Sedimentation of Prairie Pothole Wetlands: The Need for Integrated Research by Agricultural and Wildlife Interests

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Abstract
The Prairie Pothole Region (PPR) of the northern Great Plains is a major producer of cereal grains and wildlife, especially migratory waterfowl. Both agriculture and wildlife are important resources of the PPR. The objectives of maintaining productive lands for agriculture and wildlife are not mutually exclusive; both benefit under sound resource management. We examined the influence of sedimentation on wildlife values in wetlands. Results from June-July 1993 indicate that sedimentation rates ($g \cdot m^{-2} \cdot d^{-1}$) in wetlands with watersheds in summer fallow were significantly greater than in wetlands in native prairie, or in Conservation Reserve Program (CRP) lands. Our work highlights the need for integrated research that combines expertise from agricultural and wildlife disciplines to develop sound conservation practices that simultaneously promote productivity of agricultural fields and wildlife habitats.

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Introduction

Spatial position and morphology of prairie wetlands in agricultural fields make them highly vulnerable to sedimentation (Neely and Baker 1989). Sediment is the most important pollutant of surface waters in the United States and the greatest source of sediment is erosion of agricultural lands (Robinson 1971; Long 1991; Wayland 1993). Impacts of suspended sediment and accelerated sedimentation on fish and aquatic life in riverine systems have been intensively studied (Ritchie 1972; Newcombe and MacDonald 1991; Waters 1995), but the influence of sediment on prairie wetland ecosystems is largely unknown. Sediment input from agricultural fields on prairie wetlands is of particular concern because these wetlands provide critical habitat required by breeding, migrating, and resting waterfowl (Batt et al. 1989), shorebirds (Eldridge 1987), and other wetland-dependent wildlife (Duebbert 1981). In addition to high wildlife values, wetlands are valued for flood control (Brun et al. 1981; Ludden et al. 1983), ground-water recharge (Winter 1989), and other societal values (Stevens et al. 1995).

A few studies have examined the influence of agricultural land-use on sedimentation of prairie wetlands (Adomaitis et al. 1967; Martin and Hartman 1987; Dieter 1991; Dryer et al. 1996), but impacts on water quality, primary productivity, and aquatic food webs are poorly understood (Gleason and Euliss 1996). Soil erosion is a primary concern of agricultural interests because erosion reduces the integrity, productivity, and sustainability of agricultural lands (Timmons 1980). Agricultural research and policy have been instrumental in developing and implementing agricultural conservation practices on private lands that reduce soil erosion, in order to maintain productivity and enhance soils and water quality. However, the success of conservation practices is normally evaluated from an agricultural perspective and generally does not include wildlife considerations (Miranowski and Bender 1982). Integration of goals from multiple interests and disciplines in conservation policies is in line with recent political emphasis on developing holistic agricultural programs (Gerard 1995). The amalgamation of pertinent interests and disciplines into research programs will ensure that appropriate information is available to policy makers.

Here we present an overview of research on the influence of agricultural land-use practices on sedimentation rates in prairie wetlands, and discuss potential effects of sedimentation on wetland ecology. We also discuss management strategies that reduce sediment inputs into prairie wetlands and the need to integrate research by wildlife and agricultural interests to develop holistic management strategies.

Soil Erosion and Sedimentation of Prairie Wetlands

During 1993-1995, we examined sedimentation rates in wetlands with watersheds (i.e., catchments) in native prairie with no prior history of tillage, land in CRP, and summer fallow land-use treatments (Gleason and Euliss 1996). Preliminary results from June-July 1993 indicated that sedimentation rates ($g \bullet m^{-2} \bullet d^{-1}$) were up to 70 times greater in summer fallow ($\bar{x}$=269.88) than in native prairie ($\bar{x}$=15.74) and CRP ($\bar{x}$=3.81) (Gleason 1996). Other investigators also have documented accelerated sedimentation of wetlands in agricultural landscapes. Adomaitis et al. (1967) demonstrated that the aeolian mixture of snow and soil ("snirt") in wetlands surrounded by cultivated fields accumulated at twice the rate as in wetlands in vegetated fields. Similarly, Martin and Hartman (1987) and Dryer et al. (1996) found that prairie wetlands with cultivated watersheds accrued sediments at twice the rate of wetlands surrounded by grassland, and Dieter (1991) demonstrated that turbidity in tilled wetlands was significantly higher than in partially tilled (wetlands with a filterstrip of vegetation along their periphery) and non-tilled wetlands. Catastrophic sedimentation events also have been observed in the PPR in which wetlands have completely filled with sediment during a single episodic rainfall event (Gleason and Euliss, personal observations). Wetlands in cultivated fields are thus shorter lived than wetlands in grasslands landscapes and significant soil loss occurs in agricultural lands under conventional tillage practices.

Potential Impacts to Wetland Ecosystems

Wetland-dependent wildlife values are greatly diminished after wetlands are filled with sediment. At a less catastrophic scale, prairie wetlands in agricultural landscapes receive short spates of sediment input during precipitation events. Sediments alter water quality, primary productivity, and aquatic invertebrates in aquatic ecosystems (Waters 1995). Suspended sediment reduces light penetration and reduces the rate of photosynthesis (Ellis 1936-1 Dieter 1991) and the concomitant fallout of sediment covers substrates critical to the production of periphytic algae and macrophytes. *In vitro* experiments have shown that sediment depths as little as 0.25 cm can significantly reduce species richness, emergence, and germination of wetland macrophytes (Jurik 1994; Wang 1994). Filling of wetlands also reduces historic water depths and alters the structure of vegetative communities. A common result of wetlands losing water depth from sedimentation is the development of monotypic stands of vegetation (e.g., cattails) that provide little biological diversity and exacerbate problems with farmers because they provide roost sites for blackbirds that depredate sunflowers and other agricultural crops.

Sediment effects on primary production translate into impacts on organisms at higher trophic levels through the aquatic food chain. Aquatic invertebrates are primarily collector-gatherers and grazers that consume periphytic algae associated with detrital food chains and vegetative substrates. Declines in algal production, loss of standing vegetative structure (Krecker 1939; Krull 1970), and covering of organic matter (Murkin 1989) make wetlands less productive of invertebrates through the indirect loss of forage and habitat. Direct effects include covering of invertebrates and their eggs, and clogging of filtering apparatuses. High levels of silt and clay also are toxic to zooplankton and/or reduce feeding rate and assimilation, thus reducing energy available for reproduction (Robinson 1957; McCabe and O'Brien 1983; Newcombe and MacDonald 1991). Aquatic invertebrates play critical roles in wetlands to facilitate nutrient cycling (Merritt et al. 1984) and are required foods for wildlife (Reeder 1951; Krapu 1974a, 1974b; Swanson et al. 1974, 1985; Fritzell et al. 1979; Euliss and Harris 1987).

Management Strategies

The potential for soil erosion to degrade wetlands and reduce the productivity of agricultural lands is great. Only for the past several decades has concern over soil erosion focussed on the effects of sediment in aquatic environments. However, most work has been conducted on reservoirs, lakes, and streams, which typically receive sediment from nonpoint sources. In contrast, prairie wetlands have only recently received attention although they are located in small catchments where sources of sediment input are easily identified. Lakes and streams can be protected by implementing large-scale control measures (e.g., CRP, bufferstrips, grassways) and soil conservation practices (e.g., no-till, minimum till), whereas wetland protection can be implemented using site-specific techniques.

Efforts to reduce sedimentation of wetlands by establishing perennial cover (e.g., CRP) and using bufferstrips are effective. Benefits of CRP to wildlife in the northern Great Plains have been documented by Johnson and Schwartz (1993a, 1993b), Kantrud (1993), and Reynolds et al. (1994), but this program is confined to certain types of agricultural lands and its long-term future is uncertain. Also, there are private land programs under which wildlife agencies pay farmers to take land out of production or use certain conservation tillage practices (Payne and Wentz 1992), but these programs are often of short duration. Land-use practices such as conservation tillage and zero-tillage are becoming more common in the PPR. In 1991, minimum tillage and organic farms comprised approximately 260,000 ha in North Dakota (Conservation Technology Information Center 1992). Both practices are long-term, reduce soil erosion, enhance wildlife benefits (Cowan 1982; Duebbert 1987; Youngberg et al. 1984; Lokemoen and Beiser 1995), and promote a highly productive and sustainable agriculture.

Need for Integrated Research

Future research should examine the influence of agricultural land-use practices on wetlands and wildlife in the PPR. It is not possible to sustain continental waterfowl and other wildlife populations on limited public lands. However, enhancing productivity of private lands for agricultural purposes and wildlife is possible. To insure the integration of long-term goals for agriculture and wildlife, research needs to develop management strategies that simultaneously provide for sustainable agriculture and wetlands.

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