AP Acid Peatland System

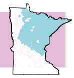


photo by Tim Whitfeld, MN DNR

Clearwater County, MN

General Description

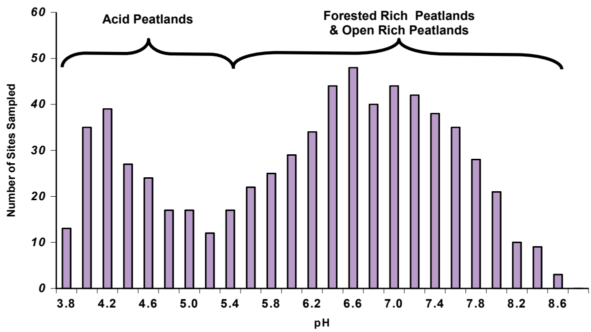
The Acid Peatland (AP) System is characterized by conifer- or low shrub–dominated communities that develop in association with peat-forming *Sphagnum*. AP communities are acidic (pH < 5.5), are extremely low in nutrients, and have hydrological inputs dominated by precipitation rather than groundwater. These communities are floristically depauperate, with the vascular flora composed primarily of a small subset of species characteristic of rich peatlands that are able to survive in the harsh, low-nutrient environments typical in AP communities. The floristic differences between forested AP communities and open, low shrub–dominated AP communities are subtle because of low species diversity in the AP System as a whole and because trees, when present, are usually sparse, making the boundary between forested and open AP communities diffuse. Therefore, this classification places all acid peatland communities into one system, unlike the rich peatland communities, which are divided into forested and open systems (i.e., Forested Rich Peatland [FP] and Open Rich Peatland [OP] systems).

AP communities are widespread in the Laurentian Mixed Forest (LMF) Province, sporadic in the northern half of the Eastern Broadleaf Forest Province, and rare in the Tallgrass Aspen Parklands (TAP) Province; they are absent from the Prairie Parkland Province. Because of marginal climatic conditions for peatland formation in the TAP Province, with precipitation barely exceeding evapotranspiration, AP communities are limited to a few localities and are not as well developed as in the main part of their range in Minnesota in the LMF Province. The development of AP communities in a landscape with widespread occurrence of prairie communities—as occurs in the TAP Province—is unusual for acid peatlands in North America.

Peatland Development

AP communities develop from FP or OP communities in areas where there is sufficient rainfall and low enough evapotranspiration to enable *Sphagnum* peat to accumulate to levels above the groundwater table. Once the peat surface is above the water table, surface water flows away from or around the elevated peat surface, reducing inputs of minerals and nutrients. *Sphagnum* adsorbs dissolved mineral cations, particularly calcium, and exchanges them for hydrogen ions, releasing organic acids and lowering the pH of stagnant surface waters. This conversion proceeds slowly until the pH falls to 5.5, below which the water chemistry switches from a bicarbonate- to a humic acid–buffered system. In humic acid–buffered peatlands, slight additions of acids rapidly decrease the pH to 5.0. Humic acid–buffered peatlands are transitional and relatively short-lived, quickly succeeding to poor fens (i.e., Northern Poor Fen [APn91]) or poor swamp forests (i.e., Northern Poor Conifer Swamp [APn81]), and therefore are uncommon. This results in a natural bimodal distribution of pH in peatland communities (Fig. AP-1) that coincides with floristic differences in vascular plants and changes in dominance in the moss layer from brown mosses to *Sphagnum*. These distinctions among peatlands are the basis for differentiating the AP System from rich peatland (FP and OP) systems. At pH of 5.0, the acidification process slows, but the peat surface continues to build up until it is no longer in contact with groundwater and becomes dependent solely on precipitation. At this point, the pH of surface water is generally about 4.2.

Figure AP-1.
Histogram of surface water pH from wetland sites in Minnesota. The natural bimodal distribution corresponds to separation of Acid Peatlands from Rich Peatlands.



It is possible to have features of AP and OP or FP communities within the same peatland because of the differing water chemistry characteristic of hummocks and hollows. In OP and FP communities, hummocks and hollows have similar water chemistry. If peat accumulates, however, and the peat surface becomes isolated from mineral-rich water, the hummocks change more quickly to acidic conditions than hollows. The peatland then becomes a mosaic of patches of AP communities within larger areas of OP or FP communities until acidic species of *Sphagnum* invade the hollows. Even when the hollows have acidified to the point where the water chemistry is characteristic of AP communities (i.e., pH < 5.5), deeply rooted minerotrophic plants, such as aquatic sedge *(Carex aquatilis)* and beaked sedge *(C. utriculata),* can persist in the hollows for some time.

Plant Adaptations

With decline in pH and nutrients, the number of vascular plant species that can survive in peatland communities drops significantly. The vascular plants in AP communities consist mainly of a subset of the species present in FP and OP communities. Within the AP System, bogs (i.e., Northern Spruce Bog [APn80] and Northern Open Bog [APn90]), which have the most acidic and nutrient-poor conditions, are inhabited by a set of only 25 species (see page PPA/TAP-AP5). Species in AP communities have many of the physiological and structural adaptations to low pH and low-nutrient environments present in plants in rich peatland communities. In addition, species in AP communities are adapted to survive in environments with very low concentrations of minerals such as calcium and magnesium. The dominant woody plants in AP communities are evergreen, an adaptation that enables plants to retain scarce nutrients. Deciduous woody plants, which lose nutrients every year when leaves are shed, are uncommon in AP communities. In addition, many plants in AP communities have thickened outer leaf membranes and alkaloids in leaf tissues that help to reduce herbivory. The low palatability of leaves also retards breakdown of litter by decomposing organisms and contributes to peat accumulation. Graminoids, which are the most abundant herbaceous plants in AP communities, are limited to short, fine-leaved sedges and cottongrasses.

In addition to physiological adaptations for obtaining or conserving scarce nutrients and minerals, it appears that vascular plant survival in AP communities is strongly linked to associations with mycorrhizal fungi. As a result, AP communities are among the most diverse communities in Minnesota in species of ectomycorrhizal fungi. Many of the plants in AP communities, including conifers, ericaceous shrubs, and orchids, depend on mycorrhizal associations to obtain minerals and nutrients and even to prevent uptake of toxic heavy metals that are soluble in waters with extremely low pH. It is possible that most, if not all, vascular plants in the AP System have symbiotic associations with mycorrhizal fungi.

Even with the adaptations mentioned above, the effect of nutrient-poor conditions is evident in reduced growth of woody plants. Trees are usually stunted and have small crowns. They are often only a few feet tall and rarely more than 33 feet (10m) tall, even when over 100 years old. The predominant shrub species are low ericaceous shrubs, such as Labrador tea *(Ledum groenlandicum)* or leatherleaf *(Chamaedaphne calyculata).* When characteristically tall shrubs such as speckled alder *(Alnus incana)* and willows *(Salix* spp.) are present in AP communities, they are sparse and diminished in size.

Like most wetland species, plants in the AP system have adaptations that allow them to survive waterlogged, anoxic conditions. Many plants in AP communities are also adapted to survive desiccation because acid peatlands are highly dependent on precipitation, and summer drought can cause drastic lowering of local water tables. Some species, such as *Sphagnum angustifolium,* have xerophytic structural and physiological adaptations that enable them to regenerate from dried tissue after desiccation. Other species, such as the ericaceous shrubs, have thick, hirsute leaves with thick cuticles that retard moisture loss. The extremes of summer drawdown are also modified in peatland environments by the wicking capability of *Sphagnum*, which draws water from the water table by capillary action and can hold up to 25 times its weight in water. Because of the characteristically rapid growth of *Sphagnum*, other acid peatland plants have adaptations to prevent being overtopped by accumulating peat. Black spruce, for example, is able to layer, or reproduce vegetatively, from branches that become covered by moss.

Because the AP communities in the TAP Province are at the western edge of the range of peatland development in Minnesota, several peatland species characteristic of the numerous and expansive AP communities in the LMF Province, such as pitcher plant *(Sarracenia purpurea),* sundews *(Drosera* spp.), bog laurel *(Kalmia polifolia),* bog wiregrass sedge *(Carex oligosperma),* tussock cottongrass *(Eriophorum vaginatum)*, and tawny cottongrass *(E. virginicum)*, are scarce or absent.

Floristic Regions

Only one floristic region is recognized in the AP system in Minnesota, the Northern Floristic (APn) Region (Fig. AP-2). APn communities are similar to the continental bogs north of Minnesota in Ontario. They differ from the maritime bogs characteristic of Maine and eastern Canada, which receive significantly more precipitation and are not subjected to severe drought and low water tables during the summer. In comparison with maritime bogs, continental bogs have developed more recently, have rapidly accumulating peat, are wooded, lack surface pools, and have a crested profile in cross section rather than a convex or plateau shape.

Plant Community Classes in the TAP Province

Only two of the four plant community classes in the AP system occur in the TAP Province, Northern Poor Conifer Swamp (APn81) and Northern Poor Fen (APn91). Northern Poor Conifer Swamps and Poor Fens have pH greater than 4.2 and receive some minerotrophic groundwater or surface water. The other two classes, which are true bogs and have pH less than 4.2 and are totally dependent on precipitation for minerals, do not appear to extend west into the TAP Province. It is possible that Northern Spruce Bogs (APn80) were present in the TAP Province in the past but were converted to more minerotrophic peatlands (i.e., Northern Poor Conifer Swamps) over the past 100 years by mineralization of peat from ditching and increased fire frequency, and by mineral inputs from windblown dust from the vast agricultural areas to the west of the province.

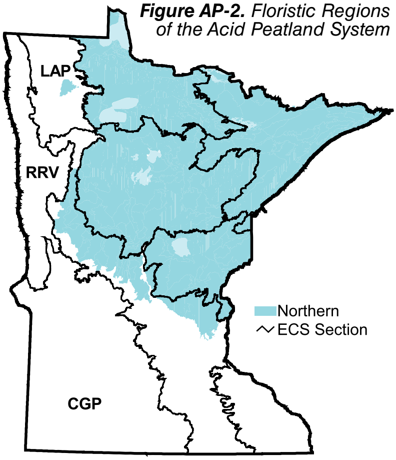


Figure AP-2. *Floristic Regions of the Acid Peatland System*

The two AP Classes that occur in the TAP Province are distinguished from one another in part by water-table level. Northern Poor Conifer Swamps develop on drier sites and are characterized by the presence of a tree canopy and associated shade-tolerant understory species. Northern Poor Fens occur on sites with water tables high enough to prevent survival of trees, which favors the presence of shade-intolerant species not common in forested swamps. Because the AP System is climatically at the edge of its range in the TAP Province, these two classes are not as well developed as they are in the LMF Province, and distinctions between the classes are not as clear.

Succession

In the absence of external influences, such as flooding by beaver activity or other changes in hydrology, succession in peatlands moves in the direction of conversion of rich peatlands (OP or FP communities) to acid peatlands (AP communities) and from open to forested peatlands; this is driven by accumulation of *Sphagnum* peat, which leads to acidification of surface waters and development of aerated hummocks on which trees can become established. Succession to more acidic conditions, however, can be stopped (or even reversed) by mineral inputs from outside sources that offset depletion of calcium by *Sphagnum*. Even groundwater inputs of less than 5% of the total water budget (i.e., relative to inputs from precipitation) can neutralize the acids produced by *Sphagnum* and raise pH above 5.0. The predominance of calcareous till and the marginal climatic conditions in the TAP Province apparently prevent succession of poor fens or poor conifer swamps to true bogs.

Non-Mineotrophic Peatland Species

Because only those species listed below can persist in the ombrotrophic conditions of bogs, the occurrence of any other species can be considered an indicator of minerotrophic conditions. However, some seedlings, particularly of tree species, can germinate in bogs but are short-lived and should not be considered as minerotrophic indicators.

	Common Name	Scientific Name
Tree	Tamarack	*Larix laricina*
	Black spruce	*Picea mariana*
	Jack pine	*Pinus banksiana*
Low Shrub	Bog rosemary	*Andromeda glaucophylla*
	Leatherleaf	*Chamaedaphne calyculata*
	Creeping snowberry	*Gaultheria hispidula*
	Bog laurel	*Kalmia polifolia*
	Labrador tea	*Ledum groenlandicum*
	Lowbush blueberry	*Vaccinium angustifolium*
	Velvet-leaved blueberry	*Vaccinium myrtilloides*
	Small cranberry	*Vaccinium oxycoccus*
	Lingonberry	*Vaccinium vitis-idaea*
	Dwarf misletoe	*Arceuthobium pusillum*
Forb	Stemless lady's slipper	*Cypripedium acaule*
	Round-leaved sundew	*Drosera rotundifolia*
	Heart-leaved twayblade	*Listera cordata*
	Indian pipe	*Monotropa uniflora*
	Pitcher plant	*Sarracenia purpurea*
	Three-leaved false Solomon's seal	*Smilacina trifolia*
Graminoid	Bog wiregrass sedge	*Carex oligosperma*
	Few-flowered sedge	*Carex pauciflora*
	Poor sedge	*Carex paupercula*
	Three-seeded bog sedge	*Carex trisperma*
	Tussock cottongrass	*Eriophorum spissum*
	Tawny cottongrass	*Eriophorum virginicum*