

# Human Impacts to Minnesota Wetlands

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**ABSTRACT**—Minnesota's 3.6 million ha of wetlands have been impacted by a variety of human activities, including agricultural drainage, urbanization, water control, and nonpoint source pollution. More than half of Minnesota's wetlands have been destroyed since the first European settlers arrived, an average loss of about 35,600 ha/yr. Drainage for agriculture is the major cause of wetland loss in Minnesota, particularly in southern Minnesota and the Red River Valley. In addition to impacting wetlands directly, wetland drainage affects downstream areas by increasing flood flows, and releasing sediment and nutrients. Urban development and highway construction affect a smaller proportion of Minnesota's wetlands, but substantially alter their physical, chemical, and biological properties. Hydrology has a major influence on the structure and function of wetlands, so changes in the frequency, duration, depth, and timing of wetland flooding can severely impact wetlands. While wetlands can assimilate low levels of sediment and nutrient enrichment, excessive inputs can be detrimental. Peat harvesting is not currently extensive in Minnesota, but could cause substantial impacts. Cumulative impact, the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, is becoming an area of increasing concern.

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## Introduction

Minnesota has been blessed with an abundance of wetlands. As of the late 1960s, Minnesota's 3.6 million ha of wetlands (1) constituted about 9 percent of the nation's wetlands (2) and 28 percent of its peatlands (3). Wetlands provide Minnesota with many ecological benefits, such as fish and wildlife habitat, flood peak reduction, and water quality improvement.

Minnesota's wetlands, however, have been impacted by a variety of human activities (Table 1). More than half of the state's wetlands have been destroyed since the first European settlers arrived (1), an average loss of about 35,600 ha/yr (Figure 1). While the current wetland loss rate is much lower, it is still substantial: 2,100 ha/yr (4). Not included in these statistics are the thousands of hectares of wetlands which still exist, but have been severely degraded.

Impacts to Minnesota's wetlands are both direct and indirect, and can affect wetlands individually and cumulatively. This paper discusses the extent, severity, and consequences of human impacts to wetlands, using examples from Minnesota and other states. Types of impacts discussed include agriculture, urbanization, hydrologic alteration, non-point source pollution, and peat extraction.

## Agricultural Drainage

Drainage for agriculture is the major cause of wetland loss in Minnesota. In 1982, crops were grown on 4.2 million acres of wet soils, those for which excess water is the dominant agricultural limitation (5). This exceeds the total area of wetland loss in the state (about 3.9 million ha), because the definition of wet soils includes areas not wet enough to be considered wetlands. However, the proportion of wet soils cropped (47 percent) approximately equals the proportion of

wetlands lost since presettlement. The area of wet soil cropped in 1982 was 12 percent higher than the area cropped in 1977 (6), indicating that agricultural drainage is a continuing source of wetland loss. An estimated 112,000 km of public and private drainage ditches span the state, as compared with 142,400 km of rivers and streams (4).

Drainage of wetlands for agriculture has resulted in much higher wetland loss rates in Minnesota's major cropland areas. An estimated 99 percent of the wetland area in southern Minnesota and the Red River Valley has been lost, primarily to agricultural drainage (4). In contrast, only 11 percent of the wetlands area in predominantly forested northern Minnesota has been lost. The "Prairie Pothole" region of southwest Minnesota and the Dakotas, which produces half of the ducks in the contiguous United States, has been particularly hard hit. Wetland drainage rates in this region were 55,850 ha/yr between 1959 and 1966 (7). While current drainage rates are lower, it is estimated that wetland drainage from 1980 to 1990 will eliminate 20,000 of the 246,000 ha of marshes and shallow ponds remaining in the Prairie Pothole region (4).

Partial drainage of wetlands reduces the depth and duration of surface water without completely destroying the wetland. Partial drainage is a common practice for lowland pasture improvement, and also results from drainage system failure and stream channelization. The partial draining of wetlands alters their plant communities (8), promotes the invasion of exotic plant species, increases shrub encroachment (9), and reduces wetland value to waterfowl and other wildlife.

Since the purpose of drainage ditches is to accelerate water removal from wetlands, it is not surprising that wetland drainage increases downstream flood flows. Larson (10) used a hydrologic model to simulate stream flows from two watersheds in Jackson County, Minnesota, assuming conditions ranging from no drainage to complete drainage of all wetlands in the watersheds. The use of ditches to drain depressional wetlands significantly increased annual runoff, storm runoff volume, and peak discharges from the watersheds. Enlarging and straightening the watersheds'

Table 2. Primary physical and chemical effects of construction activities on wetlands (14).

#### *Circulation*

- Loss of wetland habitat
- Reduction of habitat diversity
- Modification of normal seasonal flow patterns
- Drastic fluctuation in water levels and flow rates
- Reduction in flow volume
- Increased downstream flooding

#### *Sediment*

- Creation of canals in swamps and marshes
- Increase in turbidity
- Increase in sedimentation
- Alteration of bottom topography

#### *Chemical and physical properties*

- Reduction in light penetration
- Elevation of temperature
- Modification of natural chemical composition
- Increased oxygen demand
- Addition of chemical pollutants
- Build-up of bottom pollutants

vegetation, or by open water. Seepage of water from impoundments can also alter the hydrology and vegetation of adjacent wetlands (20,21). Wetlands that have been subjected to prolonged hydrologic disturbance are susceptible to the invasion of exotic and/or undesirable plants when water levels return to normal (22).

Hydrology is an important determinant of floodplain forest ecology, affecting reproduction, species composition, net primary productivity, litter decomposition, and nutrient cycling. The anthropogenic alteration of hydrology, therefore, can have far-reaching effects on the ecology of floodplain forests (23,24). Construction of levees, dams, and channelized streams throughout Minnesota has greatly altered the extent and ecology of the state's floodplain forests, such as those along the Mississippi and the Red River. The floodplain forests of the Minnesota River, however, remain largely intact (25).

Wetlands within or adjacent to reservoirs are subject to drastic hydrologic fluctuations. Periodic drawdown of flooded areas desiccates and kills submerged and emergent vegetation, permitting invasion by annual weeds (26). Prolonged inundation can kill emergent vegetation (27), while frequent or extreme fluctuations in water level create a broad unvegetated zone around the edge of reservoirs. Fluctuating water levels can also cause nest failure and reduce hatching success of waterfowl (28,29).

The discharge of heated water from power plants has a dual impact on wetlands. Not only is wetland hydrology altered, but the prolonged vegetative growth stimulated by elevated water temperatures can kill herbaceous plants due to depletion of overwinter carbohydrate reserves (30). At the U.S. Department of Energy's Savannah River Plant in Georgia, portions of a floodplain forest wetland continue to deteriorate after more than 30 years of thermal loading (31).

### **Sedimentation and Nutrient Enrichment of Wetlands**

Sediment and nutrient inputs to wetlands have been increased by a variety of human activities. These discharges are often intentional, due to the increasing use of wetlands

for stormwater retention and waste disposal (32,33). Non-point source pollution inputs to wetlands have increased in both urban and agricultural areas as land uses have intensified. Sediment from agricultural nonpoint source pollution accumulated at rates as high as 2.4 cm/yr in a Wisconsin wetland, resulting in average annual nutrient accumulations of 2.6 g/m<sup>2</sup>-yr P and 12.8 g/m<sup>2</sup>-yr N (34).

While the retention of sediment and nutrients in wetlands is desirable for keeping pollutants out of lakes and streams, it can have undesirable effects on the wetlands themselves. Suspended sediments can reduce photosynthesis, decrease oxygen concentrations, impair fish respiration, and interfere with the feeding and nutrition of aquatic animals (13). Sediment deposited on the wetland surface can kill benthic organisms, reduce fish food supplies, destroy fish habitat, and adversely affect fish reproduction by eliminating spawning areas or smothering eggs and larvae. Excessive siltation can also stimulate the encroachment of exotic and undesirable plant species (35).

The discharge of wastewater to natural wetlands may have adverse effects, depending on application rates and the characteristics of the receiving wetland (36). Some nutrient enrichment studies have shown relatively little wetland response, primarily in the form of increased vegetation growth (37,38). If application rates are excessive and prolonged, however, wetland hydrology and vegetation may be drastically altered (39). If the chemistry of the effluent is much different than the chemistry of the natural wetland (e.g. adding alkaline effluent to an acid bog), there may be rapid vegetation changes (40). Altered plant composition may, in turn, alter aquatic macroinvertebrate and animal populations higher in the food chain (41). Studies of cypress domes in Florida, for example, showed a significant increase in the number and diversity of bird species in wetlands receiving wastewater discharge (36).

Wastewater discharge to natural wetlands is fairly common in Minnesota; the U.S. Environmental Protection Agency identified 36 Minnesota wetlands receiving wastewater effluent in 1983, some as much as 1.2 million gallons per day (48). However, little is known about specific wetland impacts at these sites.

### **Peat Harvesting**

Although there have been numerous attempts to establish a Minnesota fuel peat industry, beginning shortly after statehood (42), little of the state's peatland area has been destroyed since European settlement (Figure 1). Fuel peat extraction could cause substantial environmental impacts to Minnesota's peatlands (43,44,45,46), but no long-term studies of the effects of peat mining have been conducted because interest in fuel peat development has largely waned with declining oil prices. The extraction of horticultural peat, which is a small but growing industry, should have similar impacts (i.e. lowering of groundwater, removal of vegetation and topsoil, increased airborne particulates). Peatlands are also impacted by agriculture, partial drainage, and road construction (9).

### **Cumulative Impacts to Wetlands**

Impacts that may be individually insignificant can accumulate over time and space to cause significant environmental degradation. Cumulative impact, the incremental impact of an action when added to other past, present and reasonably foreseeable future actions, is becoming a subject of increasing

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