AP Acid Peatland System

photo by N.E. Aaseng MN DNR

St. Louis County, MN

General Description

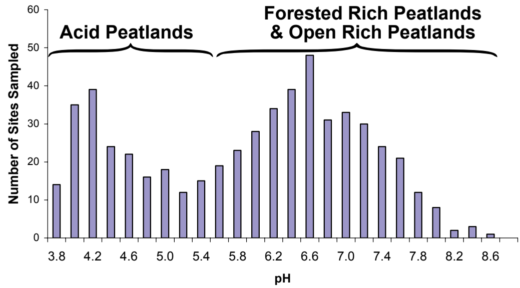
The Acid Peatland (AP) System is characterized by conifer-, low-shrub, or graminoid-dominated communities that develop in association with peat-forming *Sphagnum*. AP communities are acidic (pH < 5.5), extremely low in nutrients, and have hydrological inputs dominated by precipitation rather than groundwater. These communities are floristically depauperate, with the flora composed primarily of a small subset of species characteristic of rich peatland Systems that are able to survive in the harsh, low-nutrient environments typical in AP communities. The floristic differences between forested and open 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.

AP communities are widespread in the Laurentian Mixed Forest (LMF) Province because of cool climate, abundant precipitation, numerous poorly drained basins, and extensive poorly drained glacial lake plains, which produce favorable conditions for peat development across much of the Province. AP communities tend to be prevalent in basins in areas with non-calcareous soils and on lake plains underlain by impermeable clayey and loamy soils, which minimize movement of groundwater through the overlying peat.

Peatland Development

AP communities develop from Forested Rich Peatland (FP) or Open Rich Peatland (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* absorbs 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 or poor swamp forests, 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 the 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. In the best-developed examples of raised peatlands, a crest with a radiating pattern of black spruce forms that is visible on aerial photos.

Figure AP-1. *Histogram of surface water pH from wetland sites in the Laurentian Mixed Forest Province. 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. Mosaics of AP with OP or FP communities occur most commonly in peatland Systems where woody plants (shrubs and trees) are abundant, creating varied microtopography with hummocks developing initially over woody debris or around tree bases. These peatlands are most likely to develop in settings with water-table drawdowns large enough to provide the aerated microhabitats necessary for establishment of trees. Where the water table does not fluctuate significantly and woody plants are not common, more uniform peatlands develop that are dominated by OP or FP communities and lack small inclusions of AP communities.

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; only tussock cottongrass *(Eriophorum vaginatum),* tawny cottongrass *(E. virginicum),* few-fruited sedge *(Carex pauciflora),* and bog wiregrass sedge *(C. oligosperma)* are unique to the AP System. Within the AP System, bogs, which have the most acidic and nutrient-poor conditions, are inhabited only by a set of 25 species (see page LMF-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. Most 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. 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. Although most species in AP communities are physiologically adapted to extract nutrients from substrates with very low nutrient concentrations, a few characteristic peatland species, such as pitcher plant *(Sarracenia purpurea),* sundews *(Drosera* spp.), and intermediate bladderwort *(Utricularia intermedia)* have developed means of supplementing their intake of nitrogen and phosphorus by capturing and digesting insects.

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 ericads, conifers, 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 bog rosemary *(Andromeda glaucophylla),* Labrador tea *(Ledum groenlandicum),* and bog laurel *(Kalmia polifolia).* When characteristically tall shrubs such as speckled alder *(Alnus incana)* or 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 over-topped by accumulating peat. Black spruce, for example, is able to layer or reproduce vegetatively from branches that become covered by moss.

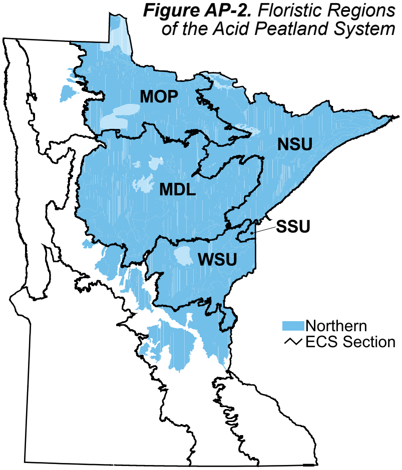
Floristic Regions

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.

Variation Among Acid Peatland Classes

The four plant community Classes in the AP System are divided into two moisture groups that also correspond to amount of tree cover. The drier group includes the wooded Classes, Northern Spruce Bog (APn80) and Northern Poor Conifer Swamp (APn81). The wetter group includes the more open Classes, Northern Open Bog (APn90) and Northern Poor Fen (APn91). These two groups are further divided by pH and mineral concentration. Spruce Bogs and Open Bogs have pH <4.2 and are dependent on precipitation for minerals. Poor Conifer Swamps and Poor Fens have pH >4.2 and receive some minerotrophic groundwater or surface water.

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



Succession

In the absence of external influences, such as flooding by beaver activity or changes in hydrology, the succession of peatlands in the LMF Province moves in the direction of conversion of rich peatlands (OP or FP) to acid peatlands (AP) because of accumulation of *Sphagnum* peat. Within the AP System, the trend is also from less acidic to more acidic communities, in this case from Northern Poor Fen, to Northern Poor Conifer Swamp, to Northern Spruce Bog. 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.

In Minnesota, Northern Open Bogs develop only in special circumstances. In large (>250,000 acres [100,000ha]) peatlands with well-developed Northern Spruce Bogs, the peat surface can become raised over time and develop incipient drains. The drains channel surface water with increased concentrations or fluxes of cations downslope and in the process can convert Northern Spruce Bogs to Northern Open Bogs (and ultimately to Northern Poor Fens or even Northern Rich Fens [OPn91]). In basins and possibly in large raised bogs, fire can convert Northern Spruce Bogs into Northern Open Bogs by destroying the tree canopy, resulting in reduced evapotranspiration and increasingly water-logged conditions. This causes a shift toward greater presence of carpet-forming *Sphagnum* species (relative to hummock-forming *Sphagnum* species) and the development of wet hollows.

Vascular plant species that occur in bog Native Plant Community Classes.

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 tree species, can germinate in bogs but are short-lived and should not be considered as minerotrophic indicators.

			Northern Spruce Bog	Northern Open Bog
			APn80	**APn90**
	Common Name	Scientific Name	Frequency(%)	
Tree	Tamarack	*Larix laricina*	51	62
	Black spruce	*Picea mariana*	100	82
	Jack pine	*Pinus banksiana*	4	6
Low Shrub	Bog rosemary	*Andromeda glaucophylla*	49	74
	Leatherleaf	*Chamaedaphne calyculata*	87	94
	Creeping snowberry	*Gaultheria hispidula*	44	–
	Bog laurel	*Kalmia polifolia*	91	94
	Labrador tea	*Ledum groenlandicum*	99	74
	Lowbush blueberry	*Vaccinium angustifolium*	45	12
	Velvet-leaved blueberry	*Vaccinium myrtilloides*	29	9
	Small cranberry	*Vaccinium oxycoccus*	95	94
	Lingonberry	*Vaccinium vitis-idaea*	31	–
	Dwarf misletoe	*Arceuthobium pusillum*	1	–
Forb	Stemless lady's slipper	*Cypripedium acaule*	19	–
	Round-leaved sundew	*Drosera rotundifolia*	38	35
	Heart-leaved twayblade	*Listera cordata*	3	–
	Indian pipe	*Monotropa uniflora*	28	–
	Pitcher plant	*Sarracenia purpurea*	29	59
	Three-leaved false Solomon's seal	*Smilacina trifolia*	86	18
Graminoid	Bog wiregrass sedge	*Carex oligosperma*	17	76
	Few-flowered sedge	*Carex pauciflora*	33	41
	Poor sedge	*Carex paupercula*	22	–
	Three-seeded bog sedge	*Carex trisperma*	79	9
	Tussock cottongrass	*Eriophorum spissum*	72	88
	Tawny cottongrass	*Eriophorum virginicum*	14	3