to the future management of its peat resource. In light of this, the 1977-1979 legislative appropriation was used to help finance two major mammalian field studies.

The first study is titled "The Importance of Peatland Habitats to Small Mammals in Minnesota." Investigators for the study include Dr. E. C. Birney, associate professor and curator of mammals at the Bell Museum of Natural History, University of Minnesota, and Ms. G. E. Nordquist, research assistant from the Department of Ecology and Behavioral Biology, University of Minnesota. The objectives of their study are twofold. First, determine which environmental factors have the greatest effect on the presence or absence of small mammals in peatlands, and second, determine the degree to which individual species and entire communities are dependent upon peatlands. The second study, titled "Utilization of Minnesota Peatland Habitats by Large Mammals and Birds", has, in part, been described above. In addition to their work with game birds, Dr. Tester and Ms. Pietz are also conducting field studies on the snowshoe hare and white-tailed deer. Using the techniques of radio-telemetry, their objectives are to study the habitat preferences of these species, both diurnally (i.e. within a 24 hour period) and seasonally.

1) Small Mammals

There are two major phases to the peatlands small mammal study. The first, the statewide survey, was designed to examine geographic and spatial aspects of the distribution and abundance of peatland small mammals. Its prime objectives were to provide: 1) baseline information concerning which small mammal species are associated with peatland habitats; 2) information regarding changes in small mammal species assemblages, both geographically and with habitat type; and 3) to identify any rare or regionally restricted species that occur in peatlands.

For the purpose of the survey Minnesota peatlands were divided into six regions. Within each region peatland habitats judged representative of the area were sampled, together with one adjacent non-peat habitat. Altogether, eight sites were trapped per region, once in the fall of 1977 and once again in the fall of 1978. In an attempt to mitigate the effect of differential trapability of several of the small mammal species, several types of traps were employed in the survey. Traps that were used included Museum Special Kill traps, Victor rat kill traps, Sherman live traps, cone pit-fall traps and tube live traps. Specimens that were collected in the traps were identified and frozen for later analysis. Further analysis will include gathering information regarding the age, sex and reproductive condition of each specimen. Stomachs were also collected for a future study of food habits. Several of the skins and skeletons have been prepared and are available as voucher specimens in the Bell

Museum of Natural History, University of Minnesota.

The second major phase of the project was an intensive study designed to explore the temporal aspects of peatland small mammal communities. The objectives are to determine the structure and stability of the communities and to determine their dependence upon particular aspects of the peatland environment. Toward this end, population structure, local distributions, and habitat utilization of component species of the communities are being examined; simultaneously, seasonal fluctuations in climate, vegetation and dietary items are being recorded.

The peatlands near Big Falls, Minnesota, in Koochiching County, were selected as the intensive study site. Following extensive reconnaissance of the area, 10 peatland sites representing the major peatland habitats of the region and 2 adjacent non-peat sites were chosen. Each site will be monitored extensively throughout the year. In addition, as a supplement to the core sites, similar habitats in the region will be surveyed occasionally for comparison of local differences in small mammal communities with the core sites. All animals collected in the field are identified and held for later processing. Laboratory analysis of the specimens is the same as that for the statewide survey.

All the specimens collected to date during the statewide and intensive survey have been tentatively identified; positive identification, will be done with laboratory analysis of the specimens. From the preliminary tabulations however, the 2,444 specimens collected during the statewide survey represent up to 21 species of small mammals (Table 6). Two species, the thirteen-lined ground squirrel and woodland jumping mouse, were never taken from peatlands while two other species, the star-nosed mole and bog lemming, were never collected from non-peat areas. In addition to the specimens collected, sign (i.e. tracks, pellets, etc.) was noted during the survey for the following species:

Plains pocket gopher	non-peat only
Gray wolf	peat and non-peat
Black bear	peat and non-peat
White-tailed deer	peat and non-peat
Moose	peat only

Data collection for the intensive study pahse of the research is still in progress with results being preliminary and incomplete. Table 7 summarizes the small mammals collected from the core sites at this time. In addition to those captured, sign has been noted for the following species:

Beaver	peat and non-peat
Coyote	non-peat only
Gray wolf	peat and non-peat
Red fox	peat and non-peat
Black bear	peat and non-peat
Fisher	non-peat only
Mink	peat only
White-tailed deer	peat and non-peat
Moose	peat and non-peat

Because sightings such as these are obtained opportunistically they should not be considered complete estimations of habitat utilization.

TABLE 6. List of small mammals collected from the state survey.

Shrews	
	Masked shrew
	Arctic shrew
	Pygmy shrew
	Short-tailed shrew
Chipmunks and Squirrels	
	Eastern chipmunk
	Least chipmunk
	Thirteen-lined ground squirrel
	Franklin's ground squirrel
	Red squirrel
	Northern flying squirrel
Mice and Voles	
	Deer mouse
	White-footed mouse
	Southern red-backed vole
	Meadow vole
	Meadow jumping mouse
	Woodland jumping mouse
Others	
	Star-nosed mole
	Snowshoe hare
	Ermine
	Bog lemming (southern and/or northern)

TABLE 7. Small Mammals associated with peat and adjacent non-peat sites of the intensive study in Koochiching County, Minnesota

	Open Fen	Wooded Fen	Swamp Thicket	Open Bog	Muskeg	Open Tamarack	Closed Tamarack	Open Black Spruce-Tamarack	Open Black Spruce	Closed Black Spruce	Black Spruce-Feathermoss	Cedar		Non-Peat Habitats
Masked Shrew	X	X			X		X		X	X	X	X		X
Arctic Shrew							X							
Short-tailed Shrew							X				X			X
Snowshoe Hare											X	X		X
Red Squirrel					X		X		X	X	X	X		X
Northern Flying Squirrel										X				
Deer Mouse											X	X		X
Southern Red-backed Vole	X	X			X					X		X		X
Ermine							X					X		

Although data is still being collected and compiled, several preliminary statements regarding obvious trends can be made. First, regional differences do exist in the species composition of peatland small mammal communities. These differences are accounted for primarily by differences in the structure of the vegetation and in the floral composition. For example, the bog lemming, which was more commonly associated with open bog habitats, was not found in the southernmost sites that lack this habitat. The arctic shrew, which was often associated with grassy peatlands, was captured in greater numbers in the southern sites where grass is a more common component of the habitats.

A second major point is that the total number of small mammal species and the number of individuals per species varied dramatically between habitat types. Habitats that are typically low in the number of small mammal species and total individuals include open bogs, flooded open fens, and black spruce/feathermoss forests. Such habitats are characterized by their low plant diversity, flooded conditions and/or highly acidic water. Habitats that were high in small mammal numbers and species include cedar swamps, drier tamarack swamps and swamp thickets. These peatlands are typically characterized by their higher plant diversity, drier peat, and/or their more nutrient-rich waters. The structure of the vegetation may also play an important role. When a dense shrub layer or a significant amount of windfall is present in the understory, the habitat generally supports a more diverse and latger small mammal community.

The third major point is that the number of individuals and species in a given habitat may vary from year to year. For example, the masked shrew was the dominant species of peatland habitats in 1977, but was conspicuously low in the northern sites in 1978. Large variations in many mammal populations have been well-documented in the literature.

The fourth and final observation that can be drawn from the data is that the small mammal species show varying degrees of preference for or avoidance of peatland habitats. Some species, such as the masked shrew, pygmy shrew and southern red-backed vole are nearly ubiquitous throughout a variety of peat and non-peat habitats. This contrasts sharply with the status of species such as the star-nosed mole and bog lemming which appear highly restricted to the few types of habitats in which they are found.

Any discussion of the magnitude of the kinds discussed above, or their significance to the overall picture of the ecology of peatland small mammals must await additional analyses of the data.

2) Large Mammals

The study area and field techniques for Dr. Tester's study were briefly described earlier. In addition to their studies of ruffed grouse and spruce grouse, snowshoe hare and white-tailed deer were also chosen for intensive radiotelemetry work. To date 20 snowshoe hare and 8 white-tailed deer have been trapped. All 20 hare have been radio-tagged but only 2 of the deer were suitable for tagging. Because their necks swell during the rutting season, radio collars could not be placed on male deer.

Data from eight snowshoe hare have been used for a preliminary analysis of habitat preferences. The results indicate that the individual animals vary considerably in their patterns of habitat use. Yet, despite this overall variability, all hares demonstrated some degree of selection for alder habitats. More than half of the animals also demonstrated some preference for black spruce-tamarack bogs, while only two individuals demonstrated selection for mixed uplands. Snow track surveys and a pellet count conducted on the study area further emphasized the primary importance of alder and the high utilization of coniferous lowlands.

These preliminary results correspond well to conclusions reached by earlier studies. During years when snowshoe hares are low or intermediate in abundance lowland conifer and shrub habitats are very important. The avoidance of open areas demonstrated by all individuals monitored in the present study is also in accordance with earlier findings. Radio-telemetry, snow track survey and pellet survey data all indicate that open lowland habitats and open upland habitats are not used. When snows are deep enough to cover low shrubs, much of the scrub fen is also avoided.

White-tailed deer also appeared to be strongly individualistic in their patterns of habitat utilization. One yearling female was found primarily in jack pine uplands year-round. Although she demonstrated a preference for alder and black spruce-tamarack bogs from April through September. On the other hand, an adult doe, with fawn, demonstrated a strong preference for mixed upland and jackpine habitats throughout the year.

Findings from other studies have suggested that during the summer months deer utilize upland habitats in proportion to their availability, while all lowland habitats are actively avoided. This is inconsistent with the behaviour of the radio-tagged yearling female in the present study who showed selection for conifer bogs and alder throughout the summer. Further analysis may provide more data pertinent to this finding in addition to revealing how extensively the lowlands are utilized by deer during the winter.

REPTILES AND AMPHIBIANS

The extensive literature review that characterized various aspects of the peatland wildlife during Phase II of the Peat Program did not include a characterization of the peatlands reptiles and amphibians (the herptofauna). This is partly due to the paucity of records: virtually nothing is known concerning the nature of the utilization of peatland habitats by the herptofauna of Minnesota. Nevertheless, these animals are a major component of the terrestrial fauna and are an important link in the food chains of peatlands and wetlands in general. Studies have also shown the herptofauna to be very sensitive indicators of various environmental parameters. Amphibians in particular deserve special attention. Because they breed and pass through crucial early developmental stages in water and, as adults, usually require abundant water, they will be one of the first components of the peatland environment affected by man-made disturbance.

In light of these facts, a study of the relationship of amphibians and reptiles to peatland habitats in Minnesota was initiated with funds appropriated by the legislature. The objectives of the study were threefold: 1) to document what species of amphibians and reptiles are found in Minnesota peatlands, 2) to document which species utilize the various peatland habitats and the nature of their utilization, and 3) to identify the key ecological factors responsible for controlling these habitat relationships. Investigators responsible for this study include Dr. P. J. Regal, associate professor of ecology and curator of Herpetology at the University of Minnesota, Minneapolis, and D. R. Karns, the project research assistant.

Characterization

To carry out the objectives listed above, the area chosen for study was central and southern Koochiching County and western Beltrami County, north of Upper Red Lake. Although work during the 1978 field season was concentrated within a fifteen mile radius around the community of Big Falls in central Koochiching County, other peatland sites were also visited on a regular basis. The field work included setting traps for reptiles and amphibians at seven locations throughout the summer (including six trapping locations within peatlands and one within an upland habitat), conducting frog call surveys during the spring breeding season and conducting egg and tadpole surveys later during the season. Various water quality parameters were also measured throughout the summer. Laboratory studies were designed to test egg hatching success, tadpole survivorship and adult tolerance to various water quality treatments. Preliminary results of this work are presented below.

Table 8 presents a species list for the peatlands study area. Among approximately 1100 specimens collected from the seven trapping sites were five different frogs, one toad, two salamanders, two snakes and two turtles. No lizards were found. The results in Table 8 clearly indicate that amphibians are the dominant element of the peatlands herptofauna. This is true both in terms of the number of species present and their overall abundance. In light of amphibians dependence upon water throughout their life cycle, this is not surprising.

The peatlands herptofauna can be further characterized by its low diversity of species. This is, in part, to be expected. Unlike the warm-blooded birds and mammals, reptiles and amphibians are cold-blooded animals (ectotherms) and, as such are suited to warmer, particularly tropical, environments. They are not considered to be "good" colonizers of northern environments. This is easily demonstrated by the greater diversity and abundance of species one encounters while traveling further south.

The absence of specialist species also characterizes Minnesota's peatland herptofauna. The herptofauna is, instead, composed largely of generalist species, noted for the wide range of

TABLE 8. Checklist of the Amphibians and Reptiles of the Peatlands of central and southern Koochiching and western Beltrami County, Minnesota.

	Number Collected
Amphibians	
Frogs and Toads	
Northern Spring Peeper	10
Gray Treefrog	5[2]
Chorus Frog	79
Wood Frog	540
Northern Leopard Frog	8
American Toad	483
Salamanders	
Blue-spotted Salamander	29
Mudpuppy[1]	
Reptiles	
Snakes	
Eastern Garter Snake	10
Northern Red-bellied Snake	8[2]
Turtles	
Western Painted Turtle	3[2]
Common Snapping Turtle[1]	

[1]These species were not actually collected but available evidence indicates their presence in the area.

[2]Specimens were collected only from the upland habitat that was sampled.

habitats in which they are found. This is in contrast to other bog areas that have been studied. For example, the bogs of the New Jersey Pine Barrens are noteworthy for their presence of the Pine Barrens Tree Frog; an endangered species that breeds preferentially in sphagnum pools of the area. Because a relatively small area within Minnesota's peatlands is involved in the present study, the investigators do not eliminate the possibility that such a specialist may yet be found.

The seven sites where trapping was conducted during 1978 were disproportionately utilized by reptiles and amphibians. The upland habitat was, by comparison, the most diverse and productive, both in terms of the number of species recorded and the number of individuals caught (349 individuals, 10 species). The site's proximity to a small fen, which was an active breeding area, was undoubtedly a factor in its productivity. Among the six peatland habitats sampled the more productive sites included a raised bog dominated by black spruce (195 individuals, 4 species), a tamarack lowland (190 individuals, 4 species), and an open fen/swamp thicket (158 individuals, 5 species). The habitat that appeared least attractive to the peatland herptofauna was the white cedar/black spruce forest where only 67 individuals, representing 4 species, were collected. The dense, shady and cold environment within this forest may be the principal reason for its low productivity.

In addition to the overall habitat preferences described above, the study has further demonstrated seasonal preferences for habitats. For example, during the spring breeding season nearly all the wood frogs caught in the upland were adult males and females in reproductive condition. During mid-to-late summer however, the upland breeding site was largely abandoned as the adult frogs dispersed in the latter part of the season. The increasing dryness of the site may have been an important factor. By contrast, the wetter open bogs and raised bogs experienced a late summer invasion of adult frogs.

Several factors are responsible for the patterns of habitat utilization described above. The key factors that have emerged in this study are:

1. Temperature

For cold-blooded animals such as amphibians and reptiles temperature is probably the single key factor. Habitats do not become available for their utilization until the average temperatures reach the range within which a species is active. For example, in the spring, the peatland habitats remain colder longer than the uplands and hence, are unavailable.

2. Precipitation

Rainfall is not the key factor in peatland habitats that it is in drier areas. Rainfall is correlated,however, with local movements. It was found in this study that amphibians are more mobile during rainly or extremely humid periods. This confirms results from other researchers.

3. Resource Availability

It is valuable to view the peatlands in terms of the availability of crucial resources. If the proper resources are not available at the proper time an organism may perish. Three key phases of the amphibian life cycle are discussed in this regard:

A. Breeding

Amphibian reproduction requires standing pools of water which last for a reasonable period of time. Obviously there is a great deal of water in peatland habitats; the question is one of quantity and quality. Many peatlands are like shallow subsurface rivers. Although they are wet, local accumulations of open (i.e. pools or ponds) water may be scarce or absent. Water quality is also important. Results from the egg-hatching and tadpole survivorship experiments clearly demonstrate the toxic properties of acidic, peatland waters for three amphibian species. "Good" breeding sites can therefore become a restricted yet valuable resource.

B. Water Balance

Amphibians are constantly losing water through evaporation. The water-saturated environment found in peatlands is therefore a valuable resource for such organisms.

C. Overwintering

Both amphibians and reptiles in this area spend approximately half of the year dormant, burrowed in at overwintering sites. Water-saturated environments however, may offer severe constraints as to where overwintering can successfully occur. For several species, overwintering mortality is apparently high in wetland habitats. Hence, suitable overwintering sites may be a very restricted resource in peatland areas.

Impacts

It is impossible to say anything specific about the effects of major peatland development on the peatlands herptofauna at this time. A few general points however can be made.

Amphibians and reptiles are an important element of the peatlands community. Although these groups may not be rich in species, they are abundant and their importance in the food chains of wetland ecosystems has been well-documented. Any disturbance that affects them would certainly have ramifications for many other species. In particular, anything affecting the availability of key resources would be of importance, especially water quantity and water quality. A significant change in the hydrologic setting of the area due to development would have a major impact upon amphibian populations.

AIR QUALITY

The objective of the Phase II air quality study was to make a preliminary evaluation of the potential air quality impacts that may result from development of the peat resource. All the current state and federal regulations for air quality standards were reviewed. In addition, an evaluation of the potential local and regional impacts of peat development and a review of the available measures of mitigation were included. Models that several agencies have developed for modeling particulate matter emissions were briefly reviewed. The consultant responsible for the Phase II air quality study was Environmental Research & Technology, Inc., M. H. Conklin directed the Minnesota study titled, "The Potential Air Quality Impacts of Harvesting Peat in Northern Minnesota."

Phase II Characterization

The region of northern Minnesota which is presently being considered for peat development is less populated and developed than other areas in the state. According to the latest available census estimates, only one city, Duluth, has a population larger than 50,000 (100,578-1970). Seven additional population centers adjacent to peatland areas reported census estimates which ranged from approximately 6,000 to 33,000. (Brainerd, Cloquet, Grand Rapids, Hibbing, International Falls, Virginia and Superior, Wisconsin). Because of locally intense industrial development (primarily the taconite and paper industries) the air quality near several of these population centers does not meet federal standards.

For example, the present air quality over the cities of Duluth and International Falls does not meet the primary standards designed to protect public health. However, the air quality over regions of northern Minnesota that are sparsely populated and that lack industrial development does meet federal standards.

Additional features of northern Minnesota that are important to peatland development and its resulting impacts upon air quality include several seasonal factors. For example, the short summer season restricts the time available for harvesting activities. The bogs must be thawed if the method of harvesting requires either water suspension or water drainage. In addition, warm temperatures are necessary for drying the peat before it is harvested. One benefit of the time restriction for conducting these activities is that the average wind velocity is generally lower during the summer months. Theoretically then, impacts due to peat dust emissions would be reduced. The prevailing wind directions during the summer season are southeast and west, which is away from the more densely populated southern area of the state.

Various federal and state regulatory actions will be of concern in developing peat areas in Minnesota. Peat harvesting will be subject to restrictions that limit the amount of pollutant, primarily particulates, that could affect air quality in the region. Important legislation includes the Clean Air Act of 1970 and the Clear Air Act Amendments of 1977. Under the 1970 legislation the Environmental Protection Agency established National Ambient

Air Quality Standards (NAAQS). Because the standards are subject to review by 31 December 1980, and at frequent intervals thereafter, there is the possibility that during the years when peatlands may be developed, the NAAQS could change (becoming more or less stringent). The 1977 amendments to the Act essentially classify the air quality of areas within regions that are meeting NAAQS and establishes regulations to prevent any significant deterioration. Of concern to potential peat development is the designation and location of Class I areas. These have been defined as areas in which practically any air quality deterioration would be considered significant, and therefore little or no energy or industrial development is allowed. Class I areas include national parks and wilderness areas in excess of 6,000 acres. In northern Minnesota this would include Voyageurs National Park and the Boundary Waters Canoe Area. In addition, Indian reservations, of which there are several in northern Minnesota, have the option to be classified as Class I areas if they desire. Most of Minnesota's peat resources, however, are located in areas designated as Class II. Class II designation refers to areas in which any air quality deterioration that would normally accompany moderate well-controlled growth would not be considered significant.

Phase II Impact Analysis

One major impact from peat development that is of concern to regional air quality is the release of peat dust from harvesting activities. The amount of dust generated during harvesting is variable and depends on the harvesting technique. Milled peat harvesting, the most efficient and frequently used method, generates the largest amount of peat dust. Once the harvested peat is broken up and dried, the peat particles become airborne quite easily. In addition, the dried peat is handled extensively during other harvesting activities. Two other harvesting methods, sod harvesting and slurry harvesting, do not generate as much dust.

Any population center located within 20 to 30 miles downwind of a harvesting area has the potential for experiencing peat dust emissions. Dust that travels this far will be composed of small particles that scatter light and thus decrease visibility. Closer to the source, peat dust can cause ambient air quality problems at ground level and decrease visibility significantly. Steps to mitigate the effects upon peat workers include either pressurizing or elevating the cabins on the machinery. The peat dust can also be a nuisance to nearby residents, as any obstructions (houses, cars, garages, etc.) will be covered with a thin layer of dust.

The amount of dust generated by the various harvesting methods can be mitigated by several techniques. Recommended methods include the construction of parallel wind barriers, perpendicular to the direction of prevailing winds, and the construction of small ridges to roughen the surface of the drying fields. Surface roughening will retard movement of larger particles and reduce exposure of smaller particles to the wind.

Although not associated directly with harvesting, another major impact from peat development would be the stack emissions from industrial plants designed to utilize the harvested peat. Some of the possibilities discussed later in this summary include the construction of a peat gasification plant, a peat-fired district heating plant, or an industrial chemical plant. Because peat contains less sulfur than coal, sulfur dioxide emissions should be substantially reduced. At present, however, the potential problems of stack emissions from industrial plants utilizing peat have not been addressed.

3 SOCIO-ECONOMICS

REGIONAL SOCIO-ECONOMICS
RED LAKE INDIANS

REGIONAL SOCIO-ECONOMICS

The prospect of new, expansive development in the peatlands of northern Minnesota carries the potential for producing considerable change in regional socio-economic conditions. Introducing new industries into a relatively undeveloped, sparsely populated area, could significantly alter the economic and demographic structure of local communities. Furthermore, if development were to proceed rapidly, without due consideration of the potential social and economic impacts or the possible environmental impacts, cultural values and traditions could also suffer. In light of these considerations an important priority of the Minnesota Peat Program was to characterize the present social and economic environment of northern Minnesota. Then, based upon the initial characterization, the potential impacts of peatland development could be assessed.

Such an investigation was conducted in two different stages by the Peat Program. During the first stage a socio-economic characterization and impact assessment was conducted for an entire eight county study region. Designed to assess the regional impacts of development the study was conducted during Phase II of the program. The second stage of the investigation, funded with the 1977-1979 legislative appropriation, addressed the unique concerns of the Red Lake Indian Reservation.

The regional assessment of socio-economic conditions and the potential impacts of peatland development was conducted by Dr. W. R. Maki, L. A. Baulainen, Jr., and P. D. Meagher. Titled "Economic Effects of Peatland Development" their study was a joint effort on the part of the Department of Agricultural and Applied Economics and the Minnesota Agricultural Experiment Station at the University of Minnesota, St. Paul. The objectives were threefold: 1) to describe the natural setting of the area and its existing peatland development; 2) to select scenarios (a hypothetical case situation) for future peatland development; and 3) to estimate the potential impacts of such development. To accomplish the latter a regional impact simulation and forecasting system (SIMLAB) was developed by economists at the University of Minnesota in an effort to provide policymakers with a tool for projecting the impacts that resource development could bring to northern Minnesota. The results of their application of SIMLAB to peat development are summarized below.

Natural Setting

An eight-county study region was selected for the characterization and peat development impact analysis. This region comprised seven northeast and north central counties in Minnesota (Cook, Lake, St. Louis, Carlton, Aitkin, Itasca and Koochiching Counties) and Douglas County, Wisconsin, Several extensive peatlands are located within the region, particularly within Aitkin and Koochiching Counties.

An inventory revealed that approximately 3,350,000 acres of peatland are located within the study area, with nearly 1.2 million acres and .6 million acres in Koochiching and Aitkin Counties respectively. About 20,000 acres are already developed, primarily for agricultural production, although some acreage is devoted to peat extraction for horticultural purposes. In addition, the study area already has, in Virginia, Hibbing, Ely and other localities, firms and industries that sell equipment, parts, supplies and services to the taconite industry. Should peatland development occur, it is very likely that this existing infrastructure, which has developed to serve one extractive industry, will simply extend itself to serve the peat industry. Douglas County, Wisconsin was included in the study region because the entire Duluth-Superior area represents a potential market for peat products, and serves as a base for retailing, service, and other industries. There are few large population centers in northern Minnesota. Outside the port cities of Duluth and Superior the largest population centers in the study region are located along the Mesabi Iron Range, an oblong band of iron ore deposits that stretches from Grand Rapids, Minnesota northeast to Ely, Minnesota. Extensive mining development has spurred the economic growth of this area. The outlying regions, however, are sparsely populated and largely undeveloped.

The economy of the entire eight-county study region is heavily dependent upon the development of natural resources. In addition to the iron ore industry mentioned above, logging, wood products and paper products are also important natural resource-using industries which contribute significantly to the regional economic base. The wilderness-like quality over much of the entire eight county area has provided a prime tourist attraction so that many of the service industries associated with tourism are also important.

Development Scenarios

In order to assess the potential socio-economic impacts of peatland development, it was necessary to construct a development scenario, i.e. a reasonable (though hypothetical) set of events that might realistically take place in the near future. Each of the options for utilizing Minnesota's peat resources had to be evaluated with respect to its likelihood of occurrence. Those options that were deemed most likely to occur in the near future were incorporated into the scenario. Dr. Maki and his staff chose the five following options for their peat development scenario in northern Minnesota: 1) peatland agriculture; 2) peat mining; 3) synthetic gas production; 4) peat coke production; and 5) synthetic gas distribution. Reasons for the selection of each of these industry options can be found in the original report but, the essential elements of the scenario can be summarized here.

Of prime importance to the scenario was a realistic estimation of the magnitude of development. For example, it was estimated that a peat gasification plant would employ approximately 1,260 workers, extract 18 million tons of peat per year and produce 250 million cubic feet of gas per day. This level of development will require a capital investment of approximately $525 million (in 1970 dollars). Similar figures were also projected for the other industries included in the scenario.

The second element that was required for the peat-development scenario was an evaluation of the markets for peat-derived products. For example, there are two possible marketing alternatives for synthetic natural gas produced from peat: 1) to sell all of the gas outside of the study area - the only social and economic impacts in the study area would be those resulting from production of the gas; and 2) to sell part of the gas to consumers in the study area. In this particular case, the evaluation led to the formulation of two development scenarios, one scenario corresponding to each of the two marketing alternatives.

The third and final element required in the scenarios was an assumption concerning the timing of peat industry development. A time estimate was necessary because the impacts resulting from development must be measured relative to the social and economic conditions that are expected to prevail at the time development occurs. Dr. Maki and his staff assumed the simplest situation with respect to timing - namely that crop production, peat mining, peat gasification and distribution, and peat coke production will commence simultaneously in 1985. Construction for these operations will be conducted in 1982, 1983 and 1984.

Projected Impacts

The socio-economic impacts that could result from the realization of either scenario I (synthetic natural gas sold outside of the study region) or scenario II (some synthetic natural gas is sold within the study region) were estimated using SIMLAB. SIMLAB is an acronym for the regional socio-economic computer model developed at the University of Minnesota for the quantitative analysis of the socio-economic effects of events such as peatland development. The model analyses three different levels of socio-economic impacts. The first level referred to as direct effects, are changes in the volume of production, employment and earnings to the peat industries and to firms in the study area that furnish supplies, materials and services to peat-related industries. Indirect effects, the second level of impact refers to similar changes in other business firms that furnish goods and services to directly-affected firms. Finally, household spending of peat industry payrolls generates the third level of impacts - the induced effects on the retail, wholesale and service sectors of the area economy.

Although many of the socio-economic impacts will differ, depending on whether scenario I or scenario II is considered, the direct effects are essentially independent of the marketing alternative chosen. The direct effects of peatland development are summarized in Table 9 for the years 1985 and 2000. The effects have been estimated by demonstrating changes in the following: 1) gross output (the value of the goods produced at the producer's price); 2) employment; 3) earnings (number of workers employed by the

TABLE 9. DIRECT EFFECTS OF PEATLAND DEVELOPMENT AS REFLECTED BY CHANGES IN GROSS OUTPUT, EMPLOYMENT, EARNINGS AND INTERMEDIATE PURCHASES IN THE YEARS 1985 AND 2000 IN THE EIGHT COUNTY STUDY REGION[1]

Peat Industries	Gross Output (Value of Production at Producer's Price) In 1970 Dollars		Employment		Earnings (#workers X worker earnings) In 1970 Dollars		Intermediate Purchases[2] (Materials & Services from Study Area Firms) In 1970 Dollars	
	1985	2000	1985	2000	1985	2000	1985	2000
Peatland Agriculture	6,000,000	9,000,000	150	100	1,200,000	850,000	1,380,000	2,140,000
Peat Mining	59,000,000	65,000,000	1120	1160	14,300,000	18,500,000	13,500,000	15,600,000
Synthetic Gas & Chemical By-Products	182,000,000	217,340,000	1260	1300	14,700,000	21,000,000	26,150,000	30,110,000
Peat Coke	3,000,000	4,000,000	30	30	350,000	510,000	620,000	810,000
Synthetic Gas Distribution	170,000,000	196,000,000	225	225	2,126,000	2,600,000	11,760,000	13,580,000
TOTAL	420,000,000	491,340,000	2785	2815	32,676,000	43,460,000	53,410,000	62,240,000

1. All figures have been rounded off

2. These figures exclude the purchase of goods from other peat industries - for example the purchase of peat for the peat coke industry from the peat mining industry.

industry times average earnings); and 4) intermediate purchases (the value in producer's prices of materials and services supplied to the peat industries by other study area business firms - excluding materials and services purchased from other peat industries). In order to establish a basis for comparison, all dollar figures have been expressed in terms of 1970 dollars.

The figures in Table 9 clearly demonstrate the direct effects of peatland development. The peat industries alone create nearly 3,000 new jobs in the eight county study region.

Although the direct effects of development are independent of the marketing alternative chosen for synthetic natural gas, the indirect and induced effects of development are dependent on whether scenario I or II is chosen. Scenario I is the easiest to model and will be discussed first.

It was mentioned earlier that construction was projected to occur during 1982, 1983 and 1984, while plant operations would commence in 1985. Because 1985 was considered a transition year, when peat industries are just beginning production, it was more appropriate to consider 1986 for initially investigating the total impact (direct, indirect and induced) of peat development. A summary of the impacts over the eight county study region is presented in Table 10.

Changes in the impact indicators between the years 1986 and 2000 illustrate again the socio-economic impacts of peatland development. The figures in Table 10 were derived by considering the potential impacts of peat development on all industries in the study region. Overall, the total impacts were absorbed primarily by three industrial segments: trade, services (e.g. medical services, lodging and private education), and public administration (e.g. state offices and public education). An explanation for the decrease in employment and population between 1986 and 2000, is complicated. However, the prime reason is the trend toward increasing worker productivity in the taconite and manufacturing industries.

The scenario for the second marketing alternative, whereby a portion of the synthetic natural gas produced is sold within the study region as a substitute for curtailed supplies of natural gas, is considerably more difficult to model. Substituting synthetic natural gas derived from peat could make continued study area economic growth possible. However, it is possible that a cutback in the rate of study area business expansion might offset some of the positive impacts of peatland development. If the peat derived gas is more expensive than natural gas, then growth may proceed more slowly due to higher energy costs.

Computer runs were made in an effort to demonstrate these effects. However, during the fifteen year period between the years 1985 and 2000 no such impacts were detected. This conclusion is contingent on assumptions made by the investigators that are explained in their report.

TABLE 10. A SUMMARY OF THE DIRECT, INDIRECT AND INDUCED EFFECTS OF PEATLAND DEVELOPMENT AS REFLECTED BY CHANGES IN EMPLOYMENT, POPULATION, EARNINGS AND GROSS OUTPUT IN THE YEARS 1986 AND 2000 IN THE EIGHT COUNTY STUDY REGION.[1]

Impact Indicator	Baseline Option		Development Option		Impact	
	1986	2000	1986	2000	1986	2000
Employment	181,000	155,000	193,000	173,500	+12,000	+18,500
Population	379,000	317,500	398,000	348,000	+19,000	+30,500
Earnings (1970 Dollars)	1,475,899,000	1,553,735,000	1,571,620,000	1,735,528,000	+95,721,000	+181,793,000
Gross Output (1970 Dollars)	4,484,519,000	5,551,965,000	5,114,026,000	6,420,841,000	+629,507,000	+868,876,000

1. All figures have been rounded off.

RED LAKE INDIANS

The previous study has addressed many of the important socio-economic considerations associated with peatland development. By investigating impacts over the entire eight county study area it has provided a valuable regional perspective of the potential development. Yet, despite the necessity of examining impacts at a regional level, many local interests can be equally important. An important local interest in the peatlands of northern Minnesota is the Red Lake Band of the Chippewa Indians. The federal government owns approximately 25% of the peatlands in this area. However, virtually all of the federally administered land is represented by the Red Lake Indian Reservation. In fact, the Red Lake Indians are the largest non-state holder of peatland in the entire upper Great Lakes region.

The land owned by the Indians consists of the diminished reservation and the ceded lands. The diminished reservation consists of a solid block of land 636,964 acres in size, bordering the Upper and Lower Red Lakes. The ceded lands consist of 156,690 acres of scattered tracts which extend northward to Lake of the Woods County. As a result, any attempt to utilize peat resources on state lands in this region would rarely be more than a few miles from Indian land.

Because of the importance of addressing the unique concerns of the Red Lake Indians legislative monies were used to fund a study by the Walter Butler Company of St. Paul, Minnesota. The purpose of the study was to identify and elaborate on the key environmental, social, and economic issues of the use or non-use of the peat resource on, or adjacent to, the Red Lake Indian Reservation. The study had three major focal points: 1) the acquisition of specific information about peat utilization on the reservation; 2) communication of information to the reservation residents; and 3) compilation of an inventory of opinions and attitudes of Red Lake residents toward peat development. Titled "Peat Utilization and the Red Lake Indian Reservation" the study has been completed and was submitted to the Minnesota Peat Program in February, 1978.

The legislative study emphasized the unique legal status of the Red Lake Reservation. Classified as a "closed reservation" the land is communally owned by the tribe. All legal, social and economic development aspects of reservation life are managed by the Red Lake Tribal Council. The State has no jurisdiction over these activities. As a result, the Tribal Council is the dominant political force over a major portion of the peatlands in the area. The tribe's participation in the formulation of a management policy for peat is therefore essential to the effectiveness of that policy.

To evaluate the potential impacts of peat development on the Red Lake Indians it is necessary to understand the tribe's dependence upon the primary resources of the peatland wilderness. The principal economic activities of reservation residents are fishing, forestry, and wild rice harvesting. In addition, hunting is considered to be much more than a sport by the Indians. Game taken from the land provides a major year-round food source. It has been estimated that over 50% of the Indian's food supplies are derived from wildlife and fish alone. Because all of these activities could be significantly affected by attempts to utilize the peat resource in the Red Lake area it is important to examine each of these economic activities in more detail.

Fishing

Fishing has long been a way of life for the Red Lake Indians. Established in 1929, the Red Lake Fishery has become the major source of employment and income to the tribe. Nearly two-thirds of the non-public employment is generated by this resource. In 1977 the Fishery produced over 1.5 million pounds of fish; this excludes a substantial amount of fish caught for personal consumption by the Indians.

The tribe harvests fish from the Upper and Lower Red Lakes. Of the many different fish species these lakes support, eight have acquired a commercial value: walleye, yellow perch, whitefish, northern pike, goldeye, sheepshead, black bullhead and white sucker. The walleye and perch catches provide nearly 50% of the total catch and are thus the most economically important to the area. Although the total harvest of all species has varied considerably from year to year, commercial fishing on the Red Lakes has generally prospered for many years.

Because of the importance of the Red Lake Fishery to the reservation residents the existing water quality of the lakes must be safeguarded to insure a continued abundance of fish. Many literature sources however have documented the sensitivity of fish populations to changes in the following water quality parameters: oxygen, pH, dissolved and suspended solids, temperature, color and toxic substances. Preliminary studies have also indicated that fish could be adversely affected by any one of these possible water quality changes. Because any reduction in the amount of fish available to the fishery would have a severe impact on the Red Lake economy, the impacts of peat development upon water quality must be properly addressed.

Forestry

The Red Lake Indian sawmill, located at Redby, Minnesota, has been a source of reservation employment and income for over half a century. Over one-third of the non-public employment on the reservation is provided by the mill. The mill's level of production however, has varied considerably in recent years. During the ten year period between 1966 and 1976, the mill attained its desired level of production only once, during the 1969 fiscal year.

The problems with profitability in the mill are the result of basic changes in the raw materials available. Ever since the availability of pine has diminished the mill has been facing extreme difficulty keeping production up to profitable levels. The concensus of several studies that have been commissioned by the Tribal Council is that the sawmill must expand its utilization of the more predominant timber types, primarily aspen and black spruce.

The potential utilization of Minnesota's peat resource could affect the forestry activities of the Red Lake Indians through its impacts on ground and surface waters. Depending on the type and scale of development the water impacts are likely to be directly transferred into forest impacts since trees have a narrow tolerance for changes in the water table. Methods of peat harvesting that involve drainage will lower the water table in the immediate working area while raising the level in the area to which the water is drained. Raising the water level in the surrounding area is of prime importance. A temporary rise of the water level in conifer lowlands, sufficient to cause flooding for just a few months, is enough to kill the tree growth. Modest long term rises in the water level will retard the growth of the trees. On the other hand, lowering the water table in lowlands bordering a peat utilization site could benefit timber growth.

Compared to the significance of the impacts associated with changes in the water table, changes in water quality are not expected to be critical. Lowland trees apparently have a wide range of tolerance for different levels of acidity.

The fibric peats of the raised bogs support a very poor growth of trees, growth that, for the most part, is less than that required for commercial forest production.

Wildlife

For hundreds of years the Red Lake Indians have hunted, fished and foraged for all their food needs. Today fish, venison, moose, partridge, grouse and ducks still comprise a large portion of the diet of reservation residents. The area's rich wildlife diversity has sustained the Indians dependence upon these primary resources.

Peat utilization could affect the area wildlife in a variety of ways. The most prominent impact would be the destruction of habitat, forcing animals to move elsewhere in search of food and cover. The introduction of heavy motorized equipment for harvesting, transporting and processing peat products could also pose a serious threat to wildlife. Scientists have just begun to direct their attention to the effects of noise on the wilderness inhabitants.

The extraction of peat deposits is also likely to result in the formation of a series of ponds. Presumably these shallow ponds could support more waterfowl and water-dependent mammals than the present bog habitat, although the increase would be at the expense of the more land-dependent wildlife. The possibility that peat development may negatively affect water quality must also be considered in light of the potential impacts to wildlife. Because game taken from the land constitutes a major year-round food source for the reservation, negative impacts to the area's wildlife would constitute a severe impact to the Red Lake residents.

Wild Rice

Wild rice occurs naturally in several locations on the Red Lake reservation. The region's flat topography, abundance of moisture and cool temperatures provide very favorable growing conditions for the grain. The Red Lake Indians have harvested naturally growing wild rice in the area for many years. Long before the arrival of the white man in the Red Lake area, the Indians were harvesting the grain for food and as a medium for trade.

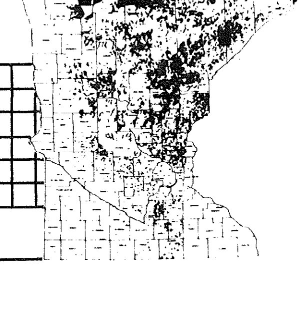
Today the tribe considers wild rice as the one agricultural product with the greatest potential for expanded development. In addition to those areas where the grain naturally occurs, approximately 54,000 acres of land within the reservation have been designated as potentially suitable for wild rice production. The tribe's long range plans are to develop, for commercial production, approximately 50,000 acres. Inspite of some harvesting problems that are unique to grasses such as wild rice, the Red Lake operation had 140 acres under cultivation in 1977.

Peatland utilization could affect wild rice production in a variety of ways. The extraction of peat could result in the actual destruction of areas that presently support growths of wild rice. Drained methods for extracting peat could also lower the water table in some areas and thereby expose surfaces that were once covered by water. Under such conditions the reseeding cycle for wild rice would terminate. Other potentially negative impacts that should be properly addressed include: 1) changes in water quality; 2) the release of particulate matter by different harvesting procedures; and 3) the possible release of heavy metals by harvesting and refining techniques. On the other hand, the removal of peat offers an opportunity to develop a reclaimed area into a large scale, high production wild rice site.

The Red Lake residents are relatively well-informed on the peat issue. Their attitude and opinions are based on a good under standing of the many aspects of peat use. The Tribal Council unanimously opposes any form of peat development in the area, including peat development by the tribe. This is based on the belief that the potential value of the peat resource does not exceed the risk of adversely affecting the reservation's principal resources of fishing, forestry, wildlife and wild rice. The tribe feels that they are presently utilizing their peat resource in the best manner possible - as a habitat for wildlife, land for forestry and a water source for the Red Lakes.

4 PEAT UTILIZATION OPTIONS

PRESERVATION
FORESTRY
AGRICULTURE
HORTICULTURE
INDUSTRIAL CHEMICAL TECHNOLOGY
ENERGY



The development of a management plan that provides for the wise utilization of Minnesota's peat resource will be a difficult, though challenging task. In addition to characterizing the peatland environment and the socio-economics of northern Minnesota, the establishment of a management policy for the use of peatlands requires that the options available for utilizing the resource also be reviewed. Including both non-consumptive and consumptive uses, the six major options presented in the following pages include: 1) preservation; 2) timber production; 3) agriculture; 4) horticulture; 5) industrial chemicals; and 6) fuel. The latter category includes both direct burning, to generate electric power and/or heat, and peat gasification, to produce synthetic natural gas (SNG). A schematic diagram of all six options is presented in Figure 1. With the exception of peat gasification, each option has been investigated during various phases of the Minnesota Peat Program. The technology and feasibility of converting peat to SNG is being investigated by the Institute of Gas Technology.

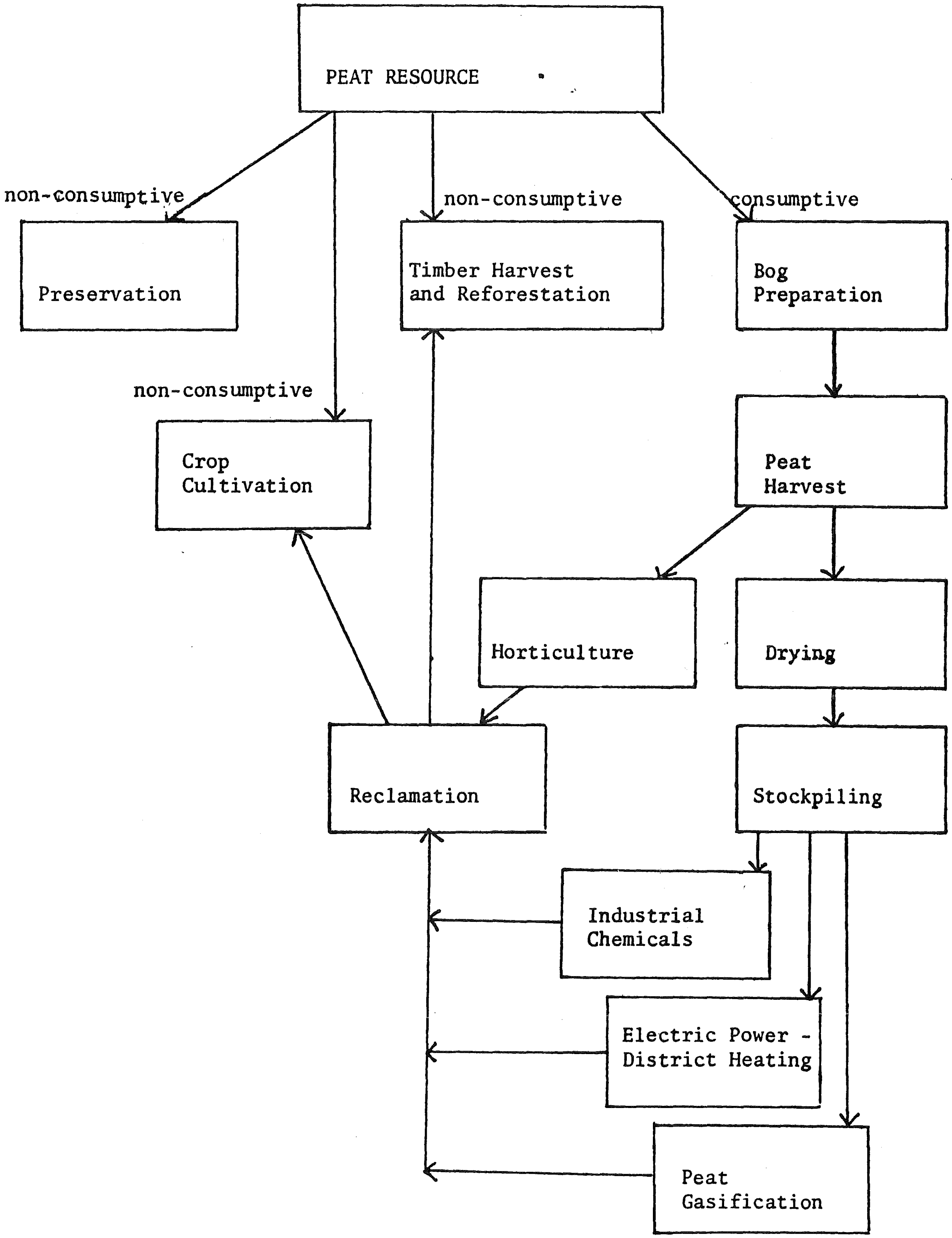


Figure 1. Options for utilizing Minnesota's peatlands

Non-Consumptive Utilization Options

Non-consumptive options for utilizing Minnesota's peatlands are options that do not involve extraction of the peat deposits. Three utilization options have been designated as non-consumptive 1) the preservation of peatlands; 2) the production of commercially valuable timber; and 3) the production of various agricultural crops.

PRESERVATION

The peatlands of Minnesota are among the last of the large undeveloped wilderness areas in the United States. Less than 10% of Minnesota's seven million acres of peatland have been developed, leaving more than six million acres that are still relatively undisturbed. Within this expansive wilderness are areas that support unique flora and fauna, represent unusual peatland types (e.g. raised bogs, string fens, ...), or contain peat profiles that exhibit important palynological records. Careful management of Minnesota's peatlands should include their preservation.

A Peatlands of Special Interest Task Force has been formed to act as a technical advisory committee to the Minnesota Peat Program. Members of this group will develop criteria for selecting peatlands of special interest and to identify areas of priority. To assist the task force, a statewide aerial photo inventory of 22 peatland features is being compiled by Paul Rundell, from the Department of Natural Resources in Bemidji. The diversity and abundance of these features within different peatlands will serve as an indicator for areas of special interest.

Criteria

Criteria for identifying peatlands of special interest have not been finalized. In the interim, the criteria established by the National Natural Landmarks Program, of the Heritage, Conservation, and Recreation Service, and the Scientific Areas Preservation Council, of the Wisconsin Department of Natural Resources, will be used as a guideline.

To be eligible for National Natural Landmark designation, a site must be:

1. An outstanding geological formation or feature significantly illustrating geologic processes;
2. An illustration of significant fossil evidence of the development of life on earth;
3. An ecological community significantly illustrating characteristics of a physiographic province or a biome;
4. A biota of relative stability maintaining itself under prevailing natural conditions, such as a climatic climax community;
5. An ecological community significantly illustrating the process of succession and restoration to natural condition following descriptive change;
6. A habitat supporting a vanishing, rare, or restricted species;
7. A relict flora or fauna persisting from an earlier period;
8. A seasonal haven for concentrations of native animals, or a vantage point for observing concentrated populations; such as a constricted migration route;
9. A site containing significant evidence illustrating important scientific discoveries; and
10. An example of the scenic grandeur of our natural heritage.

(Federal Register, Vol. 40, No. 87, p. 19503-19508).

The ranking system used by the Wisconsin Department of Natural Resources is divided into four major categories:

1. Determinants of natural area value (biological characteristics), including quality, commonness, and community diversity;

2. Physical characteristics and use value, the former including size and buffer considerations;

3. Degree of threat; and

4. Availability.

(The Michigan Botanist, 1874. Vol. 13:31-39).

Identification

Identification of peatlands of special interest according to the criteria systems available is difficult because of the lack of information regarding the distribution and abundance of plants, animals and other ecological features found in Minnesota peatlands. At present until more information becomes available, there are three methods for identification:

1. Areas that have already been officially designated;

2. Areas that are nominated by an informed individual or group; and

3. Areas that contain features that are identified from aerial photographs and are recognized as rare or unique.

Designated Natural Areas

There are areas within the Minnesota peatlands that have already been designated as areas of special interest. The National Natural Landmark Program has identified the Upper Red Lakes Peatlands and the Lake Agassiz Peatlands as areas worthy of this status.

The Upper Red Lakes Peatland was designated a national natural landmark by the Secretary of the Interior in May, 1975. The area is located in Beltrami County, north of Upper Red Lake, and encompasses 137,920 acres. This tract of land is part of the largest peatland remaining in the State of Minnesota and one of the largest in the coterminous United States. It is vast, remote, essentially undisturbed, and has outstanding scenic qualities. As a diversely patterned peatland this national natural landmark illustrates a variety of geological features and plant associations, particularly ovoid island patterns and the unusual string bog.

The Lake Agassiz Peatlands were designated a national natural landmark in 1965. The area is located in south central Koochiching County where it encompasses approximately 22,000 acres. Myrtle Lake, located within the Lake Agassiz Peatlands, is a classic illustration of an unusual natural phenomenon. Researchers have found that the surface of the peat bog surrounding the lake has naturally "built up" over the centuries, thus raising the water table and elevating the lake's surface approximately 12 feet. The Agassiz Peatlands also include examples of raised and patterned bogs.

Other areas that have been recognized by either state of federal agencies as meriting special consideration include the Tamarack-Lost Rivers peatland area in southern Koochiching County and the North Black River peatland area in northern Koochiching County.

FORESTRY

The production of commercially valuable timber is a second major option for the non-consumptive use of Minnesota's peatlands. Described earlier, the Phase II vegetation study conducted by personnel from the College of Forestry at the University of Minnesota, included an evaluation of the significance of the peat resource to Minnesota's timber industry.

Technical Background

Peatlands are of significant importance to Minnesota's timber industry. Approximately 60% of Minnesota's 7.2 million acres of peatlands are forested. Peatlands located in seven northern Minnesota counties (Aitkin, Beltrami, Carlton, Itasca, Koochiching, Lake of the Woods and St. Louis) contain more than 2 million acres of commercially valuable timber. Peatlands located in southern Minnesota however, are generally small, scattered and non-forested.

The major peatland forest types in north central Minnesota include black spruce, tamarack, white cedar, and lowland hardwoods (black ash and American elm). The total areage of each type in the seven northern counties listed above is as follows:

Forest Type	Acreage
Black Spruce	926,100
Tamarack	389,300
White Cedar	351,300
Lowland Hardwoods	599,000
	2,265,700

Black spruce is the most widely used peatland species. Not only is it the most important in terms of acreage and volume harvested, it is also of the highest economic value. The long fibers and bleachability of black spruce make it a highly desirable species for use in the manufacture of high quality papers. Minor uses include poles, lumber and Christmas trees. Among the other peatland species tamarack is used for fence posts, poles, siding, lumber, shakes and paneling. The major lowland hardwoods, black ash and elm, are used for lumber and furniture.

Possible repercussions to Minnesota's timber industry that would result from the development of peatlands could be significant. There are, at present, twelve mills in Minnesota which process wood pulp for various kinds of paper and other wood fiber products. These mills depend, with minor exception, on Minnesota forest resources. At least four of these mills depend upon large volumes of black spruce for processing high quality paper. In 1976, 24% of the pulpwood produced in Minnesota came from Minnesota's peatlands. Based upon 1976 stumpage prices the spruce and tamarack harvested in the peatlands of Koochiching County alone generated a return of over $5 million. In light of this, any significant loss of commercially productive peatlands would be a matter of critical concern.

Feasibility

Timber harvested from Minnesota's peatlands has contributed significantly to the state's timber industry. To date however, a comprehensive plan for managing the forest resource of Minnesota's peatlands does not exist. Logging contracts are dealt with as they arise while the subsequent management of clearcut areas depends upon available funds. If the timber production of Minnesota peatlands is to be encouraged and expanded, several recommendations are appropriate. First, more intensive forestry practices should be applied in areas where commercially productive timber is presently growing and in areas where it has been recently harvested. More intensive forestry practices might also be applied to unproductive swamp shrub areas by converting them to the more productive black spruce. Finally, to the extent that any acreage of productive spruce forest is destroyed by harvesting the peat, it is recommended that the area be reforested to spruce to maintain at least the present level of growth of that important species.

AGRICULTURE

The production of agricultural crops is the third major option for the non-consumptive use of Minnesota's peatlands. The objectives of the Phase II study conducted on agricultural production were threefold. First, the study undertook an inventory of all peatlands that are currently utilized for agricultural production. The second objective was to gather data concerning the major operational problems and current management practices of peatland cultivation. In light of the complex hydrology of peatlands, cultivation might pose unique problems for the farmer. Finally, an extensive literature review was conducted of all current agricultural uses of peatlands, including the type of crops, the suitability of peatlands for agricultural cultivation and the management problems associated with cultivation. Dr. R. S. Farnham, a professor in the soil science department at the University of Minnesota, was responsible for conducting the study. His study was entitled: "Status of Present Peatland Uses for Agricultural and Horticultural Peat Production." Horticultural peat production will be discussed under the "Consumptive Options" section heading.

Technical Background

Approximately 8.7% of Minnesota's peatlands are utilized for agricultural purposes. They are used primarily for hay, pasture or forage crops, which accounts for 519,407 acres of 665,845 acres that are under agricultural cultivation. The cultivation of row crops, such as corn and soybeans, ranks second in importance (89,284 acres) while the cultivation of wild rice ranks third (18, 507 acres).

The best peatland crops are ones that have either short growing seasons or the ability to withstand occasional light frosts in late summer and early fall. Currently the main commercial crop in Minnesota is carrots. Their importance as a peatland crop is prompted by several factors including the ease with which they are harvested from the rich organic soil and the ability to control their length (to some degree) by controlling the height of the water table. An average yield for carrots in peatland soils may be as high as 10 tons per acre. Other commercial crops grown in Minnesota include cabbage, cauliflower, celery, potatoes, cultured sod, lettuce, radishes and onions.

Many of the peatlands in Minnesota that are used for agricultural production are located in the southern two-thirds of the state. Three southern counties, Faribault, Freeborn and LeSueur, currently use over half of their peat resources for agricultural production. Although most of the state's peatlands lie in northern Minnesota, the significantly shorter growing season of the region has hereto prevented extensive cultivation.

Farming organic soils is a highly specialized enterprise which requires different technology than farming mineral soils. The successful utilization of peatlands for agricultural production depends upon consideration of several important factors. As mentioned above, the suitability of a crop to the soils and climate of peatlands must be carefully considered. Other important management factors include drainage, water-level control, prevention of shrinkage, frost control and fertility.

Feasibility

At the present time there are a variety of crop plants suitable for growth on Minnesota peatlands. In addition to the traditional vegetable, grain, and forage crops, promising new crops include wild rice and high-protein grasses. The feasibility of a particular peatland for crop production depends on several factors. Peat thickness, type of mineral substrate underlying the peat, ability to drain the peatland and the chemical and physical properties of the peat must be evaluated when considering agricultural development. In the event that some of Minnesota's peatlands are considered for energy development, their subsequent use for crop production should also be considered as a reasonable option for reclamation.

Consumptive Utilization Options

Consumptive options for utilizing Minnesota's peatlands involve the removal of peat deposits. Three major consumptive options include the production of: 1) horticultural peat products; 2) industrial chemicals; and 3) fuel (gasification or direct burning).

At some point in the production process all of the above options require extracting water from the harvested peat; the amount that must be removed varies among the options, ranging from approximately 30-50%. Before it is harvested, the average water content of peat is approximately 94%. Because the water is held in suspension with the associated organic matter, it cannot be extracted easily. The drying process currently utilized by most European countries is to fragment the harvested peat in order to maximize the surface area and facilitate air and sun-drying. Air, or sun-drying, has apparently been sufficient for the small-scale technology that has been developed to date, but is likely to be insufficient for the large-scale development that may utilize peat for either gasification or direct combustion. The Minneapolis Office of the U. S. Bureau of Mines has recently been conducting tests involving peat mining and mechanical dewatering techniques. The purpose of the tests is to develop a method of extracting and drying peat more efficiently and economically in the quantities required to operate a large-scale gasification plant. Preliminary tests were conducted at Pine Island Trail near Waskish, Minnesota and in Vancouver, British Columbia. These tests were of such short duration that insufficient data were obtained to provide conclusive results. The lack of appropriate technology for water removal is currently a major obstacle for utilizing peat for either gasification or direct combustion.

HORTICULTURE

The study of horticultural peat production, a consumptive option for utilizing Minnesota's peat, was conducted by Dr. R. S. Farnham of the University of Minnesota. Included as part of his Phase II study on agricultural peat production summarized earlier, Dr. Farnham's objectives were to inventory all peatlands in Minnesota that are currently utilized for horticultural production and to review the pertinent literature regarding the utilization of peatlands for horticultural purposes.

Technical Background

Less than .02 percent of Minnesota's peatlands (1400 acres) are utilized for the production of horticultural peat products. These products include sphagnum peat moss, reed-sedge peat, potting soil, and growing mixes. The major use for all the peats sold in the United States is for improving lawn and garden soils. Although the bulk of it is sold in packaged form (bales or bags) in garden supply stores, some domestic peat is sold in bulk for landscaping purposes and golf courses.

The largest commercial peat project in Minnesota is located in Carlton County. This development is owned by the Michigan Peat Company and utilizes 840 acres, or .7% of Carlton County's

123,294 acres of peatland. Other commercial operations are located in Aitkin, Itasca and St. Louis Counties.

There are three methods currently used for the harvest of peat for horticultural purposes - the milled peat method, the hydro-peat process and the machine-cut method. Because of the size of the machinery required for the milled peat method, large level bogs are necessary. An average peat depth of 6.5-10 ft, with reasonably level bottom contours is also needed. The hydro-peat process has advantages in areas with large quantities of woody material while the machine-cut method has advantages in being applicable even during periods of wet weather.

Feasibility

The feasibility of expanding Minnesota's commercial horticultural peat industry depends upon several factors. The quality of the peat, including its degree of decomposition and root content are among the most important factors. The extent of our present reserves is also an important consideration. Dr. Farnham estimates that Minnesota has approximately 20,000 acres of high quality sphagnum moss peat and at least one million acres of good quality, moderately, decomposed reed-sedge. Dr. Farnham defined the term 'high quality' as referring to those deposits that are approximately 7 ft. in thickness and are of potential commercial interest. Other important factors include the location and accessibility of the reserves, the feasibility of drainage, the availability of lands, the harvesting technology and local climatic conditions.

There are good prospects that the horticultural peat industry in the U. S. will continue to expand as the demand for these products continues to increase. Between 1972 and 1977 the U. S. production of horticultural peat products has increased from 900,000 short tons to 1.3 million tons. Nevertheless, during the same time period, Minnesota's production remained level.

INDUSTRIAL CHEMICALS

Minnesota peat is also of potential interest as a source of industrial chemicals. Its complex chemical composition can be of considerable economic value. When many of the separate chemical components are recovered they can acquire the high monetary values associated with specialty products. Although peat has long been used as a raw material in Europe for the production of a wide variety of chemical products, similar uses have yet to be initiated in American industry.

In Phase II of the Minnesota Peatland Program, Dr. C. H. Fuchsman, Director of the Center for Environmental Studies at Bemidji State University, conducted a study titled "The Industrial Chemical Technology of Peat." Dr. Fuchsman's study summarized the available literature and the information he gathered while visiting research institutes in Russia and Denmark and while attending a peat workshop in Germany.

Technical Background

The industrial chemicals produced from peat can be grouped into four major categories. Chemical products in three of the categories are produced by extractive methods that use low to moderately high processing temperatures. They include: peat bitumens, peat carbohydrates and peat humic acids. Pyrolytic methods, or methods that use high processing temperatures that significantly alter the peats' chemical composition, generate the fourth category of chemical products represented primarily by peat coke.

The term peat bitumens refers to components of peat that can be extracted using conventional organic solvents. Chemically they are a mixture of paraffin, terpene and aromatic hydrocarbons, alcohols, acids, and esters. The major product these chemical components yield when processed is wax. Peat wax is quite similar to montan wax (wax derived from brown coal) and is used as a substrate for carnauba wax or beeswax, as an ingredient in shoe polish or furniture polish, as a waterproofing agent in paints and as an anti-blocking agent in plastics (i.e. an agent that prevents plastic sheets from sticking together). Foreign sources state that the highest wax contents are likely to occur in peats that are highly decomposed, particularly those containing residues of shrubs and trees. Peats that could be considered for commercial production should contain at least 5% wax (dry weight basis), although wax contents of 2 to 5% may be of marginal interest.

Peat bitumens may also be rich in steroids. In the Soviet Union, peat-derived steroids have been processed for chemotherapeutic use, especially for the treatment of skin and eye disorders.

Peat carbohydrates, when suitably treated, yield a sugar-rich food on which yeast can be grown. The yeast culture can be optimized either for the production of alcohol or for the production of high-quality protein supplements. Although there is a possibility that these supplements may be used in human foods in the future, their current use is primarily as an additive to livestock feed. Soviet criteria for the suitability of peats that will be processed to yield carbohydrates includes: 1) that they are derived from fens, 2) that their degree of decomposition does not exceed 20%, and 3) that their ash content does not exceed 5%.

Although their chemical nature is still not completely understood, humic acids also have an important use as industrial chemicals. Several properties of humic acids have prompted their extensive use in agriculture. Included among these properties are their ability to promote nitrogen and magnesium uptake by crop plants, their ability to improve root formation by seedlings and their ability to improve a crop's resistance to pests. Small volume industrial uses for humic acids include sizing for paper, an oil-well drilling mud additive and potential use as a raw material for the plastics and rubber industries.

The pyrolytic, or high temperature treatment of peat generates a carbon residue called peat coke and an oil condensate called peat tar. During the last few years, the principal use for peat coke has been the production of activated carbon. Characterized by its high absorptive capacity activated carbon has been used to remove pollutants from industrial waste gases and water. Peat coke is also useful for the production of specialty iron-alloys.

Peat suitable for coking should have a relatively high carbon content (on a dry basis) and should have little inorganic residue (ash). Generally, the greater the degree of decomposition the higher the carbon content, therefore some experts have recommended that the peat should be at least 35% decomposed with not more than 5% ash. For activated carbon production they recommend that the peat be at least 30% decomposed with not more than 6% ash.

Peat tar, which is essentially collected as a by-product of the pyrolysis of peat, is commonly burned to supply energy for the coking operations. It is also used as a source of phenols, fatty acids, solid paraffins, waxes, solvents, greases and pitch.

Feasibility

The first requirement for assessing the feasibility of manufacturing industrial chemicals from Minnesota peats is knowledge of their chemical composition. Peat is a variable material and not all peats are equally suitable for the manufacture of different chemicals. Funded with the 1977-1979 legislative appropriation, a study has been designed to characterize the chemical nature of Minnesota peatlands. The study is described in the following section titled "Current Studies."

The feasibility of the manufacture of industrial chemicals is also dependent upon the size of the commercial market and on the price and availability of competitive products. Peat wax for example, must compete with other waxes and, indeed, with other lubricants. Peat coke must compete with coke and other forms of carbon which come from coal, wood or oil. Peat as a source of carbohydrates must compete with carbohydrates derived from timber and agricultural products. In this regard the humic acids of peat have a special significance. If humic acids are used primarily for the production of chemical specialties (e.g. as soil conditioners) they will be in a very competitive market. If however, a large scale, high value use is developed for them, (e.g. as major ingredients in paints and plastics) they could become a valuable commercial commodity with far less competition. Another consideration in this regard would be to reduce any economic risk by constructing manufacturing plants that would have the capacity to produce several different industrial chemicals from the peat resource.

A final point to consider when contemplating the possibility of technological alternatives is the proposed scale of operations and the impact it would have upon the socio-economic environment. Over the course of 20 years, which is the approximate age of a manufacturing plant, the estimated minimum-sized plants for three of the above technologies would require the following acreages:

Peat carbohydrates	1200 acres
Peat coke	560 acres
Peat wax	220 acres

These values represent rather small commitments of land. Final estimates will depend largely on the quality of the peat and the depth to which it can be harvested. In addition, although detailed plant design and investment data are not available, except for coke plants, it appears likely that the minimum investment in peat chemical plants could range from a few hundred thousand dollars to something less than ten million dollars. In his study Dr. Fuchsman suggests that, by virtue of their size, and relatively modest demands for manpower and capital investments, chemical plants are not likely to be disruptive to the socio-political region in which they are established. Their economic benefits in the sparsely settled, relatively low income peatlands are likely to be significant.

Current Studies

To properly evaluate whether, and to what degree, the industrial chemical uses of peat constitute realistic policy alternatives for peatland management, it is essential to acquire chemical analytical data on Minnesota peat deposits. Presently there are two immediate needs for determining whether European chemical technology is relevant to Minnesota peat: 1) determination of the phosphorus and ash contents of peat to establish its suitability for the production of high-quality peat coke; and 2) determination of the bitumen content of the peat to establish its suitability for the production of wax. Somewhat less pressing are two additional information requirements: 1) determination of the soluble and easily hydrolyzable carbohydrate components to establish the peat's suitability for single-cell protein production; and 2) determination of the peat's humic acid content to establish its suitability for water purification use and for viscosity-control applications. Because this information is important for the formulation of a peatland management policy, legislative appropriations were used to fund a study designed to provide a preliminary analysis of Minnesota's peat. Directed by Dr. Fuchsman the study is titled "Analysis of Minnesota Peat for possible Industrial Chemical Use."

The sampling design of Dr. Fuchsman's study was to select six widely dispersed peat deposits; two each of the fibric, hemic and sapric classification. In each deposit five sampling points were chosen, one point corresponding roughly to the center of the deposit and four additional points about 2/3 removed from the center in each of the cardinal directions. Several samples, each taken at different soil depths, will be collected from each point.

Initially, samples from only three of the five sampling points at each deposit will be analyzed. These samples will be subjected to a preliminary screening analysis which will include phosphorus, ash and bitumen assays. Quantitative data on other constituents may be generated for many of the samples, where such data can be conveniently obtained in connection with the primary analysis. Such constituents might include humic acids and water soluble and readily hydrolyzable substances. A small number of samples will also be analyzed in greater detail by methods appropriate to the commercial use of peat for single-cell protein production and for use in water purification. Samples from the two remaining points will be analyzed in those cases where the initial analyses disclose phosphorous or bitumen levels of potential commercial significance.

In additon to these chemical analyses, a manual of practical analytical methods, employed by European laboratories in the chemical analysis of peat, will be assembled. The texts, where available originally in German, Russian, or other foreign language, will be translated. American analytical methods (e.g. from the coal industry) will also be included, for comparative purposes, or where otherwise pertinent.

At present, samples from four of the six peat deposits have been analyzed for their bitumen, ash and phosphorous contents. These areas have been identified as Pine Island, Norman Lake, Baudette and Salol. Preliminary tests were run to check the validity of the proposed methods of analysis and the suitability of equipment for the samples involved. On the basis of these tests appropriate procedures were selected. Results of the analyses are summarized in Tables 11, 12, and 13.

Regarding the bitumen analyses, it may be assumed that the wax content of peat will commonly be about 1/2 to 2/3 of the bitumen content. It is also likely that for wax contents less than 5%, peat cannot be economically harvested for wax production. Thus bitumen levels above 8% are required. However, as Table 11 indicates none of sampling sites appear to be rich enough in bitumens to warrant more commercial interest at present.

Table 11. Results of Bitumen analysis (Results represent raw data and may be corrected in final report.)

		% Bitumens in air-dried peat			
Site		1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.
Norman Lake	1	5.4	-	2.9	2.0
	2	3.1	8.2*	-	4.2
	3	4.0	3.9	4.2	4.2
	4	3.1	-	-	4.5
	5	5.4	4.6	2.8	3.0
Pine Island	1	7.0	-	-	-
	3	5.2*	-	-	4.0
	4	7.0	-	-	4.2**
	5	-	-	-	8.0
Salol	2	5.8	-	4.4	1.5
	3	4.0	7.1	7.1	4.1
	4	6.2	-	3.2	-
Baudette	9	3.8	-	-	4.1
	11	7.4	5.4	4.0	-
	19	5.8	-	4.9	2.9

* Average of two analyses

** Average of two analyses; one aberrant value rejected

Table 12. Results of Analysis for Phosphorus Content. (The samples are reported as parts of P per hundred parts of air-dried peat. Results are subject to correction.)

Site		1-2 ft.	4-5 ft.
Pine Island	1	0.032	0.034
	2	0.029	0.021
	3	0.033	0.024
	4	-	0.032
	5	0.056	0.036
Norman Lake NE	1	0.075	0.060
	2	0.061	0.046
	3	0.082	0.048
	4	0.070	0.061
	5	0.053	0.050
Baudette SW	1-19	0.049	0.048
	2-9	0.055	0.050
	3-11	0.055	-
	4-15	0.040	0.042
	5-7	0.039	0.048
Salol	1-2	0.046	0.026
	2-3	0.060	0.051
	3	0.051	0.053
	4	0.062	0.045
	5	0.063	-

Table 13. Results of analyses for ash content. (Results are subject to correction in the final report).

		% Ash in air-dried peat			
Site		1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.
Pine Island	1	5.1	4.2	4.2	3.5
	2	4.9	1.5	2.9	2.5
	3	7.7	4.0	2.8	2.4
	4	5.6	5.8	3.6	4.2
	5	8.3	7.1	12.0	12.0
Norman Lake NE	1	8.9	8.2	11.0	10.1
	2	0.3	7.5	8.2	8.3
	3	8.5	6.0	6.6	5.7
	4	7.9	7.7	10.5	8.9
	5	8.3	9.0	11.8	13.0
Baudette	1 - 19	8.2	-	-	9.6
	2 - 9	6.6	7.3	7.0	7.6
	3 - 11	8.2	7.5	8.8	11.5
	4 - 15	5.6	6.2	8.0	8.7
	5 - 7	6.2	5.9	8.7	8.6
Salol	1 - 2	5.2	5.6	7.0	9.7
	2 - 3	7.1	6.2	5.5	6.8
	3	6.1	5.6	5.6	6.0
	4	7.3	5.9	6.2	6.4
	5	6.1	-	-	6.6

The Pine Island Bog, however, had the largest portion of samples containing 7% or more bitumens.

Regarding the phosphorous analyses, peat coke of metallurgical grade may not have more than .06% P. Since coking reduces the weight of peat by 2/3 without removing any phosphorus, the air-dried peat should contain no more than .02% P. The phosphorus content of most of the Minnesota peat samples however, was considerably higher. Samples from Pine Island Bog have the lowest percentage of phosphorus of those analyzed.

Ash contents are not as critical as phosphorus. However, preferred ash contents in peat coke and in activated carbon are less than 15%, which requires ash levels below 5% in the air-dried peat. Table 13 demonstrates that about half of the samples from Pine Island Bog had an acceptable range of ash values for the production of coke or activated carbon.

In light of these results, the peat deposits located at Norman Lake, Baudette and Salol appear to be too low in bitumen content to support a peat wax operation and too high in phosphorus to support a peat coke operation. Peat from the Pine Island Bog however, appears to have higher bitumen content, lower phosphorus content and lower ash content than peat from the other bogs. It is of marginal interest, but may justify further study.

ENERGY

The last major option discussed is the utilization of peat deposits to provide fuel. Peat has been an important fuel in many countries for centuries. During the last few decades, the Soviet Union and several European countries have utilized their peat resources to generate electric power and to provide municipal heating. Peat has also been used for domestic heating in several countries. At present, about 25% of Ireland's energy supply is provided for by peat together with about 2% of the total energy supply of the Soviet Union. Other countries that utilize peat for fuel include Germany, Sweden and Finland.

Although the combustion of peat for electric power and heating is efficient and economical, the efficiency of the conversion of peat to synthetic natural gas is not fully resolved at this time. Several studies have suggested that the cost of converting peat to SNG is lower than the cost of converting either lignite or bituminous coal. Nevertheless, the technology for such conversion is still in its infancy and, to date, commercial operations do not exist.

Despite the extent of its peat deposits, the United States has not used the resource for energy production. In the past, the low cost and availability of other fuels such as wood, coal and oil, have delayed consideration of utilizing peat. However, in light of the recent increase in energy costs and the concern regarding their future availability, alternative sources of energy costs and the concern regarding their future availability, alternative sources of energy are now under consideration. Nevertheless, the State of Minnesota must view utilization schemes for its peatlands on a long-term basis. From a practical standpoint peat is a non-renewable resource. At best, it may have only a short-term effect on our energy needs, and even that effect may be marginal. Once the peat is gone we would still be faced with the problem of what to do next. At this point in our history we would benefit more by directing our efforts towards developing an energy source that would last longer than 10, 15 or 20 years. Because of the many potential uses for peat, some which could produce high-priced commodities while disturbing relatively small areas of land, uses requiring large-scale extraction of peat should not be given undue preference until priorities for the use of Minnesota peatlands have been established.

The following pages present a brief summary of the potential for utilizing peat for the production of synthetic gas and for electric power generation. Some of the information for these summaries was drawn from studies that were not directly funded by the Minnesota Peat Program. Their significance however deserves their presentation in this summary. Peat gasification studies were conducted by the Institute of Gas Technology through funding provided by the Minnesota Gas Company. A feasibility study for utilizing peat for power generation and municipal heating was conducted by a private consulting firm, Ekono, Inc., and funded through a special legislative appropriation.

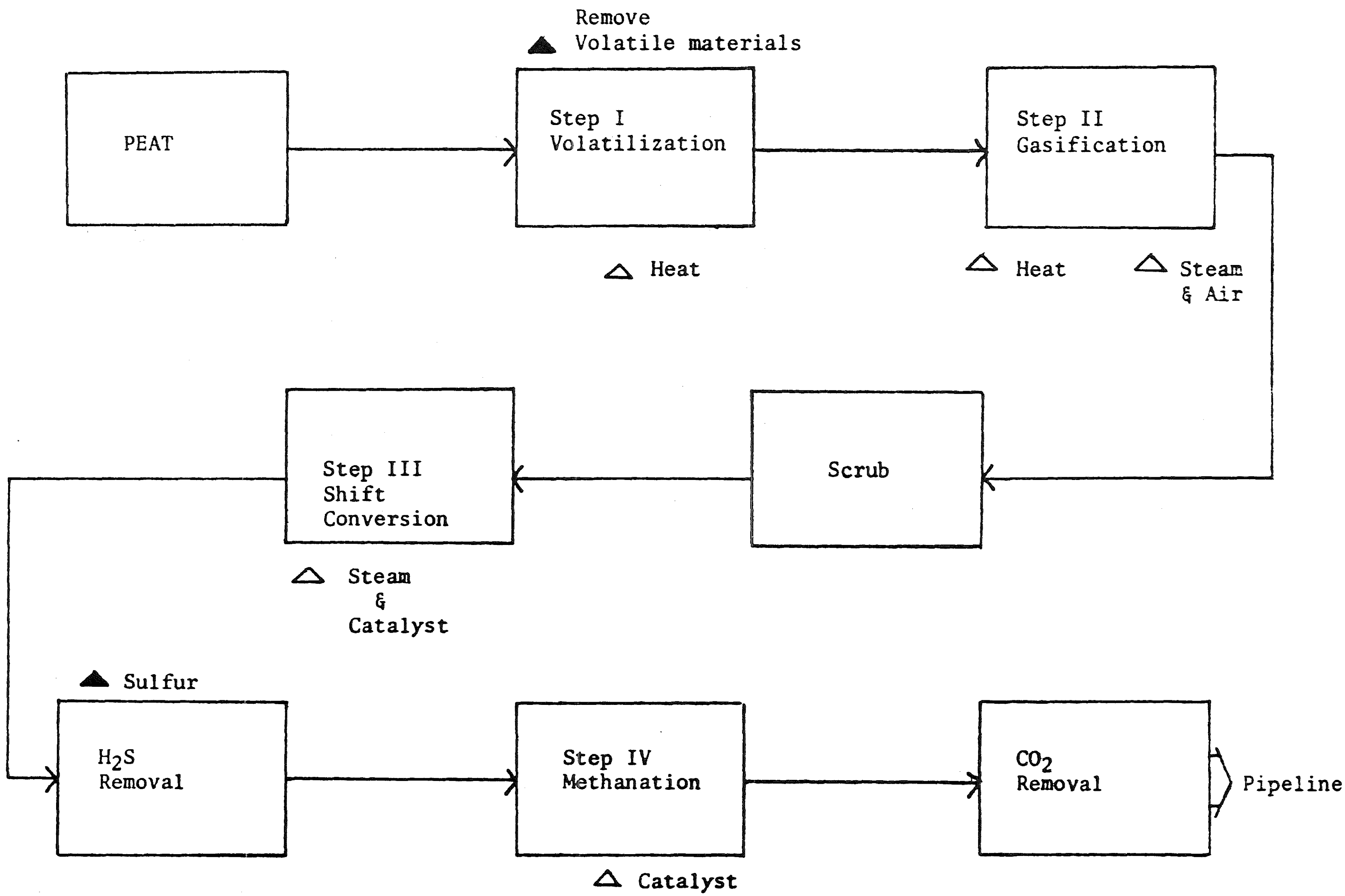


Figure 2. Basic Steps for Peat Gasification

PEAT GASIFICATION

Technical Background

Four basic steps are involved in the conversion of peat to synthetic natural gas (Figure 2.). As stated earlier, prior to any gasification operation the peat must be sufficiently dried; current studies indicate that peat can be processed effectively with moisture contents up to 50%. Once dried, volatile materials are separated from the peat via combustion and removed from the system. These materials include such products as benzene, toulene, xylene and phenol; high-octane products that may also be marketed. In the second step, oxygen and air are added (to supply hydrogen) and, upon heating, the peat is converted to a mixture of carbon monoxide and hydrogen. Various particulates and other unwanted products are then scrubbed from the system prior to the third step. Next, the mixture is passed through a catalyst bed, adjusting the carbon : hydrogen ratio to obtain the desired balance. Following the conversion, sulfur products are also removed. In the fourth and final step, the gaseous mixture is passed through a nickel catalyst which completes the conversion to methane (and waste carbon dioxide); a step that has yet to be commercially demonstrated.

As natural gas supplies continue to diminish, the need to convert various organic materials to synthetic natural gas is becoming urgent. Each of the two leading prospects for such conversion, peat and coal, have various advantages and disadvantages when compared with one another; several are listed on the following page.

1. Peat is more reactive than coal; as a result the time required for the gasification is much shorter than that for coal.

2. The higher proportion of volatile matter in peat results in the formation of larger quantities of oil compared with coal. About 25% of the feed carbon in the peat goes to oil. This is five times greater than in the case of coal (therefore a given amount of peat produces less synthetic natural gas than a given amount of coal - as stated earlier however, the oil by-products may also be marketed).

3. A given amount of peat will also produce less SNG than coal because of its lower heating value (Btu/lb.).

4. Although peat has a lower sulfur content than coal it has a higher ash content.

5. Peat gasification requires about 40% to 70% more oxygen than required in coal gasification, but consumes about 20% to 40% less steam than coal gasification.

6. About 50% more CO_2 has to be scrubbed out in the peat gasification plant compared with the coal gasification plant.

All of these considerations will have to be properly weighed when contemplating further development of the peat resources. However, in addition to these technical comparisons other considerations with regard to the location and availability of the resource must also be taken into account. Some of these considerations are presented below.

Feasibility

Because the technology for peat gasification is still commercially unavailable, many questions regarding the feasibility of such development in Minnesota remain unanswered. The Institute of Gas Technology is currently conducting research designed to develop a process for the conversion of peat to SNG and to evaluate its economics. If funding becomes available the process will be tested in an existing coal gasification pilot plant in Chicago.

Until these studies are completed, several other considerations regarding the feasibility of utilizing Minnesota's peat resource for the production of SNG may be presented.

As was mentioned earlier, one potential problem in peat gasification is the initial problem of removing a sufficient amount of water. Another problem is the large amount of peat required for the gasification operation. Midwest Research Inc. has estimated that approximately 56,000 tons a day (18 million tons a year) would be required for a full-scale plant to produce 250 million cubic feet per day of SNG. Over the 20-year operational lifetime of a full-scale plant, approximately 200,000 acres, harvested to a depth of six feet, would be required for operation. In comparison, approximately 20,000 tons of peat are now harvested in Minnesota each year. Despite the extent of Minnesota's peat resources the removal rate of peat for a gasification plant should be carefully considered. Because peat gasification can provide, at best, only a short term solution to our energy problems, this valuable resource might be utilized more wisely by selecting one or more of the other available options.

DIRECT BURNING

Technical Background

Peat is primarily used in Europe to generate electricity. The processes involved in generating electric power with peat are very similar to those involved in utilizing coal. Steam produced from the combustion of peat is used to turn the blades of the turbine and generate electric power. As in coal-fired power plants, the ash residue is deposited in a nearby pond while the gaseous residue is emitted from a tall stack. Peat-fired electric generating plants are common in the Soviet Union and several European countries.

The efficiency of any power plant, be it either peat-fired or coal-fired, is never 100%. All of the thermal energy of the fuel cannot be turned into electricity; a large quantity of heat remains in the steam that flows through the turbines. Even in large generating plants this heat loss may account for about 60% of the original energy value of the fuel. In many coal-fired plants this excess steam is condensed in cooling towers before it is discharged. Several European countries however, have utilized this waste heat in their peat-fired plants for heating water in a district heating network. Such an application is capable of reducing the original thermal loss of 60% to 20%.

As was mentioned earlier, in several countries peat is also burned within the home for heat. Peat used for domestic heating is generally in the form of small briquettes. Peat briquetting, currently carried out in Ireland, Sweden and the U.S.S.R., is a process by which milled peat is screened, dried and compressed into small briquettes to be used for both boiler firing and domestic heating.

The lower sulfur content of peat, as compared with coal, is an advantage when the fuel is directly burned for electric power or home heating. The negative effects of sulfur emissions from coal-fired plants upon local vegetation has been well-demonstrated. It is also anticipated that the NO_x emissions may be of less concern due to the lower nitrogen content of the peat fuel in combination with a lower flame combustion temperature in the furnace. However, the higher ash content of peat (10%) as compared with coal (4-6%) is a disadvantage in that more land must be cleared for disposing the ash. Another important disadvantage is the relatively low heating value of peat, which, when dried, is only about 2/3 that of an equal amount of bituminous coal. Peat's suitability as a fuel, however, depends largely upon its degree of decomposition. The hemic or sapric types of peat are most suitable. The higher the degree of decomposition, the higher the heating value of the peat.

Feasibility

Ekono, Inc. (a research-oriented Finnish engineering firm that has been active in the design of peat-burning installations in Finland) has prepared for the Minnesota Peat Program a report on the feasibility of utilizing Minnesota's peat as a fuel. The study located and evaluated four power and/or heating plants in northern Minnesota that could be converted to use peat as a fuel. Coal or natural gas are presently burned at each of the sites and supervising personnel at each plant expressed neither an interest or intent to utilize peat in the near future. At present, district heating or electric generating plants fired by peat are not economically feasible.

The preliminary screening for the selection of study sites was done in cooperation with the Department of Natural Resources (DNR), the Minnesota Energy Agency, and Ekono, Inc.. The main criteria for the selection were:

1. A satisfactory source of peat available within a reasonable distance (not more than 100 miles from the site). In most cases this distance is much less than 100 miles.

2. The potential uses must have a long operation time per year since the capital cost of the equipment is high.

3. The existing equipment should be easily convertible.

4. The selection should also include known possibilities for new plants.

Based on these criteria four study sites were selected: the city of Biwabik; the city of Hibbing; the Eveleth Taconite Company; and the city of Virginia. Since Minnesota's peat is not harvested for fuel its commercial price is not known. Therefore, the four potential peat users were evaluated by calculating how much the peat should cost in order to be competitive with other fuels. Conclusions from the four study sites are listed below:

1. Biwabik, Minnesota

Homes in the city of Biwabik are presently heated with natural gas, Because a large amount of iron ore lies underneath the city a recent proposal to move the entire town offered an opportunity to reevaluate its entire heating system.

A proposed district heating plant in the city of Biwabik could compete with electric heating at the present power price (the town buys its electric power). If the plant operating time were at least 3,000 hours per year, peat would be less expensive than oil if the peat cost $1.00/million BTU ($9.00 per ton of peat received at the plant). However, district heating cannot compete with the present price of natural gas as used in the individual homes and by other consumers within the district heating areas.

2. Eveleth Taconite Company

The iron ore pellet plant at the Eveleth Taconite Company uses a significant amount of fuel in its rotary kilns. Normally No. 2 fuel oil has been used, but a conversion to coal is going on. Since we cannot, at this point, see any reason why a similar conversion to peat cannot be done, the taconite plant was chosen as a target for further study.

Peat was deemed suitable for use in the taconite pelletizing kiln because the operating load appears steady throughout the year and the kiln produces waste heat which could be used for predrying the peat. Using peat as fuel would be less expensive than oil if the peat cost were $3.00/million BTU ($18.00 per ton as received at the plant). Conversion from oil firing to peat is slightly more expensive than conversion to coal. To be competitive, peat would have to be 20 to 40 cents per million BTU less expensive than coal, depending on the coal source.

3. Hibbing, Minnesota

The Public Utilities Commission of Hibbing operates a district heating power station, which consists of three coal-fired steam boilers and four turbines. District heating is supplied by steam extracted from the turbines. Because this station supplies both heat and electricity to the city it produces a relatively high load throughout the year. Furthermore, because the boilers have been fired with coal, they can be easily converted so that they may be fired with peat.

Modifications of the district heating power station for peat-firing would involve a major additional cost for a peat receiving, unloading, and storage system. The additional investment cost would be about $2.5 million. Additional fixed yearly cost, including personnel and maintenance, would be approximately $425,000. To break even with the total cost of coal usage, peat would have to be 17 cents per million BTU less expensive than coal.

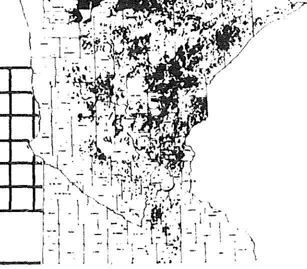
4. Virginia, Minnesota

The heat and power demands for the city of Virginia were used as a case study for constructing a new district heating power station. The capital cost of the plant designed for peat-firing would be $35 million; for oil-firing, $22 million; and for coal-firing, $31 million. If the plant operating time were at least 3500 hr/yr, using peat as a fuel would be less expensive than oil if the peat cost were $1.00/million BTU ($9.00 per ton as received at the plant). If the plant operating time were more than 5600 hr/yr, using peat as a fuel would be less expensive than oil if the peat cost were \$1.50/million BTU (\$13.50 per ton as received at the plant). To be competitive with coal, peat would have to be 20 to 40 cents per million BTU less expensive than coal, depending on the coal source.

Together these four cases represent an estimated total peat consumption of 890,000 tons per year. If the gap between peat and coal prices narrow the availability of a local fuel supply could assume greater importance. The production and cost of the peat in each case has to be clarified, but the technical know-how to complement its use does exist. Again however, because peat is not a renewable resource it cannot be considered a solution to our Nation's energy needs.

5 RECLAMATION STUDIES

FORESTRY RECLAMATION
AGRICULTURAL RECLAMATION



Minnesota's policy for peatland management will require the reclamation of all state-owned peatlands that are leased for development. In the European countries where peat is extracted for fuel and horticultural purposes, peatland reclamation has become a common practice. Laws have been enacted to establish both the depth of peat which must be left in place by harvesting operations and guidelines for the future use of harvested lands. Many of the developed peatlands have now been transformed into productive land for crop and tree production, or reclaimed to recreational uses, fish production and wildlife habitat areas.

Although the European reclamation efforts provide useful information, they have either been conducted on a relatively small-scale or have not been completely developed. Their applicability may also be limited if either the peat or mineral substrate of Minnesota's peatlands differ substantially from that found abroad. Therefore, in light of the potential importance of peatland reclamation in Minnesota, legislative monies were used to fund two reclamation studies at Wilderness Valley Farms near Zim, Minnesota.

Dr. E. H. White, of the Department of Forest Resources, University of Minnesota, was responsible for research pertaining to the applicability of forestry techniques in reclaiming peatlands. Dr. White's objectives were threefold: 1) to determine the suitability of selected tree species for forest planting of mined and unmined peatlands; 2) to determine the response of selected tree species to drainage and fertilization on mined and unmined peatlands; and 3) to determine the natural succession of vegetation on mined peatlands.

Dr. R. S. Farnham, of the Soil Science Department, University of Minnesota, was responsible for research pertaining to the agricultural reclamation of peatlands. Dr. Farnham's research was designed with five major objectives: 1) to determine the suitability of several vegetable, forage and grain corps grown on mined and unmined peatlands both in greenhouse and field trials; 2) to determine the best management practices for selected crops; 3) to establish demonstration plots of commonly grown crops; 4) to establish and maintain peat wastewater and sludge demonstration plots; and 5) to evaluate the physical and chemical properties of the peat soils at Wilderness Valley Farms.

Both of the studies above were conducted in cooperation with Mr. D. Grubich of the Iron Range Resources Rehabilitation Board. Mr. Grubich has been responsible for supervising mining and maintenance activities at Wilderness Valley.

FORESTRY RECLAMATION

To date, Dr. White's field personnel have concentrated most of their efforts on testing the effectiveness of different fertilizer treatments on five tree species planted on unmined peatlands. Trees selected for the test include white spruce, black spruce, scots pine, Norway spruce and hybrid poplar. Each species was exposed to eight different fertilizer treatments, with three replications per species; 12 trees were planted in each of the 120 treatment plots. Based upon a review of pertinent literature the following 8 fertilizer treatments were selected:

1. Control - no fertilizer
2. Nitrogen at 300 lbs/acre
3. Phosphorus at 150 lbs/acre
4. Potassium at 150 lbs/acre
5. Nitrogen at 300 lbs/acre plus phosphorus at 150 lbs/acre
6. Nitrogen at 300 lbs/acre plus potassium at 150 lbs/acre
7. Phosphorus at 150 lbs/acre plus potassium at 150 lbs/acre
8. Nitrogen at 300 lbs/acre, phosphorus at 150 lbs/acre plus potassium at 150 lbs/acre.

An additional replication will include testing the fertilizer treatments on both mined and unmined peatlands. Because of complications that were encountered in extracting the peat at Wilderness Valley only the unmined treatment plots have been planted and tested. Plans, however, include extracting the peat prior to the next field season.

At present, the analysis has consisted of an evaluation of the effect of the fertilizer treatments upon the tree species survival. Of the five species selected, hybrid poplar exhibited the greatest mortality, especially on the fertilized plots (10-35% mortality). However, overall survival was acceptable. The somewhat greater mortality of the hybrid poplar may have been caused by the increased competition from grasses that responded to the fertilizers. There may also have been some damage from the herbicide used to control the quack grass. Additional analyses will include collecting foliar samples (to assess nutrient uptake) and making annual measurements of the trees' height and goundline diameter growth.

As stated above, another major objective of Dr. White's work was to determine the natural succession of vegetation on mined peatlands. Through correspondence with various individuals and state agencies 9 sites that have been harvested for peat during the past 5 to 40 years were chosen for study. The areas being sampled are located near the northern towns of Cromwell, Hill City, Central Lakes, Zim, and Floodwood. Sampling at each of the sites will include measurements of the following parameters; 1) bulk density, pH, nutrients, conductivity and decomposition of the peat; and 2) percent cover, density and frequency of plant species. Water samples will also be collected and analyzed. Such information will help to ascertain the feasibility of utilizing secondary plant succession as a means of natural reclamation of disturbed peatlands.

Dr. White and his staff have also compiled a literature review entitled "Utilization of Peatlands for Wood Production". The paper evaluates the parameters that are important for afforestation and reforestation of peatlands. Reviewed are the general characteristics of organic soils, techniques to determine peatlands suitability for forest improvement purposes, and silvicultural considerations for peatlands forestry.

Finally, preliminary plans have been developed to install a greenhouse-laboratory for testing the effects of drainage and fertilization on early growth and survival of several tree species. Surface peat samples are being collected from the Fens, Toivola and Cromwell bogs and potted in containers in the greenhouse. Fertilizers will be applied, pots seeded with selected tree species and treatment effects evaluated. The study is being duplicated with deep peat samples collected from the last foot of peat over the mineral substrate.

AGRICULTURAL RECLAMATION

There are two major aspects to Dr. Farnham's reclamation research: 1) the establishment of vegetable and field crops at the Wilderness Valley Farms; and 2) greenhouse growth studies conducted on the St. Paul Campus of the University of Minnesota. Experimental design of the field research has included the cultivation of various vegetables and grains on both mined and unmined peatlands. Plants that have been chosen for study are listed in Table 14.

TABLE 14. Vegetable and field crops chosen for the agriculture reclamation research.

Vegetables	Field Crops
Carrots	Spring wheat
Spinach	Oats
Lettuce	Barley
Broccoli	Bluegrass (4 varieties)
Peas	Canarygrass (2 varieties)
Beans	Perennial ryegrass
Onions	
Cabbage	
Cauliflower	
Potatoes	

In addition, each of the vegetable crops, on both the mined and unmined plots, will be tested with two different fertilizer treatments. Experimental design of the laboratory research includes the planting of two assay plants, tomatoes and mums, in 7 different peat types. As in the field studies, the lab studies will also include two different fertilizer treatments. Each study is discussed in further detail below.

During early June of 1978 all ten vegetable crops were planted in the unmined study plots at Wilderness Valley. As with Dr. White's study, work was delayed on the excavated plots because of late spring ice in the peat. A total of six rows per crop were planted on the unmined plots; three per fertilizer treatment. The two fertilizer treatments consisted of applying a pre-mixed combination of nitrogen, potassium and phosphorus at the rate of 300 lbs/acre and, alternatively, at the rate of 200 lbs/acre. Together, all plantings covered an area of approximately 15,000 sq. ft. All crops were weeded and cultivated throughout the summer, including the application of appropriate herbicides when needed.

During August the planting beds for the grain and grass crops were prepared and seeded. Unlike the vegetable crops, the field crops were not harvested or tilled at the end of the growing season. Instead, the crops will be left untended so that researchers can evaluate the ability of the crops to over-winter in peatlands.

At the end of the 1978 growing season all vegetable crops were harvested and the plots prepared for planting in the spring of 1979. At the same time several hundred asparagus plants were planted to evaluate their over-wintering abilities.

Work will continue on preparing the excavated peat areas for 1979 planting. Water was pumped out of the area throughout the summer of 1978 and, as soon as weather permits, pumping will be resumed to accommodate the spring meltwater. In addition, plans for the construction of waste treatment plots are also being prepared.

Dr. Farnham's experience at Wilderness Valley during the summer of 1978 has prompted some preliminary conclusions regarding peatland agriculture. First, field preparation is of utmost importance. This includes optimum drainage, total weed eradication, uniform surface contouring, raised planting beds and proper soil fertility maintenance. Second, the importance of an early start in planting was evident, preferably mid to late May. Third, the 1978 results demonstrate the necessity of testing several different varieties per crop. In this way, varieties may be selected to allow a more broad harvesting schedule, and the varieties most apt to produce an optimum quantity of quality produce may be selected.

For the growth trials conducted at the University greenhouses seven different peat types and soils were collected during the fall of 1977. These samples included surface, subsurface (bottom) and mineral substrate material from Wilderness Valley Farms in addition to other samples representing the major peat types across Minnesota. The seven soil treatments are listed below:

1. Surface peat from Wilderness Valley (field #8)
2. Subsurface peat from Wilderness Valley (field #8)
3. Mineral substrate from Wilderness Valley (field #8)
4. Sapric (decomposed) peat from St. Louis County
5. Sphagnum peat from the Arlberg Bog
6. Hemic (surface, acid) peat from Aitkin
7. Hemic-Fibric (non-acid) peat from Roseau County

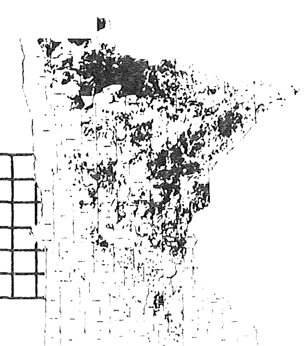
A total of six plants each (i.e. tomatoes and mums) were planted in each of the seven substrates; three plants per fertilizer treatment. The first treatment consisted of adding five grams of a nitrogen, potassium and phosphorus mix to each plant. The second treatment was to add no fertilizer at all. Because the plants were plotted in March 1978 their relative growth rates have already been evaluated.

The data illustrated that for both mums and tomatoes the surface peat from Wilderness Valley produced slightly better results than the bottom peat. The mineral substrate, which was a highly reduced sandy clay material, proved to be a poor medium for growth. Plants that were potted in the extremely acid sphagnum peat (pH 3.4) from the Arlberg Bog also fared poorly with respect to growth. The less acidic sapric and hemic peats were more favorable growth mediums.

Although these growth studies have been completed, other studies are continuing at the University labs. The primary objective is to conduct a physical-chemical analysis of peat samples collected at Wilderness Valley. Parameters that will be measured include: 1) bulk density; 2) moisture content; 3) ash content, 4) fiber content; 5) calorimetric combustion; 6) pH; 7) Kjeldahl nitrogen digestion-distillation; and 7) the percent content of 18 different elements. In addition, Dr. Farnham plans to experiment with varying amounts of nutrient applications to several indicator plants in surface and excavated soils.

6 PEATLAND POLICY

DATA COLLECTION FINDINGS



Requests for new development and for expansion of existing operations and holdings within Minnesota's peatlands have become the impetus for reviewing current management policies, regulations, and practices pertaining to peat resources. Given the present conflict of interests over conservancy and development, the management of peat resources poses a twofold question: Management for what ends and how? The problems posed by this question have been considered and dealt with to varying degrees by several states that contain significant peat deposits.

The Phase II peatland policy study was directed toward providing an overview of peatland policies in all fifty states plus Puerto Rico. Familiarity with current policies and practices in other localities can help provide useful direction when reviewing and, possibly, revising current policies in Minnesota. The peatland policy study was conducted by Dr. W. A. Fleischman, associate professor at the University of Minnesota, Duluth.

DATA COLLECTION

The findings of Dr. Fleischman's study were based on the responses to a questionnaire mailed to the Department of Natural Resources (or an equivalent organization), the Director of the State Geological Survey and the State Conservationist (State representative of the Soil Conservation Service) in each of the fifty states and Puerto Rico. These three agencies were thought to be the ones most consistently involved and knowledgeable about peat in their respective localities. The study was concerned primarily with peatlands that are under state or local level jurisdiction; the study of federal management policies and practices was beyond the scope of the study.

The questionnaire was designed primarily for gathering information pertaining to the utilization of peatlands for commercial purposes. Commercial refers to the use of peat for agriculture, horticulture, energy, and for other commercial purposes such as packing material, litter, etc. Four major conceptual areas relating to commercial utilization were covered by the questionnaire. First, an attempt was made to determine the existence and nature of current peatland management policies. Second, many questions focused on the nature and extent of the commercialization of peat. The future of peat in each of the localities was the third major area covered by the questionnaire. The fourth and final area was concerned with the availability of information about peat as a resource and the existence and level of activity focusing on peat policy development.

FINDINGS

Two major considerations regarding peatland policy are the legal status of peatlands and the mechanisms for regulating their use. Legal status refers to the generic classification applied to peatlands in each state. When peat is given a separate and specific status, response to the questionnaire revealed that it is most often classified as a mineral. Minnesota however, is among the fourteen states that, to date, have not legally designated the classification of their peat resource.

Because peat is commonly designated as a mineral, mining-related regulations, such as surface-mining laws, mining acts and mined-land reclamation acts are generally employed for regulating the utilization of peatlands. Wetland laws, environmental quality acts and local zoning ordinances may also be used for regulation. Presently the Commissioner of the Minnesota Department of Natural Resources is authorized by a statute to govern the regulation of Minnesota's peatlands. The statute provides the commissioner with a great deal of latitude for making decisions regarding peatland regulation.

The specific arrangements that would legally permit the extraction of peat and its subsequent utilization include leases, permits and the outright sale of the land. Approximately one-third of the states use one or more of these three arrangements; in Minnesota peatlands may either be exchanged or leased. Among those states that do regulate the utilization of peatlands, application fees, rent per acre and royalties are commonly employed. In Minnesota a rent per acre fee may be assessed upon companies utilizing state-owned peatlands.

The reclamation of lands that have been mined is also an important concern when establishing a policy for peatland management. Current research on peatland reclamation in Minnesota was discussed above. Although at present Minnesota does not require reclamation of its harvested peatlands, future policy will require reclamation of all state-owned lands leased for development. Reclamation was also found to be compulsory in 22 other states.

Response to other questions revealed that during 1977, twenty-one states were actively engaged in producing and selling peat. Together these twenty-one states accounted for 121 commercial peat operations, 113 of which were located on private lands. Indiana, Michigan, Pennsylvania and Washington, alone accounted for 57 of the operations. The primary use of the extracted peat in each of the peat-producing states was for agriculture and horticulture. With a total of six commercial operations, three on private land and three on state-owned land, Minnesota ranks eighth among the states in the amount of land currently under production.

Insights pertaining to the future of peatlands were gained by reviewing current state activities and preferences related to peatlands. An uncertainty regarding the future of peatlands was partially reflected by the response of eight states that reported a pressure for preserving peatlands in their respective states. Seven states also have applications that are either pending or anticipated for the development of peatlands. Uncertainty was further reflected by the fact that not a single state has developed a strategy for the management of its peat resource; nor has a preferred use of the resource been officially established.

The increasing interest in peat as a resource has increased the necessity for sharing information. Dr. Fleischman's questionnaire was designed to obtain data on two types of activities that would reflect the accumulation of additional information about peatlands in each of the respective states. The two types of information were: 1) peat inventory; and 2) committee activity related to the use and/or regulation of peat.

The findings indicated that 14 of the 21 peat producing states have had some type of peat inventory conducted. Peat inventories were generally conducted by a state agency; the most frequently employed inventory method was field mapping. As described earlier, an extensive inventory of Minnesota's peat resources is currently underway.

In addition to the peat inventory activities, four states indicated that legislative and/or administrative committees have or are conducting research regarding the use and/or regulation of peat. Those four states with such committees are Iowa, Michigan, Minnesota and South Carolina. All four states indicated the existence of administrative level committees - only Minnesota indicated the existence of a legislative committee (Legislative Committee on Minnesota Resources).

It should be apparent from this brief summary that management policies for peatlands are not well-developed. The policies that are in existence are limited in extent, specifying procedures and regulations pertaining to the extraction of peat. A well-defined framework that links the regulatory procedures with goals and objectives of peatland management has yet to be developed. Minnesota has the unique opportunity to carefully outline a management policy for peat prior to any extensive development.

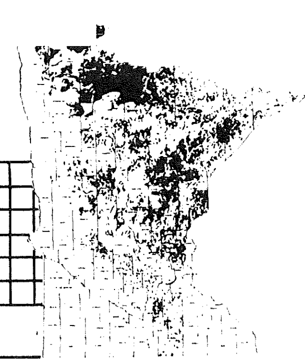
7 PUBLIC RELATIONS

SLIDE SHOW

INFORMATION FLYERS

PUBLIC MEETINGS

COUNTY COMMISSIONER MEETINGS



One of the primary objectives of the Minnesota Peat Program is to inform the public about Minnesota's peat resource and about the various options that are currently available for utilizing it. To accomplish this goal a slide show and an information flyer were prepared in addition to conducting public meetings and meetings with several county commissioners.

PEATLAND SLIDE SHOW

A slide-cassette tape presentation was prepared for use at public meetings, legislative hearings and other meetings. Prepared by BRW Inc., the presentation was designed to inform the viewer and stimulate questions concerning the management of Minnesota's peatlands. Hopefully, the resulting dialogue will lead to a more complete airing of diverse views and exchange of information.

INFORMATION FLYERS

The Peat Information Flyer has been compiled as part of an effort by the Minnesota Peat Program to inform the public about the peat issue. Two separate flyers are available, one for the State of Minnesota and the other for a three-state region, including Wisconsin and Michigan in addition to Minnesota.

The text includes a description of peat, an explanation of peatland formation processes, a discussion of alternative uses, methods of extraction and reclamation of peatlands, and a summary of the objectives of the Minnesota Peat Program.

The text for both flyers is the same. The reverse side of the flyer displays either a map showing the distribution of peatlands in Minnesota or a map showing the distribution of peatlands in the three-state region.

The distribution of these maps will be conducted in a manner (e.g. at public meetings, state parks...) that attempts to reach a cross-section of the people of Minnesota. There are a total of 18,000 flyers with the Minnesota Peatlands map and 6,000 flyers with the three-state peatlands map available to the public.

PUBLIC MEETINGS

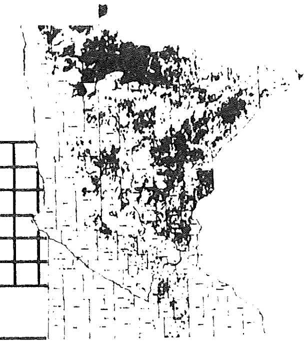
Phase I of the Peat Program conducted a total of 5 public meetings, 4 in northern Minnesota and 1 in the Twin Cities. Phase II of the Peat Program conducted public information meetings at 5 locations in northern Minnesota. The purpose of the meetings has been to inform the public and to obtain their input on the formulation of management policy.

COUNTY COMMISSIONER MEETINGS

The Peat Program Staff presented an overview of the goals and objectives of the Peat Program to the board of county commissioners in ten northern Minnesota counties. These presentations were part of an effort to disseminate information and solicit input from local groups concerning the management of Minnesota peatlands. The county commissioner meetings were followed by public meetings in the counties with the greatest potential for peat development.

8 RELATED ACTIVITIES

ADVISORY COMMITTEE
PEATLANDS OF SPECIAL INTEREST TASK FORCE



Finally, members of the peat staff were involved in two additional activities that relate to the Peat Program. The advisory committee was formed to provide advice and guidance during the program, and the Peatlands of Special Interest Task Force was designed to identify unique and/or special peatlands in Minnesota.

PEAT ADVISORY COMMITTEE

An important aspect of the Minnesota Peat Program is the direct participation of an advisory committee that represents a broad spectrum of interests. Because the program attempts to coordinate a variety of technical disciplines, legislative decisions and regulatory actions, the 20 members of the advisory committee were chosen to exhibit a diversity of experience and capabilities. Members were selected from federal and state agencies, universities, the State Legislature and the private sector. Their backgrounds reflect experience in government, zoning, economics, soil science, geology, ecology and regional planning.

The advisory committee meets three or four times each year. The objectives of the committee are primarily to advise members of the peat program in their planning and operations and to review the quality and extent of the peat program.

PEATLANDS OF SPECIAL INTEREST TASK FORCE

The Peatlands of Special Interest Task Force was formed to act as a technical advisory committee to the Minnesota Peat Program. This group is to develop criteria for selecting peatlands of special interest and to identify areas of priority. The criteria will evaluate 1) a peatland for uniqueness and presence of unusual elements (e.g. rare or endangered plants) and 2) peatlands that are representative of the peatland types common to Minnesota.

9 CONCLUSIONS & RECOMMENDATIONS

Increasing pressure to develop Minnesota's peatlands has brought to attention the need to critically review both the extent and value of the state's peat deposits. The findings presented in this summary report are an initial attempt to address many of the questions and issues pertaining to peatland development. In particular, the studies funded by Phase II of the Minnesota Peat Program were designed primarily as in-depth reviews of literature currently available regarding the nature of the peatland environment, the possible options for utilizing peat and the potential impacts of development. With the help of this comprehensive review a legislative appropriation for the 1977-1979 biennium was used to initiate several field research studies. The majority of these studies focused upon gathering first-hand information regarding the natural environment of peatlands; the paucity of available biological information has been all too evident from the Phase II studies. A comprehensive understanding of the natural environment is essential for the development of a realistic management and protection policy.

Although this report does not directly address the issues pertaining to management policy, several investigators involved with various aspects of the program made the following management recommendations based upon their research:

1. Preservation of rare, endangered and other species of special interest in areas of sufficient size to adequately protect them.
2. Preservation of examples of unique and representative peatlands for the enjoyment of future generations.

3. Because of the complex hydrology of peatlands, large areas should not be harvested by drainage methods.

4. Until the water quality impacts from harvesting are understood the water discharge from harvested areas into receiving waters should be minimized.

5. The water which is extracted from peat during drying operations should be discharged into the harvest pond or peatland rather than into ditches or receiving waters.

6. The state should insist that industries that propose to utilize peat as a fuel source provide detailed plans for waste treatment facilities. Proposed treatment processes should then be reviewed by competent, outside scientific experts.

7. Because commerically productive peatlands currently make a significant contribution to the regional timber industry it was recommended that, to the extent any acreage of productive spruce forest is destroyed, the area be reforested to black spruce to maintain at least the present level of growth of that important species. To further offset the loss of growth of peatland timber species it was also recommended that more intensive forestry practices be applied, including the conversion of some presently unproductive swamp shrub areas to black spruce.

8. Small-scale consumption and development (such as horticultural development or industrial chemical operations) may be more appropriate to introduce into the poor, sparsely-populated rural areas of northern Minnesota than large-scale development. Locally-owned, labor-intensive operations providing employment and income for young people, with minimal threat to existing social patterns, comprise a set of characteristics which may be attractive to rural peatland communities.

CONCLUDING REMARKS

The studies summarized in this status report are helping to describe the natural environment of peatlands, the regional socio-economc climate and the options available for utilizing the peat resource. This information has proved invaluable in establishing a framework for management policy.

The complex hydrology of peatlands, for example, is still poorly understood; hydrological factors however, have a profound influence upon the peatland environment. Until we gain a more complete understanding of Minnesota's vast resource it is recommended that development proceed slowly and be limited in extent.