CANADIAN LANDFORM EXAMPLES – 29

PATTERNED PEATLANDS

Jonathan S. Price
Geography Department, University of Waterloo,
Waterloo, Ontario, Canada N2L 3G1

Wetlands cover 14% of Canada's land surface, and almost 90% of these are peatlands (Zoltai 1988). Peatlands are defined as land areas which are saturated for long enough to promote hydric soils, hydrophytic vegetation, and biological processes suited to a wet environment (Tarnocai 1980). In Canada, wetlands are classified as bog, fen, swamp, marsh, or shallow open water (NWWG 1988). Wetlands that accumulate organic material in excess of 0.4 m are called peatlands, and include bogs, fens, and some swamps and marshes (NWWG 1988). Most peatlands in Canada fall within the boreal forest zone, comprising mainly bogs and fens. This geographic range provides the optimal climatic conditions (Damman 1979; Thompson 1983), with respect to growth and decay of organic material (Clymo 1984).

Peatland Development

Peatlands typically develop in stages (Ivanov 1975), being initially dependent on direct precipitation, and on water inflow from adjacent upland mineral terrain (topogenous peatlands). The hydrological connection to local or regional groundwater systems or surface water for some period during the year enriches the concentration of base cations and nutrients, enhancing vegetation diversity (Glaser et al. 1990). These systems are called fens. As peat accumulates, the water table is gradually elevated, and the peatland may become isolated from mineralized water inflow (Siegel and Glaser 1987). These systems, which are called bogs, are sustained by precipitation only (ombrogenous peatlands). Consequently, they have a low trophic status and support a limited range of vegetation species, typically dominated by Sphagnum.

The geographical distribution of bogs and fens is closely related to gradients of temperature and precipitation. These processes affect the depth and duration of surface water availability (Damman 1979), and also the rates of growth and decay of organic material (Clymo 1984). Damman (1979) suggested that the distribution of peatlands in eastern North America is a response to latitudinal gradients of temperature and meridional gradients of moisture variability. Moore and Bellamy (1974) noted that European peatlands exhibit a stronger latitudinal, than meridional, gradient, because of the oceanic climate. Bogs occur only where the average summer rainfall exceeds evapotranspiration (Damman 1979), but groundwater inflow into fens extends their southerly range.

At the regional or local scale, surface physiognomy and slope control the morphology and distribution of peatlands (Wells 1981). One of the requisite conditions for any peatland is a slope which is low enough to sufficiently delay runoff, such that a high water table is sustained. This may occur in valley bottoms, or extensively on broad, gently sloping raised marine or lacustrine terraces (Glaser et al. 1981; Price et al. 1989), which are typically underlain by fine sediments with low hydraulic conductivity. Extensive peatlands may comprise a complex arrangement of bogs and fens, which develop in response to subtle changes in hydrology, in part relating to substrate morphology (Maloney and Price, under review). For example, fens have formed at the base of the Mealy Mountains, on the Lake Melville coastal plain (Figure 1), where runoff from the mountains emerges in small channels, soil pipes, and as groundwater discharge (Price and Maloney, under review).

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Figure 1
Bog-fen complex on a raised marine terrace bordering Lake Melville, Labrador. The Mealy Mountains (background) drain onto the terrace. Major channels have become incised, so their runoff bypasses the peatland. Smaller point and diffuse sources of mineralized water drain onto the fens. Small channels and water-tracks divert fen runoff into the incised channels, so that peatlands more distant from the mountains (foreground) are isolated from this source of mineralized water. These peatlands, therefore, have developed into bogs.

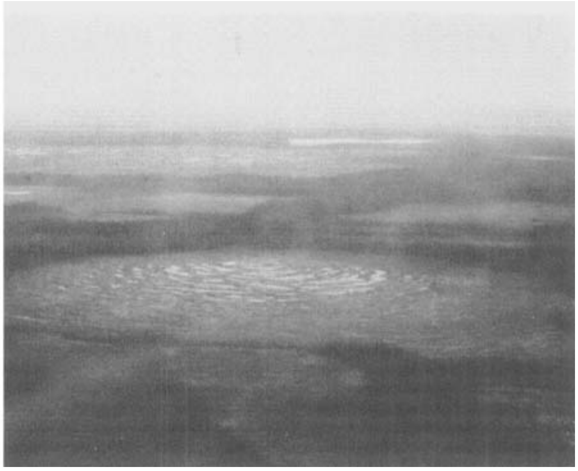

Figure 3
Domed bogs develop because peat accumulation is greater in the central portion, which is farthest removed from sources of mineralized water and water table fluctuations caused by drainage channels. Acidophylic vegetation (Sphagnum mosses) in the permanently wet central portion decay more slowly than less resistant plants near the perimeter, where the lower water table facilitates aerobic decomposition. A series of concentric pools and ridges indicates the flow is radially outward.

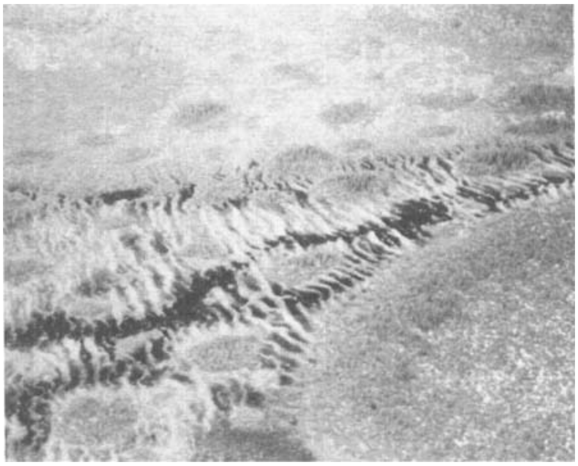

Figure 2
Bog-fen complex near southern James Bay. The ribbed fen water-track drains adjacent raised bogs. Small tear-drop-shaped bog islands have developed in the fen, where autogenic processes cause accelerated local peat accumulation. Ridges are oriented perpendicular to the direction of water flow, which is from left to right. This water-track is unrelated to substrate topography.

Bogs develop where sufficient peat accumulation has occurred, or where access to minerotrophic water is otherwise denied. Piracy of mineralized water by fen water-tracks, and by incised channels, can hydraulically isolate the bogs, as visible in the patterned bogs shown in the foreground of Figure 1. Alternatively, localized differences in peat accumulation can progressively alter the local hydrological and ecological relationships, so that small isolated bog islands occur within fen systems (Figure 2) (cf. Zoltai and Johnson 1985). As a consequence of the low decomposition rate of acidophylic mosses in bogs, peat accumulation is accelerated and further raises the surface of the peatland. As a result, the drainage pattern is erratic (Figure 1) but generally flows outward from the point most removed from the minerotrophic influence (i.e., where peat accumulation is greatest). These sometimes are called raised bogs, and in their most developed form become Domed bogs (Figure 3) (NWWG 1988).

Water Tracks

Water-tracks are linear depressions that have become zones of preferred flow within a peatland system (Ingram

Figure 4
A system of water-tracks has developed where upland drainage and groundwater discharge are focused onto the peatland. The water-tracks shown here developed in small incipient channels carved into the substrate before peat accumulation began. Individual pools are not related to specific substrate features, but localized pool development occurs where abrupt decreases in hydraulic gradient occur, causing water to pond.

1967). They are usually associated with higher water flows in fens, but also occur in bogs. Minor channels, soil pipes, and groundwater discharge zones form the loci for water-track development (Figure 4). Some water-tracks follow incipient drainage-channels in the substrate (Maloney and Price, in review). However, differential rates of peat accumulation in a bog-fen complex may also result in water-tracks (Figure 2). Here, more rapid peat accumulation in bogs has raised them above the water level in the water-track. Consequently, the adjacent bogs drain into the water-track, which acts as a local conduit for regional drainage. Some water-tracks diverge and disperse water over the peatland (Figure 4), some converge and drain eventually into channels (Figure 2), and some simply wither as water is lost to evaporation. In any case, water-tracks possess the requisite conditions for surface pattern development, which is abundant surface water.

Figure 5
Ridges in a fen water-track. These ridges are low (5–20 cm), and frequently overtopped by floodwater. The flooded pools limit new vegetation growth and promote degradation of existing basal peat.

Figure 6
Ridges and pools in a patterned bog. The ridges are relatively high (20–50 cm) and sustain a groundwater ridge. These features limit pool-to-pool water transfer.

Pattern Development

Patterned peatlands, common in the boreal forest zone (Foster 1985), are characterized by parallel peat ridges oriented perpendicular to the direction of slope and drainage (NWWG 1988). Pool-and-ridge microtopography evolves in previously unpatterned peatland because of a combination of physical and biotic factors operating simultaneously or consecutively, including hydrological and lithological factors and the dynamics of plant growth and decomposition (Moore and Bellamy 1974; Boatman et al. 1981; Foster and King 1984; Seppala and Koutaniemi 1985; Kubiw et al. 1989). The shift to a ridge and pool morphology, at sites in eastern North America and Scandinavia, occurred 3000 to 5000 years BP following a change to a cooler wetter climate, and a consequent rise in the water table (Seppala and Koutaniemi 1985; Foster et al. 1988.)

Pool formation is initiated by hydrological change resulting from peat accumulation, which smooths the surface irregularities, thereby promoting surface flow. Water ponded in slight depressions inhibits plant growth and peat accumulation, so that with time a pool forms, followed by peat degradation and pool enlargement (Foster 1985). Local conditions which facilitate surface flooding include a change to a lower substrate slope (Maloney and Price, in review), or differential rates of peat accumulation, which cause local changes in surface slope (Glaser et al. 1990). These conditions are commonly achieved in water-tracks (figures 2 and 4), but also develop where more diffuse water flow occurs (Figure 3). There is little information on the rate of pool development, although Boatman (1972) found an appreciable increase in the area of an individual pool over the period 1942 to 1969. Pool degradation can also be rapid when pipes or channels cause abrupt drainage (Foster et al. 1988).

Pool-and-ridge microtopography in fen water-tracks results in a sequential cascade of water, which, while slowing the passage of water, maintains an orderly delivery of water and nutrients to downslope systems. The ridges are low (Figure 5) and do not support an elevated water table. The extreme asymmetry of these systems, and the presence of abundant surface water delays runoff, and promotes evapotranspiration (Price et al. 1991). These processes, in turn, benefit the development of vegetation communities, and ultimately, their arrangement into surface patterns. In raised bogs, the outwardly radial flow from such landforms results in concentric pool-and-ridge microtopography (Figure 4), where, as in fens, the ridges are oriented perpendicular to direction of flow. Unlike fens, however, there is a much more limited supply of water, and ridges are more elevated (Figure 6), thus better retaining what water is available. The water-table elevation within the ridges are local maxima, which greatly reduces the rate of pool-to-pool water transfer, and ultimately, runoff (Price et al. 1991). This has the ecological advantage of prolonging the time during which living vegetation can extract nutrients from a limited source. Furthermore, the large evaporative water loss enhances the concentration of the remaining mineral elements and plant nutrients.

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