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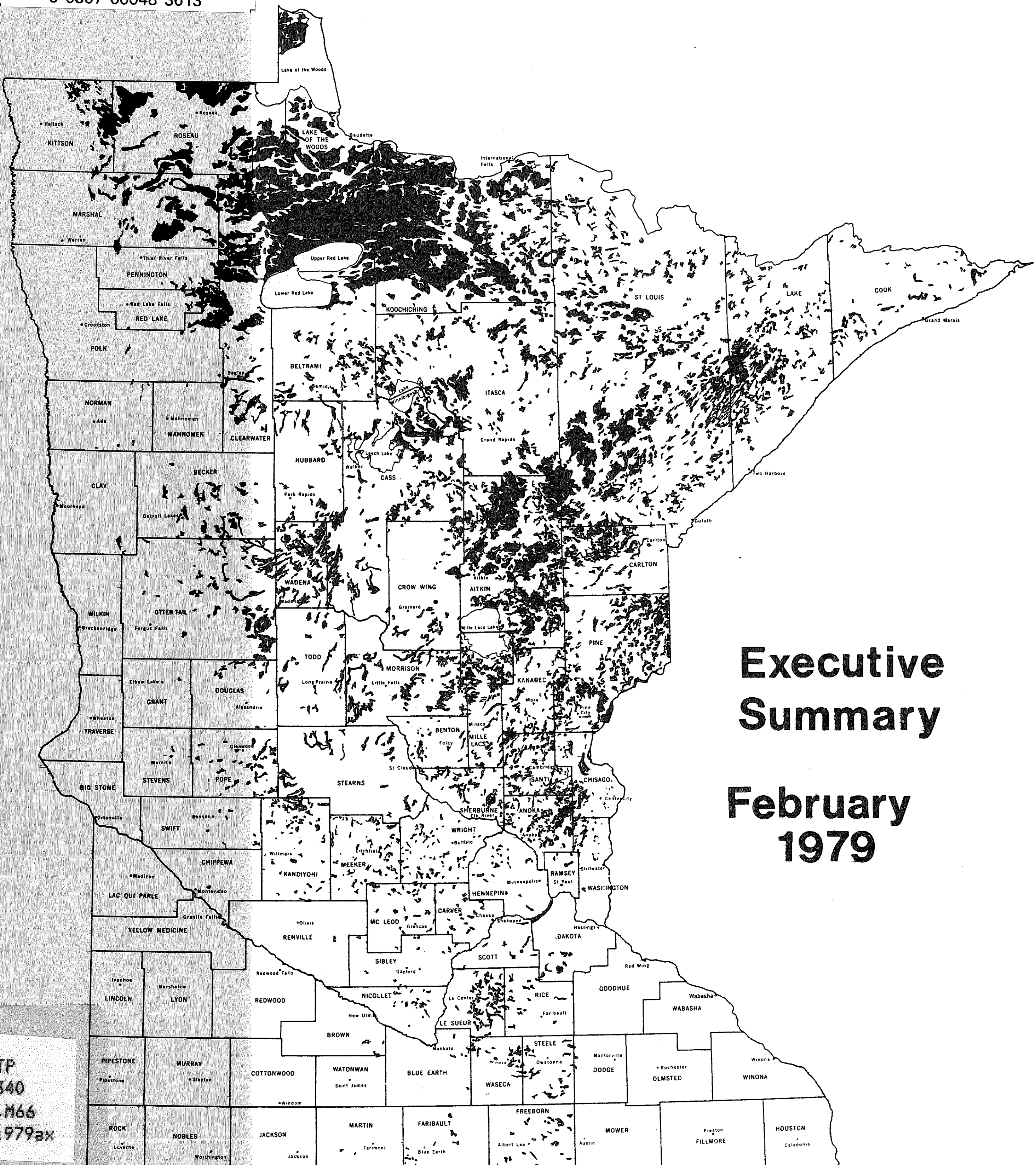

Executive Summary

February 1979

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

EXECUTIVE SUMMARY

PHASE II -- PEAT PROGRAM

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Submitted by the

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

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MINNESOTA PEAT PROGRAM
EXECUTIVE SUMMARY OUTLINE

FORWORD

This executive summary is a compilation of the work carried out by the Minnesota Department of Natural Resources staff, consultants and university researchers under Phase II of the Minnesota Peat Program. In order to prepare this summary, we borrowed liberally from the final reports prepared by those named below.

The following contractors participated in Phase II:

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

Introduction

The peatlands of Minnesota are recognized as a valuable resource and, as such, deserve careful study if they are to be used in a rational and well-planned manner. It is a rare opportunity to be able to plan for the management of an important resource prior to its extensive development and, as such, it provides a challenging task to resource managers. In preparation, the Department of Natural Resources (DNR) 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 following pages present a summary of the work conducted under Phase II of the Minnesota Peat Program. Phase II was a 16-month study funded by the Upper Great Lakes Regional Commission with a grant of $190,000. The objectives of the study were to gather information on the peatland environment, the socio-economic condition of peatland regions and the potential uses for peat deposits and peatland areas. Information summarized in this report has been made available to the public, to the legislature, and to interested private and governmental entities. 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.

Phase I and Phase II studies are complementary to peat studies that have been funded by a special legislative appropriation and by the Legislative Committee on Minnesota Resources.

Peatland Environment

The peatland environment is the product of a complex interaction among plants, water, time and a cool climate. Formed within the shallow beds of large glacial lakes or atop former glacial outwash plains, wetland 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.

Study of the peatland environment involves an evaluation of factors that are important to the ecological development and maintenance of the unique features of the peat resource. Factors that were chosen for study include water resources, vegetation, wildlife and air quality.

Water Resources

Water resource studies attempted to identify and evaluate factors and processes that govern the hydrology of Minnesota peatlands. An understanding of these natural processes was 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 that can estimate the hydrologic response of peatlands to alterations of the habitat.

Participants in these 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."

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 groundwater inflow from 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 (weight/volume) of the soil influence the rate of water movement through the soil 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 (i.e. a hydraulic gradient) water movement. Surface peats are less decomposed, more porous, and exhibit higher rates of water movement than peats located at greater depths. The hydrology of an area is also an important factor governing water flow. 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 soils. 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 least 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. Minerotrophic fens yield waters of a more neutral pH, lighter color and higher mineral content due to the groundwater inflow. 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.

Impacts

The impacts of peat harvesting are difficult to predict because the hydrology of peatlands 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 receiving waters. Studies have also indicated that algal growth in natural waters may be stimulated upon receipt of bog water.

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 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 absorb 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 utilized.

Vegetation

The vegetation study conducted a review of previous investigations that characterized the flora of peatland vegetation. Unique vegetational features and species of special concern were also identified. Conducting this aspect of the Phase II peatland 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."

Characterization

The diversity of peatland vegetation directly reflects the diversity of complex interactions among the flow, level and chemistry of the peatland water. 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 under water resources, along with a third major category 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 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 were used to characterize each of these vegetation categories.

The presence and abundance of unique, rare, or uncommon plant species within these communities are important. Ten peatland plant species of "special concern" were selected. The 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.

Impacts

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.

Wildlife

The 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 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 was 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."

Birds

Characterization

Approximately fifty bird species, including several hawks, shorebirds, and songbirds, are known to utilize peatlands for breeding habitat. The species list, presented in Table 1., was drawn from several studies conducted in bogs located in Itasca State Park and from an extensive study conducted in the Canadian peatlands. Future studies will be required to verify the accuracy of the list for the different habitats found in Minnesota peatlands.

Several species listed in Table 1. 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 sharp-tailed grouse suggest that the bird is only dependent on peatlands during the winter, when the habitat provides important roosting cover for the birds. Recent field studies however (studies that were not funded under the Phase II program), 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 a 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 peatland area.

Unlike the smaller peatlands in southern Minnesota, the peatlands in northeastern and northcentral Minnesota are extensive areas, often thousands of acres in size. As a result, the breeding density and diversity of their avian 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 600 pairs per 100 acres. Data indicates that one of the younger successional communities, muskegs, is perhaps the lease 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.

Impacts

Because the avian populations of Minnesota's peatlands are not well-studied it is difficult to predict 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.

TABLE I. BIRDS OF PEATLANDS

<u>Sedge Willow</u>

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

<u>Fens</u>

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

<u>Tamarack</u>; <u>Tamarack/Black Spruce</u>

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

<u>Swamp Conifer/Black Spruce</u>

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

<u>Muskeg</u>

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

MAMMALS

Characterization

The available literature indicates that eight large game and fur-bearing species, along with thirteen small mammal species, are inhabitants of Minnesota's peatlands (Table 2.). The lack of detailed studies for many of these species suggests that the list should only be considered preliminary until future studies are conducted.

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 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 originally not 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 popular; 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 (no. of individuals/unit area) 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 classififed as species of "changing or uncertain status." 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 2. 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.

Impacts

The difficulty in predicting the impacts from peatland development to large and small mammal populations is similar to that encountered for birds. Pertinent information is often 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 can recover quickly if the habitat is reestablished.

TABLE 2. MAMMALS OF PEATLANDS

Moose
White-tailed Deer
Eastern Timber Wolf
Canada Lynx
Fisher
Marten
Beaver
Snowshoe Hare
Cinereus Shrew
Short-tailed Shrew
Arctic Shrew

Red Squirrel
Northern Flying Squirrel
Red-backed Vole
Star-nosed Mole
Least Chipmunk
White-footed Mouse
Southern Bog Lemming
Northern Bog Lemming
Meadow Vole
Meadow Jumping Mouse

AIR QUALITY

The objective of the 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."

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 Clean 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 Voyageur's 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.

Impacts

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 industrail 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.

Socioeconomics

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. In light of these potential changes, 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 peat development could bring to northern Minnesota.

The study, titled "Economic Effects of Peatland Development," was conducted by Dr. W. R. Maki, L. A. Laulainen Jr., and P. D. Meagher. 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 hypothecial case situation) for future peatland development; and 3) to estimate the potential impacts of such development. Their results are summarized below.

Natural Setting

An eight-county study region was selected for the peat development impact analysis. This region comprised seven northeast and northcentral 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. Towards the western edge of the study region, in western Aitkin and Itasca counties, agriculture also makes a significant contribution to the local economy. 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 necesary 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 socioeconomic 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 3. 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 (gross pay, or no. of workers employed by the industry x earnings per worker); 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 - exluding materials and services purchased from other peat industries). In order to establish a basis for comparison, all dollar figures have been

TABLE 3. 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.

expressed in terms of 1970 dollars.

The figures in Table 3. clearly demonstrate the direct effects of peatland development. The peat industries alone create nearly 3000 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 4.

Changes in the impact indicators between the years 1986 and 2000 illustrate again the socio-economic impacts of peatland development. The figures in Table 4. 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). An explanation for the decrease in employment and population between 1986 and 2000, observed in both the baseline and development options, 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. It was predicted that a cutback in the natural gas supply would result in a cutback in the rate of study area business expansion which might offset many of the positive impacts of peatland development. Substituting synthetic natural gas derived from peat could make continued study area economic growth possible. However, if the peat-derived gas is more expensive than natural gas, then growth may proceed more slowly, due to higher energy costs.

TABLE 4. 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 1986	Baseline Option 2000	Development Option 1986	Development Option 2000	Impact 1986	Impact 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.

Peat Utilization Options

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 socioeconomics of northern Minnesota, to establish environ- for the use of peatlands the options available for utilizing the resource must 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.

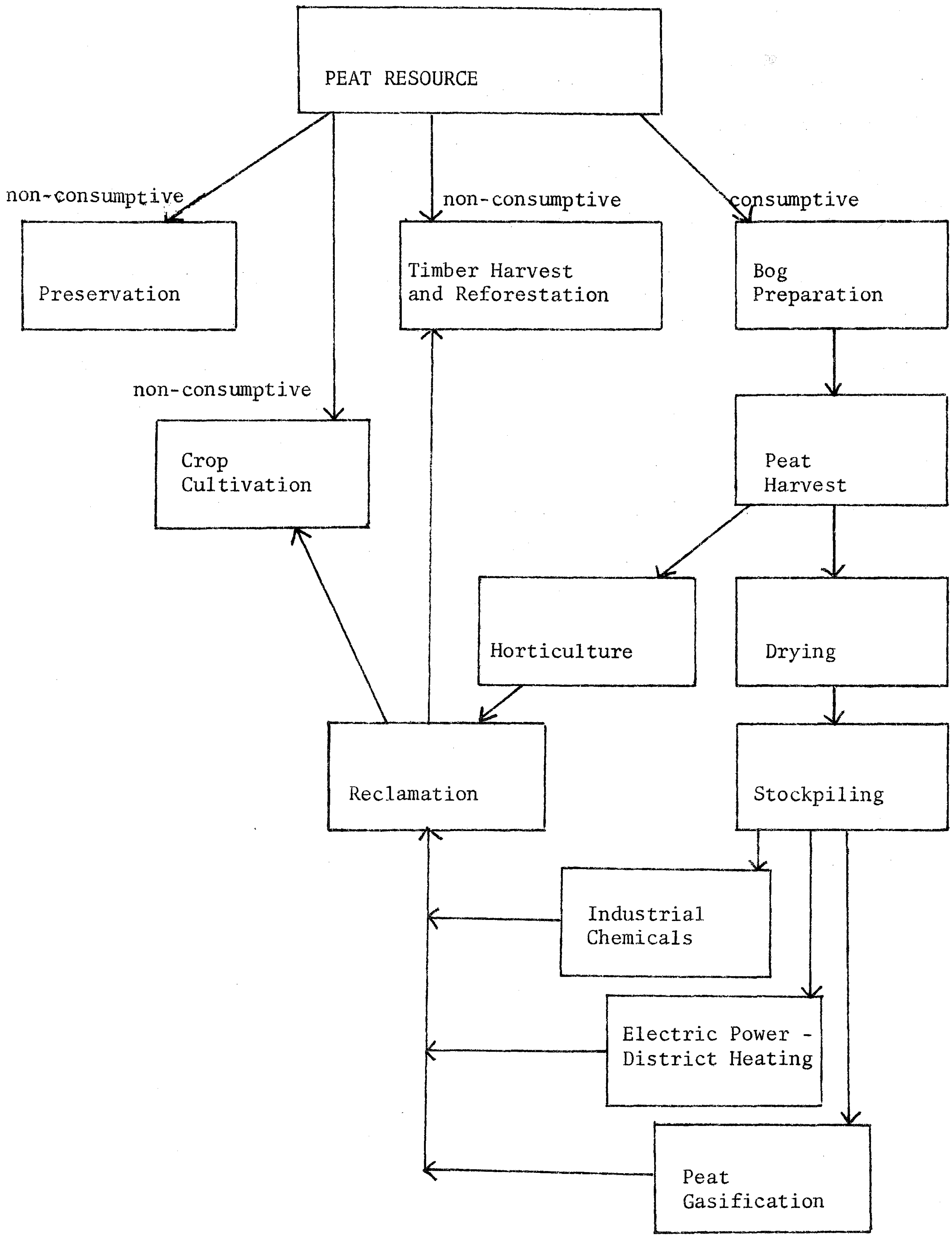

Figure 1. Options for utilizing Minnesota's peatlands

Non-Consumptive 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 report is being compiled by Paul Rundell, from the Department of Natural Resources in Bemidji, of a statewide aerial photo inventory he conducted of twenty-two different peatland features. 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 or federal agencies are 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 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 acreage 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 and, to some extent, for pulpwood. White cedar is used for fence posts, poles, siding, lumber, shakes and paneling. The major lowland hardoods, black ash and elm, are used for lumber and furnitues.

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's 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.

Agricultural Peat Production

The production of agricultural crops is the third major option for the non-consumptive use of Minnesota's peatlands. The objectives of the 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.

Most 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 enterprize 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 peatlands in Minnesota. 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 which affect crop plants 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 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.

Horticultural Peat Production

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 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 spahgnum 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 Chemical Peat Technology

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 in Russia and Denmark while attending a peat workshop in Germany.

Technical Background

The industrial chemicals produced from peat can be grouped into four major catagories. Chemical products in three of the catagories are produced by extractive methods that use low to moderate 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 catagory 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. Until an appropriate characterization of the chemical nature of Minnesota's peatlands can be conducted the feasibility of this technological alternative for peatland development is unknown.

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 the products of our fields and forests. In this regard the humic acids of peat have a special significance. If humic acids are used primarily for the production of chemical specialities (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 socioeconomic 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.

Energy

Minnesota's last major option is to utilize its 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 conversion of peat to synthetic natural gas is approximately twice as efficient. Furthermore, 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 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. Information for these summaries were drawn from studies that were not funded by the Phase II 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.

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, carbon dioxide 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

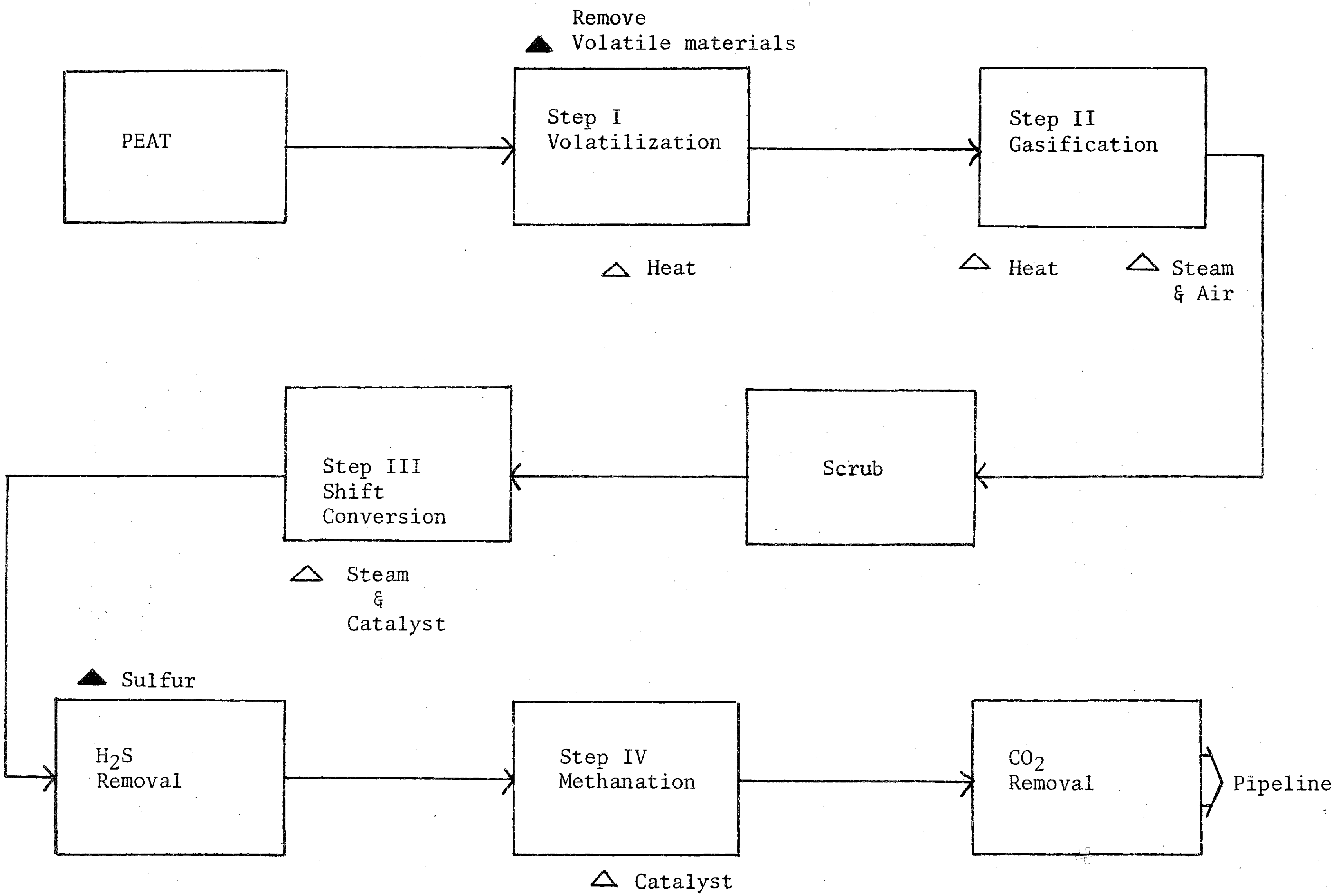

Figure 2. Basic Steps for Peat Gasification

another; several are listed below:

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 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 very 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 $2.00/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.

Peatland Policy

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 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 localties. The study was concerned primarily with peatlands that are under state or local level jurisdiction; the study of federal management policies and practices were 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

Policy

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 sold 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. Reclamation is the purposive action on the part of some one or some agency or business to attempt to convert the mined or extracted area to a condition that allows for future uses that meet some acceptable definition. Although at present Minnesota does not require reclamation of its harvested peatlands, reclamation is compulsory in twenty-two states. Twenty-two states also have some type of environmental constraints placed on the harvesting or mining of peat resources.

Production

During 1977, twenty-one states were 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.

Future of Peatlands

Insights pertaining to the future of peatlands can be gained from reviewing current activities and preferences related to peatlands. An uncertainty regarding the future of peatlands is partially reflected by the response of eight states that reported a pressure for preserving peatlands in their respective states. Seven states also currently have applications pending or anticipated for the development of peatlands. Uncertainty is 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.

Peatland Information and Committee Activity

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 or 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. An extensive inventory of Minnesota's peat resources is currently underway and nearing completion.

In addition to the peat inventory activities, four states also 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.

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 therefore, has the unique opportunity to carefully outline a management policy for peat prior to any extensive development.

Public Relations

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.

Peat Information Flyer

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.

Related Activities

Finally, two additional activities that members of the staff were involved with relate to the Peatlands Program: the advisory committee, which was formed to provide advice and guidance during the program; and the Peatlands of Special Interst Task Force, 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.

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.

Based upon this comprehensive review, Minnesota has begun to develop an appropriate management and policy framework for the future utilization of its peat resource. Nevertheless, although the information has begun to establish a firm foundation for knowledge regarding peat, further work is contingent upon the collection of additional information. In the following pages we have compiled a summary of the numerous recommendations proposed to the state by all of the participants in Phase II of the Minnesota Peat Program. The recommendations were divided into two broad catagories, recommendations for further research and recommendations pertaining to the planning or management of peatland utilization.

Research Recommendations

Nearly all studies conducted during Phase II drew attention to the fact that at present, Minnesota has very little information regarding the extent and characteristics of its own resource. An inventory of peatlands and peat deposits is therefore a research priority. Information that should be collected during such an inventory would include:

A. Information pertaining to the peatland environment

1. A comprehensive study of peatland floristics, especially concerning grasses, sedges, mosses and lichens.

2. Further study of peatland fauna, documenting their seasonal dependence upon peatlands.

3. Extensive characterization of the hydrology of peatlands, with a priority given to natural minerotrophic fens which, among all peatlands, are most likely to be harvested.

4. Extensive characterization of the water quality parameter of peatlands.

5. A complete inventory of all commercially productive peatland forests.

B. Information pertaining to peat deposits

1. A complete inventory of the extent and location of all peat deposits in Minnesota.

2. A chemical characterization of peat deposits including information regarding the concentration of:

A. Wax
B. Ash
C. Phosphorous
D. Humic Acid
E. Heavy Metals

3. A physical characterization of peat deposits including information regarding:

   A. Degree of decomposition

   B. The organic material from which the peat was derived

   C. Characteristics of peat particles, e.g. particle size distributions and settling characteristics

   D. Nature of the mineral substrate beneath the peat deposits.

The second major gap in our knowledge that the Phase II studies drew attention to regards the impacts of the various options available for utilizing peatlands. The experience of many European countries in the development of their peat resources provides a basis for making several predictions. In most instances however, data regarding the environmental impacts of development are sorely lacking. Because many of the options for utilizing peatlands involve, at some stage, the extraction of peat, many of the research recommendations focused upon the impacts of peat harvesting. The major recommendation for study was the initiation of a comparative study of the relative impacts of different harvesting techniques which would address:

1. Management of wind and dust problems

2. Quantification of hydrologic processes before and after harvesting

3. Quantification of water quality before and after harvesting. This would include further research of the impacts of introducing bog water into the receiving waters of lakes and streams.

An additional research recommendation included the construction of pilot projects designed to investigate, on a small scale, the feasibility of various development options. For example, a pilot peat-gasification plant would investigate the feasibility of producing SNG from peat and could further investigate the problem of removing large quantities of water. On the other hand, pilot chemical plants could explore new technology for peat-derived substances. The construction of pilot projects would also provide an opportunity for monitoring various impacts, both environmental and socioeconomic, of peatland development.

Management Recommendations

Several recommendations concerning the future management of Minnesota's peatlands also arose from the Phase II studies. Included among the suggestions were the following:

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 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, 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 species from possible development 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

Studies conducted during Phase II of the Minnesota Peat Program have revealed the extent of knowledge available regarding the peatland environment and the options available for utilizing its resources. Although this information has provided a valuable background for developing a management policy, the studies have also revealed many of the deficiencies in our knowledge. Before these deficiencies are addressed, the State of Minnesota has insufficient data on which to base decisions concerning leasing of land for peat development.