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THE UTILIZATION OF PEATLANDS IN MINNESOTA (USA)

SOIDEN KÄYTÖSTÄ MINNESOTASSA (USA)

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Minnesota's peatland resources are described, and their historical, current, and prospective uses are reviewed. Minnesota has a large peat resource that has not been intensively utilized. The state government actively encourages both the industrial development of peatlands and the preservation of significant natural peatlands. Future peatland utilization in Minnesota will probably not be monopolized by a single use, for example, traditional fuel peat production.

Key words: Minnesota, peatland utilization, peat utilization.

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INTRODUCTION

The state of Minnesota is located in the northcentral part of the United States at the western end of the Great Lakes (Fig. 1), and contains the most extensive peat deposits in the country excluding Alaska. Since the mid 1970's, public and private organizations have shown great interest in the industrial development of these peat resources, yet economic and geographic factors have hindered most of these developments. During this time much inventory work and research was completed, so a good knowledge base for managing and developing these peatlands now exists.

This paper briefly describes the present state and future prospects of peatland utilization in Minnesota.

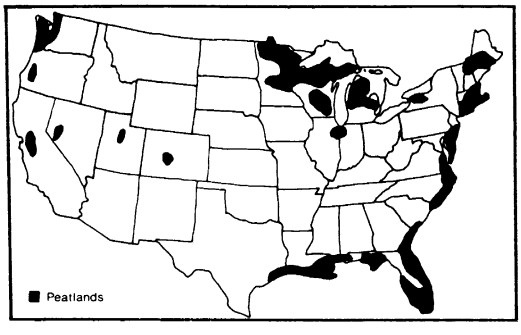

Figure 1. General peatlands areas in the United States.

Kuva 1. Soiden sijainti Yhdysvalloissa.

PEATLAND FORMATION IN MINNESOTA

Peatlands occupy about 3 million hectares (14 %) of Minnesota's 22 million hectares of surface area. The most extensive and thickest deposits occur in the northcentral and northeastern parts of the state, where about 70 % of the total peatland area is located (Fig. 2). The climate of this area is essentially boreal and receives 610—762 mm of average annual precipitation and has an average annual temperature of 1.7—3.9°C. The climate becomes drier and warmer to the south and west and is less favorable for peatland existence (Malterer & Farnham 1984).

Extensive continental glaciation in Minnesota during the Wisconsin Ice Stage (>50,000—10,000 years ago) created a landscape favorable for peatland formation. Glacial lake basins, relatively flat ground moraines, outwash plains, and ice block depressions all provided places for peatland development because water movement was slowed there.

Paludification, which began about 4,500 years ago, has been the most important peatland formation process in Minnesota (Heinselman 1963), and has produced extensive peat deposits on glacial lake plains and sand plains. A cool wet environment, very flat topography, and relatively impermeable lacustrine soils favored the paludification of the glacial lake basins (Olson et al. 1979), and

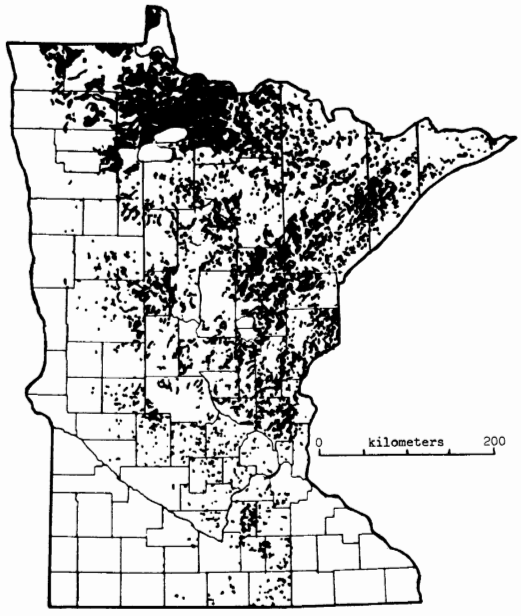

Figure 2. Distribution of peatlands in Minnesota.

Kuva 2. Soiden esiintymisalueet Minnesotassa.

these areas now contain large contiguous deposits that range up to 100,000 hectares and 9 m thick. A high water table in the sand plain areas helped to favor paludification there, and today these deposits range up to 400 hectares and 2 m thick (Malterer & Farnham 1980).

Lakefill is the other important peatland formation process in Minnesota. Moraine areas, till plains, and drumlin areas all have provided numerous sites for the shallow lakes and ponds, that have been changed to peatlands by lakefill. These peatlands are quite numerous in many parts of the state, and they vary greatly in size, but they are usually smaller than 200 hectares and thinner than 6 m (Malterer and Farnham 1980).

PEAT TYPES

Peat types in Minnesota are often classified into three categories: fibric, hemic, and sapric. These categories can be thought of as equivalent to the International Peat Society's (1976) field classification categories, (R1), (R2), and (R3), respectively. Generally in Minnesota, fibric peat is weakly decomposed and comprised of *Sphagnum* mosses, hemic peat is moderately decomposed and comprised of herbaceous or woody plant material, and sapric peat is comprised of almost completely decomposed plant remains (Olson et al. 1979).

A highly generalized profile of Minnesota peat would have a thin basal sapric layer covered by a relatively thick hemic layer of reed-sedge peat, which would be capped by a thin fibric layer. Thicker fibric caps of *Sphagnum* peat occur in ombrotrophic or raised bogs, and deposits of almost solely sapric peat are not uncommon. Although Minnesota's peat deposits may vary greatly, the vast majority of its peat resources are probably hemic peats of reed-sedge origin.

VIRGIN PEATLAND

The vegetation of Minnesota's peatlands can vary from dense white cedar *(Thuja occidentalis)* forests to open *Sphagnum* bogs, and from open sedge-dominated wet fens to 15 m tall black spruce *(Picea mariana)* forests. Large areas of Minnesota's peatlands are covered by low shrubs or stunted black spruce and tamarack *(Larix laricina)* forests, yet some areas support good forest stands. The most common peatland tree species are black spruce, tamarack, and white cedar.

Some peatlands in Minnesota, including the state's largest, have strongly developed surface patterns. These patterns and their development have been described by Glaser and Wheeler (1980). Because of the uniqueness of these areas, many have been recommended for or given protected status (Asmussen 1981).

As natural areas, Minnesota's peatlands support the growth of unique and rare plants and provide important wildlife habitat. Many species or orchids (which are protected plants in Minnesota) along with other unusual plants, such as insectivorous species, occur almost exclusively in peatlands. These peatlands are unique in North America because they occur in an area where three major biomes meet (boreal forest, temperate grassland, and temperate deciduous forest). Although peatlands are not as productive as upland sites for wildlife, they still are important areas. Some bird species nest only in peatlands and many birds and animals regularly and seasonally use peatlands and the ecotone areas along peatlands margins (Asmussen 1983). White cedar stands, which often occur on shallow, mineotrophic sapric peats, are very important white-tailed deer wintering areas. In the agriculturally dominated landscape of western Minnesota, peatlands can be one of the only natural areas available for wildlife habitat (Asmussen 1981).

AGRICULTURE AND FORESTRY ON PEATLANDS

Major European settlement in Minnesota's peatland areas began in earnest during the late 1800's and with it came the utilization of some of these areas for forestry. Many of these areas supported good stands of black spruce, white cedar, and tamarack, which were used for lumber and poles. Black spruce has also been harvested extensively from peatlands for use as Christmas trees. Today four or five paper-mills in the state use large quantities of black spruce, a good portion of which comes from peatlands. Currently, forestry is the major industrial use for peatlands, yet very little intensive forestry (draining and fertilization) is practiced. A predicted increased demand for wood products could alter this situation in the future (Malinka & Mangan 1981).

During the early 1900's, drainage ditches were dug in many peatland areas for reclamation purposes, but the ditches were spaced too far apart (often 1.6 kilometers or more) (Fig. 3) for effective drainage and only local changes in the hydrology occurred (Glaser & Wheeler 1980). Early schemes for introducing agriculture to these peatlands failed not only because of insufficient drainage but also because of the need for added fertilizers and the increased chance of summer frosts in these areas. In spite of these and other problems, nearly 10 % (277,000 hectares) of the state's peatlands are now used for agriculture. It must be noted, however, that most of this area is occupied by low-value nonintensive crops (hay and forage) (Table 1), and many of these fields may be harvested only during climatically favorable years.

Figure 3. Some old peatland ditches are in poor condition. This one has been blocked by a beaver dam.

Kuva 3. Osa vanhoista suo-ojista on huonossa kunnossa. Kuvassa majavapadon tukkima oja.

Table 1. 1983 estimate of crop production on Minnesota peat soils (Farnham 1983).

Taulukko 1. Minnesotan viljeltyjen soiden vuoden 1983 satoarvio (Farnham 1983).

Crop type *Viljelykasvi, tyyppi*	Area, ha *Pinta-ala, ha*	% of total *% viljeltyjen soiden kokonaisalasta*
Hay and forage *Heinä ja laidun*	208,00	75.1
Corn and soybeans *Maissi ja soijapapu*	40,000	14.5
Vegetables *Vihanneskasvit*	8,000	2.9
Wild rice *(Zizania aquatica)* *Intiaaniriisi*	6,400	2.3
Turf grass (sod) *Turveruoho*	5,600	2.0
Grain crops *Viljakasvit*	4,800	1.7
Certified grass seed *Tarkastettuja ruohonsiemeniä*	4,000	1.4
Total *Yhteensä*	276,800	100

Corn and soybeans and vegetable crops are mainly grown near the populous Minneapolis-St. Paul metropolitan area and in the southern part of the state. Vegetable crops that produce an underground product (carrots, radishes, potatoes, and onions) and cool weather vegetables (cabbage, parsnips, broccoli, cauliflower, and celery) are the types most commonly grown. A relatively short frost-free period, normally June 1 to August 15, hinders vegetable production on northern Minnesota peatlands (Farnham 1983).

Wild rice *(Zizania aquatica)* and turf grass (or sod) are two commercial crops whose production on peatlands has increased significantly in recent years (Farnham 1983). Wild rice is a native aquatic grass which produces a grain that has been used for centuries by American Indians as a staple food, and today is also used widely as a gourmet or specialty food.

Turf grass sods are carpet-like strips of densely grown grass plants and adhering soil which are harvested and transplanted to form new lawns (Fig. 4). Organic soils are favored over mineral soils for turf grass production because they are more suitable for intensive management, a marketable product can be produced in shorter time on them, and the marketable product from them is lighter in weight, making it easier to handle and cheaper to transport (Rieke et al. 1968).

Figure 4. Turf grass sod production in northern Minnesota. Rolled sod strips are in foreground; tractor in background is cutting and rolling the sod strips.

Kuva 4. Turvealustalla kasvatetun nurmimaton valmistusta Pohjois-Minnesotassa. Etualalla nurmisuikalerullia, joiden takana traktori leikkaamassa nurmisuikaleita.

Grain crops and certified grass seed are also important peatland crops, but cranberries, blueberries, and mint are not commonly grown on Minnesota peatlands, even though they are often grown on peatlands in other states. However, current horticultural work may soon develop new plant strains that are suitable for commercial production on Minnesota's peatlands.

HORTICULTURAL PEAT

Virtually all of the peat consumed in the United States has been for horticultural and other non-fuel purposes. From 1950 to 1960 peat production in the U.S. increased by about 3.6 times and consumption increased by about 2.9 times. During the same time period in the Lake States area (Michigan, Minnesota, and Wisconsin), production increased by about 14.9 times (Table 2), although about 90 % of this production was from Michigan alone. Much of Minnesota's horticultural peat industry developed at that time, but even by 1978, Minnesota's peat production was only 16,300 tons or about 2.2 % of the total U.S. production (Singleton 1980), despite having the largest peat reserves of any state except Alaska.

In 1978 the U.S. imported 32 % of its peat consumption, most of this was high quality *Sphagnum* moss peat from Canada. The 1978 average prices for domestic and imported peats were $18.74/ton and $109.15/ton, respectively. Thus, although the U.S. imported about 1/3 of its peat on a tonnage basis, it imported nearly 3/4 of its peat on a value basis (Singleton 1980).

Interest in the economic potential of Minnesota's raised bog areas prompted the Minnesota Department of Natural Resources (DNR) to inventory the state's raised bogs and their associated *Sphagnum* peat deposits. They identified 224 raised bogs covering 52,292 hectares and containing 66 million tons of *Sphagnum* peat. Forty-four of these bogs covering 10,474 hectares and containing 34 million tons of *Sphagnum* peat were considered to have commercial deposits because the *Sphagnum* peat deposits were 1.5—3.0 meters thick. The 34 million tons represents 75 times the 1977 *Sphagnum* moss consumption in the U.S. (Malterer 1980).

Minnesota's horticultural peat industry is expanding because of an increasing U.S. demand and the availability of significant reserves of horticultural peat in Minnesota. In 1986 the Minnesota DNR recognized 7 active horticultural peat operations in the state, 4 of which were greater than 16.2 hectares (the largest operation covers about 480 hectares and has been harvesting moss peat since 1958) (Minnesota Dept. of Natural Resources 1986). Finland's VAPO has even taken an active role in developing Minnesota's horticultural peat

Table 2. U.S. peat production and imports (1,000 tons) during selected years (Singleton 1980).

Taulukko 2. U.S.A.:n turvetuotanto ja turpeen tuonti (1 000 tn) (Singleton 1980).

Year *Vuosi*	Production, *Tuotanto*			Imports *Tuonti*	Consumption *Kulutus*
	U.S. *U.S.A*	Lake States	Minnesota		
1950	119	14	ND	112	231
1960	428	203	ND	239	667
1978	746	242	16	345	1091

ND = no data available, *tiedot puuttuvat.*
Lake States = Michigan, Wisconsin, and Minnesota.
Consumption = U.S. production + imports, *Kulutus = U.S.A.:n tuotanto + tuonti.*

resources by creating a new Minnesota peat producer, "Peatrex", which will be harvesting horticultural peat in northern Minnesota. News reports in May 1986 heralded a Minnesota company's planned construction of a new $3.3 million peat processing plant that will produce a livestock feed additive and horticultural peat products. The company also plans to explore and develop other industrial uses for Minnesota peat.

Figure 5. Sod peat production in northern Minnesota.
Kuva 5. Palaturpeen valmistusta Pohjois-Minnesotassa.

FUEL PEAT

Minnesota has had virtually no fuel peat industry except for the production of fuel peat for production demonstration projects and test burns. Very little real interest in developing peat fuels existed in Minnesota until 1976 when the Minnesota Gas Company (Minnegasco), a private natural gas distributor, announced its intentions to plan and research for the construction of a synthetic gas plant that would use peat from the Red Lake Peatland as the feedstock. The proposed plant would have produced 7.08 million cubic meters of gas each day and would have consumed about 2,000—4,000 hectares of peatland per year. Because of a combination of economic factors and potential environmental and social problems created by the development, construction was never started. The project did, however, create a lot of concern and interest in Minnesota's peatland and resulted in the creation of the Minnesota DNR's Peat Program to study peat utilization and its impacts, to gather baseline environmental data, and to inventory Minnesota's peat resources so that these peatlands could be effectively managed (Asmussen 1983).

During the 1980's, high fossil fuel prices and the threat of future fuel shortages helped to sustain interest in research into the use of peat as an alternative fuel. The state helped to sponsor test burns in various research and municipal boiler systems and demonstration fuel peat harvesting operations (Fig. 5). They have also encouraged fuel peat use by offering low interest loans for retrofitting boiler systems to use peat or other fiber fuels, and by proposing to clear and drain some peatlands in advance to attract fuel peat harvesting operations to locate in Minnesota (Asmussen 1983).

In 1986 the Minnesota DNR recognized only four fuel peat producers in the state. Three of these were over 16.2 hectares in size but only one was active (Minnesota Dept. of Natural Resources 1986). Fuel peat production in Minnesota has included sod peat, milled peat, and peat briquettes.

The main reason that Minnesota's fuel peat industry has not developed is because cheaper fuel alternatives have been readily available. The nearby states of North Dakota, Wyoming, and Montana have substantial deposits of relatively clean burning, easily produced lignite and subbituminous coal, with which, Minnesota peat has not yet been able to compete. Although the short term prospects for fuel peat use seem poor, probable future price increases and shortages in traditional fossil fuels, along with improvements in peat fuel technology will probably make Minnesota's peat an attractive alternative fuel source once again.

Much technological research into creating indirect fuels, such as synthetic natural gas, methanol, and bio-energy crops from peat and peatlands has been conducted in the U.S. In Minnesota, interest has been concentrated on bio-energy crops, and the most promising of these have been *Typha spp.* (cattail) (Garver et al. 1983), *Salix spp.* (willow), and *Populus spp.* (poplar) (Berguson et al. 1983). Already many boiler systems in northern Minnesota have been converted to burn fiber fuels like these and peat. Bio-energy crops may also be an excellent way to reclaim exhausted fuel peat harvesting sites. Minnesota's largest electricity producing company has recently shown interest in developing bio-energy crops on peatlands to fuel electricity producing plants in northern Minnesota.

PEAT CHEMICALS

As peat chemical technology has developed, it has become apparent that peat may be an excellent feedstock for a number of valuable chemical products such as waxes, phar-

maceuticals, single cell protein, organic acids, activated carbon, and so on (Fuchsman 1978). The use of peat for chemical utilization probably would yield a product with a higher unit value than peat fuels, would be consumed on a smaller scale for a longer period of time (slower depletion of the resource), and could possibly result in less environmental and social problems than would large scale fuel peat harvesting.

Peat chemical technology research has shown that more than one valuable product can be produced from the same peat feedstock (coproduction), reducing harvesting and production costs and possibly resulting in the beneficiation of one of the products. This could result in making marginally economical operations economical. An example of this would be a peat processing plant to produce fuels and waxes.

Peat in Minnesota typically has a wax yield too low for economical extraction, but by treating it with wet carbonization, wax yields can be more than doubled, probably making the operation economical. The peat material left over from this process may be valuable as a high quality fuel because it can have a higher energy value than the original peat because of beneficiation by the wet carbonization process and it may be a cleaner burning fuel because of the removal of bitumens during the wax extraction procedure (Spigarelli et al. 1985). Recent research also suggests that this debituminized peat can be as good or better than whole peat as a soil conditioner (Rengo, unpublished results). It is possible that other products can be obtained during the wax extraction process, e.g. industrial resins separated from the waxes and single cell protein grown on the wet carbonization waste water. Thus from one unit of harvested peat can come not just one product but possibly many products with added value (Spigarelli et al. 1985).

PEAT AND PEATLAND RESEARCH

Most of the peat and peatland research in Minnesota is conducted by state agencies or universities. The Minnesota DNR is the state agency responsible for the management of the state's peatlands, and it has sponsored or conducted research directed toward inventorying and characterizing peatlands; assessing the environmental, socio-economic, and technological aspects of peatland development; and promoting the industrial development of peatlands (Fig. 6). Various other state agencies have been involved in related research, but to a lesser extent.

Figure 6. Minnesota Department of Natural Resources research site. Poor natural revegetation on an old (>20 years) abandoned peat harvesting site.

Kuva 6. Minnesota Department of Natural Resources:n tutkimusalue. Luonnollisen kasvillisuuden kehittyminen on heikkoa yli 20 vuotta sitten hylätyllä turpeennostoalueella.

Much research in peatland ecology, soils, hydrology, agriculture, and reclamation has been produced by researchers at the University of Minnesota. The Center for Environmental Studies at Bemidji State University has been investigating non-fuel industrial uses of peat and has sponsored International Peat Symposia in 1981 and 1983. In 1983 the Natural Resources Research Institute (NRRI) was established as part of the University of Minnesota, Duluth. Its purpose is to conduct applied research to help promote the economic development of the state's natural resources, including peat. The NRRI's peat research plans include projects to study the production of ornamental and horticultural plants on peatlands and studies to help promote the development of an industry based on peat energy resources. Because of the donation of Professor Rouse Farnham's (University of Minnesota) peat literature collection, the NRRI now has the largest peat literature library in the U.S.

Peat product research is also being conducted by different companies and individuals in Minnesota. These products include peat pelletizing equipment, livestock feed additives, and a pressed peat product containings seeds and fertilizer, which is intended to be used in the same manner as turf grass.

MANAGEMENT

The Minnesota DNR is charged with managing the state's peatlands, of which about 50 % are publicly owned. The DNR regulates peat harvesting by controlling mining leases on state lands, by requiring operations greater than 16 hectares to meet certain standards before they are issued a permit to mine (e.g. approved reclamation plans and insurance), and by requiring the completion of an environmental review before they are issued permits for drainage activities, air pollution emissions, and water pollution discharges. The environmental review required for projects of 65—110 hectares is the "environmental assessment worksheet", and for projects larger than 110 hectares, it is the more extensive "environmental impact statement". The permitting and leasing processes are used by the DNR to direct peatland utilization to the most environmentally and economically appropriate sites (Asmussen 1983).

The DNR's official policy is to encourage multiple uses of the state's peatland resources, including both extractive uses (e.g. horticultural, fuel, and chemical mining) and non-extractive uses (e.g. forestry, agriculture, bioenergy crops, and wildlife management). Certain peatland areas have been recommended for preservation because they are ecologically significant (Malinka and Mangan 1981). The state also actively promotes industrial peatland development by sponsoring and conducting peat technology research and by offering economic incentives to potential peat producers and consumers.

CURRENT AND FUTURE PROSPECTS

The use of peatlands is actively encouraged in Minnesota because of the anticipated economic benefits that it would bring, particularly to the economically troubled northern Minnesota area. It is hoped that the development of a larger peat-based industry will aid in the economic recovery of this area and will bring greater economic stability and diversity for the future.

The development of Minnesota's Peat Program in the 1970's was in response to the energy crisis and the threat of unregulated development of the state's peatlands for energy production. Since then, most of the peat industry development interest has been focused on fuel peat, yet lately more and more interest is being directed toward non-fuel uses of peat and peatlands. Public and private money is currently being invested into research aimed at peat product development, with the thought that this research is the key to peat industry expansion in Minnesota. The peat and peatland research conducted during the last 10 years has provided the necessary information for the wise management of Minnesota's peatlands and has produced information that should greatly aid in the industrial development of these peatlands. Yet because of the geographic and economic problems of Minnesota peat utilization and because of competition from other related industries, these research efforts must continue and perhaps expand in order that Minnesota's future peat industry will develop and thrive.

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TIIVISTELMÄ:

SOIDEN KÄYTÖSTÄ MINNESOTASSA (USA)

Minnesotan suoala on n. 3 milj. ha, mikä on 14 % osavaltion pinta-alasta. Suurin osa soista on keskittynyt osavaltion koillis- ja pohjois-osiin (kuva 2). Turve on useimmiten ruokosaraturvetta, mutta Minnesotassa tavataan myös melkoiset määrät rahka- ja puuturpeita. Alaltaan suurimmat suot sijaitsevat hyvin tasaisissa jääkauden jälkeen täyttyneissä järvialtaissa. Niiden pinta-ala saattaa olla jopa 100 000 ha ja turvekerroksen paksuus 9 m.

Jonkin verran suoalueita on suojeltuina niillä kasvavien harvinaisten kasvilajien vuoksi, eläinten muutonaikaisina turvapaikkoina tai harvinaisina ekosysteemeinä. Suurimmalla osalla luonnontilaisia soita puuston kasvu on heikkoa, mutta osalla voidaan tavata melko järeäpuustoisiakin mustakuusen *(Picea mariana),* Kanadan lehtikuusen l. tamarakin *(Larix laricina)* tai Kanadan tuijan *(Thuja occidentalis)* muodostamia metsiköitä. Mustakuusta hakataan soilta jonkin verran, mutta soiden ojitusta ja lannoitusta ei juuri ole.

Noin 10 % suopinta-alasta on viljelyssä, mutta suurin osa tästä on heinällä ja laitumena (taul. 1). Paikallisesti ovat merkityksellisiä soilta saatavat vihannekset, intiaaniriisi ja turveruoho.

Kasvuturvetta on Minnesotassa nostettu vuosikymmeniä, joskin sen määrä on ollut melko pieni. Vuonna 1978 määrä oli 16 300 t vastaten 2,2 % koko USA:n tuotannosta. Osasyy pieneen määrään ovat pitkät kuljetusmatkat päämarkkina-alueille. Minnesotan kasvuturvetuotanto on lisääntymässä USA:n kasvavan tarpeen myötä.

Minnesotassa ei ole juurikaan ollut polttoturpeen tuotantoa, vaikka siihen kiinnitettiinkin paljon huomiota energiakriisin jälkeen. Viereisten osavaltioiden halvan hiilen saatavuus on ollut suurin Minnesotan polttoturvetuotantoa rajoittava seikka. Tutkimustoimintaa turpeen polton alalta on ollut melko paljon, ja monet Pohjois-Minnesotan lämmityslaitokset pystyvät käyttämään turvetta polttoaineena. Tällä hetkellä näyttää kuitenkin siltä, että turpeen energiakäyttö tulee olemaan vain marginaalista luokkaa.

Suurin osa turpeen kemian teknologian tutkimuksesta on suunnattu turpeesta saataviin vahoihin. Luultavasti niitä pitäisi kuitenkin eristää yhdessä jonkin toisen tuotteen (esim. turve-energian) kanssa, jotta toiminta olisi taloudellisesti kannattavaa.

Minnesotan Luonnonvarain toimisto (The Minnesota Department of Natural Resources, DNR) on vastuussa soiden käytöstä. Toimistossa kartoitetaan turvevaroja, tehdään ympäristö- ja teknologista tutkimusta, säädellään soiden käyttöä, edistetään turveteollisuutta ja suojellaan tärkeitä suoalueita. Soiden teollista käyttöä rohkaistaan, mutta se ei saa aiheuttaa suuria ympäristöongelmia.

Minnesotassa on tehty paljon soihin ja turpeeseen liittyvää tutkimusta etupäässä Minnesotan yliopistossa, Bemidjin valtionyliopistossa ja Luonnonvarain toimistossa. Tämän tutkimuksen täytyy jatkua ja mahdollisesti laajentua, jotta Minnesotan turveteollisuus voisi kasvaa.

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