Abstract: Big Meadows, a 63-ha fen in Rocky Mountain National Park (RMNP), was ditched for agricultural purposes in the early part of this century. Although use of the ditch ceased after the establishment of RMNP in 1915, it continued to intercept sheet flows in the central and southern portions of the fen, causing the ground-water level to decrease and aerobic soil conditions to develop in the mid- to late-summer of most years. In 1990, the ditch was blocked in an attempt to restore the hydrologic regime in the central and southern portions of the fen. Water-level data from three years prior to restoration and four years after restoration show that blocking the ditch successfully restored surface sheet flow, high late-summer water-table levels, and anaerobic soil conditions in much of the central and southern portions of the fen. Conditions in these areas are now similar to those in the northern portion of the fen. The long-term data from this site also indicate that summer rainfall has a greater influence on the magnitude of late-summer drying than the size of the winter snowpack. In a post-restoration year with extremely low rainfall in July and August, water levels throughout the fen decreased to levels similar to those observed throughout most of the pre-restoration period. The study suggests that this and other fens in the southern Rocky Mountains are extremely sensitive to summer precipitation and the hydrologic changes created by even small ditches or water diversions.

Key Words: fen, hydrology, restoration, Colorado, Rocky Mountains

INTRODUCTION

In many portions of the world, peatlands have been used for fuel or horticultural materials by direct harvesting, or they have been converted to agricultural or silvicultural uses by the construction of drainage ditches. These activities have been well-studied in Europe and Asia (UNESCO 1975, Zuidema 1975, Stewart and Lance 1983, Coulson et al. 1990, Götlich et al. 1993, Heathwaite et al. 1993), Canada (Rubec et al. 1988, Dang and Lieffers 1989, Hillman 1992), and in a few areas of the U.S., such as Minnesota (Rutter 1955, Boelter 1972, Glazer et al. 1981, Glazer 1987, Garfi and Brooks 1990, Bradof 1992, Keirstead 1992). In contrast, there have been almost no detailed studies on the effects of ditches, water diversions, or mining in peatlands in the western United States or other mountainous regions.

Peatlands occur where soil saturation retards the decomposition of organic matter, allowing it to accumulate (Moore and Bellamy 1974, Sanger et al. 1996). In humid maritime and some high mountain regions, precipitation alone is sufficient to maintain saturated soils. However, in regions where potential evapotranspiration exceeds precipitation, additional surface or ground-water inflows, or both, are necessary to maintain saturated soils (Cooper 1990, Mitsch and Gosselink 1993, Cooper and Andrus 1994).

The southern Rocky Mountains region has a continental climate with warm, dry summers, and peatlands occur only in areas with consistently high water tables (Cooper 1990). These water tables are sustained by local hillslope drainage (Cooper and Andrus 1994) or local or regional ground-water discharge (Cooper 1996). The dependence of Rocky Mountain peatlands on ground-water discharge means that they are all fens and are often extremely sensitive to climate variability or changes in the supply of ground water due to water diversions (Heathwaite et al. 1993).

Big Meadows is a 63-ha fen in Rocky Mountain National Park that was ditched for agricultural use prior to the establishment of the Park in 1915 (Figure 1). Earlier studies determined that even though agricultural activities ceased when the Park was formed, the ditch was still lowering water tables in the central portion of the fen (Schuter 1988, Cooper 1990). On the
basis of these investigations, a restoration program was designed and implemented in 1990.

Our hydrologic investigations have continued from 1987 to the present, and in this paper, we analyze three years of pre-restoration and four years of post-restoration water-level data to evaluate both the effects of the ditch and the success of the restoration project. These data provide an important case study of a restoration project in a high elevation peatland and insights into the hydrologic functioning of boreal-type fens near the southern limit of their occurrence in North America.

STUDY AREA

The Big Meadows wetland lies upstream of a glacial end moraine in the Tonahutu Creek drainage in the southwestern corner of Rocky Mountain National Park, Colorado at 2,865 m elevation (Figure 1). Tonahutu Creek drains westward from the Continental Divide and is a headwater tributary of the Colorado River. The northern and western area of Big Meadows is a fen supported by ground-water discharging from the toes of adjacent hillslopes, upward seepage from mineral soil, and seepage from spring-fed streams. In the fen portions of the wetland, up to 2 m of peat has accumulated on alluvial and glacial material. Adjacent to Tonahutu Creek, recent alluvial deposits occur at the surface, and no peat is present.

The fen is gently sloping, and its vegetation is dominated by the sedges Carex aquatilis Wahlenberg and C. utriculata Boott, with the willow Salix planifolia Pursh. being abundant on the fen margins where mineral-rich ground water discharges from hillside aquifers (Cooper 1990) (nomenclature follows Weber and Wittmann 1996). Conifer forests dominated by Picea engelmannii (Parry) Engelm., Pinus contorta Douglas ssp. latifolia (Engelmann) Critchfield, and Abies bifolia A. Murray occur on adjacent hillsides. The chemistry of surface water in the fen is typical of that found in granitic watersheds in the Rocky Mountains, being circumneutral to moderately acid, with extremely low concentrations of mineral nutrients (Cooper 1990, Cooper and Andrus 1994).

Big Meadows is subject to a strongly seasonal, snowmelt-driven hydrologic regime. In May and June, snowmelt runoff floods the area with up to 10 cm of slowly flowing water. Since summer precipitation is less than potential evapotranspiration, water tables typically decrease during the summer and are deepest from late August through September. The water table begins to rise in late September or October when evapotranspiration decreases. The duration and timing of the summer water-table drawdown is critical, as high water tables are necessary to maintain anaerobic soil conditions and retard the decomposition of organic matter.

In the early 1900s, a ditch was constructed through the central and southern portions of Big Meadows to enhance hay production for livestock. This ditch drains water from the fen to Tonahutu Creek and is approximately 500 m in length, 0.5 m wide, and up to 1.0 m in depth (Figure 2). Although the ditch has not been maintained since 1915, it continues to capture surface water and erode deeper into the peat. Topographic and botanical evidence indicates that, in the absence of the ditch, surface water would flow south through Big Meadows as a water track or path of concentrated water flow (Wright et al. 1992). This water track still exists in the northernmost portion of Big Meadows. We used water levels in this northern area (the area around wells 46 to 60 in Figure 2) as controls to evaluate the effects of climatic differences between the pre- and post-restoration study periods.

The diversion of this surface water, combined with