Wetland Islands in a Northern Forest: the Mystique of Bogs

Small, isolated bodies of water with quivering ground dot the northern United States and Canada. Approaching these communities, one is impressed by the tranquility, stillness, and darkness of the surrounding forest. Bristly stunted spruce and tamaracks and a thick tangle of low shrubs surround soft, moss-covered soil and cold, dark water. As the mossy matt adjusts under one's weight, a slight wave-like ripple radiates out with each step. The soil quakes quietly among the unfamiliar vegetation. Legends abound among school age kids of bog mummies and bodies found or lost in these mysterious communities. These are the stories of our youth shared around camp fires and keep us awake at night while listening to crickets and cicadas interrupting the silence of the forest.

Bogs are wetland communities without inflow or outflow of water. The ground is dominated by acidifying mosses and a thick layer of organic soil. Northern bogs of the upper Midwest, New England, and New York State are the result of glacial activity. Glaciers moved ice boulders, rock, gravel, silt, and clay considerable distances. As the glaciers retreated, a new landscape was left in its wake with moraines, eskers, kames, sandy outwash, and scattered pockmarks surrounded by glacial debris. As melt water and precipitation became impounded by glacial debris, sediments of glacial silt and clay sealed the isolated body of water.

The isolated hydrology of this new wetland created unique chemical characteristics that fostered the growth of a community dominated by Sphagnum moss (Figure Sphagnum Moss). Without the flow of water across the terrain, the wetland became limited by the scant mineral nutrition that fell with rain and snow or from weathered glacial sediments. Without water turbulence and free-floating algae, dissolved oxygen is absent from bog water. Life-giving critical elements of nitrogen and phosphorus are always limiting agents in wetlands, but even more so in bog communities.

Figure SPHAGNUM MOSS. A. *Sphagnum* moss with sporophytes growing in a bog forest. B. Red-leaved species of *Sphagnum* growing in a northern glacial bog.

Sphagnum moss is an outstanding competitor in the bog environment. Sphagnum modifies the bog physically and biochemically in a manner that reduces the growth of bacteria, fungi, and vascular plants. Although the moss body has no lignin, the unique combination of acidic polysaccharides, cellulose and phenolics prevents herbivory by insects and retards decomposition by bacteria and fungi. Sphagnum is a free element scavenger. It readily absorbs cations such as calcium and magnesium from the water and releases hydrogen ions. Hydrogen ions are associated with pH and the more that are released by Sphagnum the more acidic the environment becomes. This low pH contributes to higher aluminum ion concentrations in solution that may inhibit growth of some plants.

The Sphagnum plant body is composed of thin leaves with a single layer of cells. Stems do not possess conducting tissues, but do allow water to wick by capillary action from lower depths upward to Sphagnum hummocks. Nearly eighty-percent of the leaf structure is composed of large hyaline cells that are capable of absorbing and holding tremendous volumes of water. Personal measurements of Sphagnum water holding capacity range between 80 and 200 times (mass:mass). Even though photosynthetic cells are small and sparse throughout the leaves, Sphagnum has a high photosynthetic efficiency in the nutrient poor bog environment. The leaves decompose relatively rapidly and the stems compress to form a dense anoxic peat bed.

Mineral depleted, acidic, anoxic water shapes the community structure of bogs. Bog communities lack nitrogen fixing bacteria to pull nitrogen out of the atmosphere and convert it into nitrates and ammonia which can be used by plants. Oxygen loving decomposers are limited to living at the thin intersection between water and atmosphere as oxygen diffusion rates are very slow to deeper depths. Anaerobic methane producing microbes are capable of life in the hostile environment, but are restricted to the shallow oxic zone. The polysaccharide acids of Sphagnum bind nitrogen and prevent bacteria from utilizing this limiting nutrient. The activity of decomposers is so severely restricted that layers of organic matter build-up from the bottom of the bog. Where bog holes are 10-13 meters deep it is not unusual to have 10-13 meters of organic sediments. Bogs are massive burial grounds for carbon.

Bogs and peatlands are carbon sinks and methane sources (Figure Bog Soils). These attributes have generated much interest in climate change debates. Bogs generate less methane per unit area than swamps and marshes, but bogs and fens represent nearly 60% of the world's wetlands and they cover vast stretches of northern North America, Europe, and Asia. Thirty percent of the Earth's soil carbon is stored in wetlands and the majority of that is found in peat based soils.

Figure BOG SOILS. A. Bog soil is largely organic and is composed on plant stems. The plant remains show in this photograph are approximately 3000 years old and were extracted from eight feet below the bog surface. B. Bogs are line with silt, sand, and clays deposited as glacial fall-out. This photo shows clay from a northern bog.

Atmospheric scientists have been asking how the bog community will contribute to atmospheric carbon dioxide in response to climate change and permafrost melt. As the permafrost of northern regions melts, peatlands drain, allowing oxygen to penetrate the organic rich soils. Additional oxygen will increase the rate of organic decomposition and release of carbon as atmospheric carbon dioxide. Second, oxygen will reduce the activity of methanogenic anaerobic bacteria, but improve respiration of methanotrophic bacteria. Climate change will release large stores of organic carbon to the atmosphere, but peatlands will shift from releasing methane to releasing carbon dioxide. Given that methane is a more potent greenhouse gas than carbon dioxide, the effect of these climate feed back loop will be difficult to predict and depends balancing multiple carbon budget equations.

Four different vegetation zones can be identified on many bogs (Figure Bog Zones). Conventional wisdom suggests that bog succession proceeds from open water, mat, shrub-mat, and then bog forest. Although bog structure would seem to support this hypothesis, there is no firm empirical evidence to suggest that a bog forest is the final climax stage. White water lily (Nymphaea odorata), yellow bullhead lily (Nuphar variegata) and common bladderwort (Utricularia vulgaris) occupy the central open water corridor. The photic upper layer of the open water is absent of green algae, but microscopic golden brown algae or diatoms are likely free floaters.

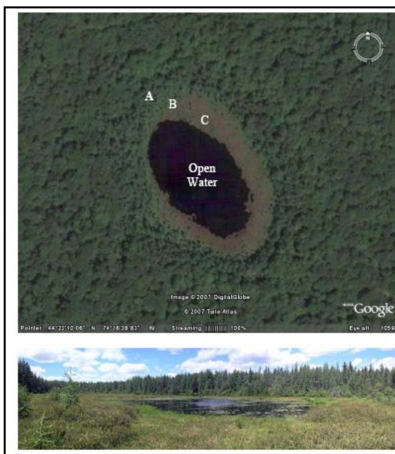


Figure BOG ZONES. A. Bog forest of dominated with American tamarack and black spruce. B. Shrub zone with Labrador tea, leatherleaf, and bog rosemary. C. Bog matt with *Sphagnum*, cranberry, pitcher plant, and cotton sedge. Panorama of Jam Pond in New York State showing bog zonation.

The bog mat is dominated by Sphagnum moss. There are many species of Sphagnum that can be found in bogs. They differ ecologically by microhabitat preferences and physically by leaf and stem attributes that often require the use of a microscope. Cotton sedge, round-leaved sundew, and small-leaved cranberry are important plants on the matt of floating Sphagnum. The floating mat is dangerous to tread upon and one could easily fall into a life or death situation to become a bog mummy. Repeated walking on a bog mat will also kill the Sphagnum, another reason for avoiding this activity. As described above, the chemistry and physical features of Sphagnum shape the ecology of the plant community on the bog.

The mat gradually gives way to a zone of larger shrubs. The roots of these shrubs occupy the upper 12 inches of the mat and provide stability to the surface. Roots acquire sufficient oxygen near the mat surface for cellular respiration. This is where humanoids enjoy jumping up and down to make the bog mat quake. Here several thick-leaved (sclerophylls) shrubs such as leatherleaf (Chamaedaphne calyculata), Labrador tea (Ledum groenlandicum), bog rosemary (Andromeda polifolia), cranberries (Vaccinum macrocarpon), huckleberry (Gaylussacia sp.), highbush blueberry (Vaccinium corymbosum), and bog laurel (Kalmia polifolia) put down their roots (Figure Bog Shrubs). These plants are all members of the acid-soil loving Ericaceae or heath family.


Figure SCLEROPHYLLOUS VEGETATION. Many species of shrubs living in bog habitats have thickened leaves with anatomical modifications that contribute to the longevity of the leaves. Examples of these plants in the Ericaceae include (A) Labrador tea with underside of leaves in panel B, (C) bog rosemary, and (D) cranberry.

The leaves of bog heaths are thick and leathery with waxy or wooly undersurfaces. Many of these shrubs can also be found on mountain tops in New England and upstate New York. The unique leaf features are adaptive on mountain tops where water is limited. Thick cuticles or pubescence covering the lower leaf surface impede the movement of water vapor through leaf pores to the external environment. In addition, these leaves prevent desiccation due to cold, dry winter winds. In the bog habitat, this leaf morphology allows the leaves to survive winter and summer for several years. Green leaves are rich sources of nitrogen which is found in chlorophyll and the photosynthetic enzyme, ribulose bis-phosphate carboxylase. Although vascular plant leaves will decompose some in the surface layer of the bog, much of the available nitrogen will be lost to the microbial community and bound by acids produced by Sphagnum. Thus, plants that retain their nitrogen-rich leaves are better adapted to life in the bog community.

The bog mat and shrub zone supports a fantastic community of flowering plants that add beauty to this mystical wetland. Bog orchids include the grass pink (Calopogon tuberosus), white fringed orchid (Platanthera blephariglottis), rose pogonia (Pogonia ophioglossoides), and the rare calypso orchid (Calypso bulbosa). Several ericaceous shrubs produce beautiful pink and white flowers. The small pinkish-white bell-shaped flowers of bog rosemary contrast beautifully against the bluish foliage. Delicate cranberry flowers are close to the ground against the backdrop of various shades of Sphagnum. The bog laurel flowers resemble small versions of mountain laurel from upland deciduous forests. The reddish anthers are held in small pockets on the petals until an insect trips over a stamen and releases tension to catapult pollen over the potential pollinator.

Small, stunted trees of American tamarack and black spruce provide a gradual transition from the shrub zone to the bog forest (Figure Bog Trees). The forest may or may not be present depending on the age and succession stage of the bog. The forest may also be a few to many meters from the bog edge to the shrub zone. The soil in the forest is very wet, soft, and all organic. The tree trunk and surface roots


FIGURE BOG TREES. The Bog forest is dominated by (A) black spruce and (B) American tamarack. Note the short spur shoots and whorled needles that are diagnostic of tamarack.

of trees may support a slightly different microhabitat for other species of Sphagnum, flowering plants and a few mosses. Sphagnum in these little hummock islands wicks water upward to support the other plants. Sufficient oxygen is present in the elevated hummock to support cellular respiration in roots. As the trees grow, their mass continues to push the tree body slowly through the organic soil. In addition, the bog Sphagnum continues to inch upward on the stem. Black spruce has the unique ability to produce new roots along the trunk in the oxygen-rich surface soil to survive.

Carnivorous plants are uniquely adapted to the mineral deprived Sphagnum community. Their ability to attract, kill, and decompose insects provides a novel source of nitrogen and phosphorus for growth (Figure Carnivorous Plants). Northern bogs and other nutrient poor wetlands will have a nice assemblage of round-leaf sundews (Drosera rotundifolia), northern pitcher plants (Sarracenia purpurea) and bladderworts (Utricularia). Sundews and pitcher plant are members of the mat community and bladderworts are floating plants in the open water.

Figure CARNIVOROUS PLANTS. The northern pitcher plant is a highly variable species. (A, B, and C) Pitchers grown in full sunlight contain more anthocyanin and are smaller than pitchers grown in the shade. (D) Round-leaf sundew is another common carnivorous plant to northern bogs.

Pitcher plants growing on the bog mat are usually brightly-colored with reddish-purple anthocyanins. The large mouth permits rainwater to collect within the pitcher. The hood forms a wide banner with attractive colors, nectaries, and slick inside surfaces with downward pointing hairs. Insects attracted to the display encounter a landscape of unsure footing and hazardous navigation. All too frequently (not from the plants perspective!), insects fall into the pitcher and fail to escape. Flies and bees require a stable, solid surface to take flight from. The watery medium of the pitcher and the slick inner surface of the pitcher fail to provide the appropriate take-off surface. The abundance of insect carcasses deep within the pitcher is strong evidence of the success of the elaborate design.

The pitcher design allows them to collect precipitation and any dissolved atmospheric pollutants. In the northeastern United States and Canada, nitrogen pollution (primarily in the forms of nitrate and ammonia) from coal burning facilities and human activities involving fossil fuel combustion in the Midwest and Northeast dissolves in atmospheric water. Nitrogen pollution then falls-out over the landscape in the form of rain, snow, or fog. In ecosystems where nitrogen is a limiting nutrient, atmospheric nitrogen pollution can have a fertilizer effect on the vegetation. When pitcher plants receive supplemental nitrate or ammonia, they adjust their pitcher form from wide-mouthed carnivorous traps to thin phyllodia with narrow pitchers that are photosynthetically more efficient (Ellison and Gotelli 2001, 2002). As a consequence, one may be able to assess the relative amount of nitrogen pollution in northeastern bogs by examining pitcher plant morphology.

Figure INQUILINE LARVAE. Sarcophagus fly and mosquito larvae of iquiline communities within northern pitcher plants.

The northern pitcher plant is home to an interesting food web of insects, protozoa, and bacteria. This inquiline community is responsible for the decomposition of insect prey and the release of mineral nutrition to the plant. Midge fly larvae and mites feed upon the nitrogen rich, exoskeleton of insects. The organic excrement and debris from these primary consumers provides food for the bacteria community. Rotifers and protozoa eat the bacteria. The pitcher plant mosquito larvae and the sarcophagous fly larvae are the top-level predators in the community (Figure Pitcher Plant Inquilines).

The northern pitcher plant has several related species that occupy nutrient poor pocosins in coastal plain and occasionally mountain regions of southeastern states. Pocosins are peatlands dominated by evergreen shrubs along the southeastern Atlantic coast. Unlike the northern pitcher plant, the more southern relatives possess hoods over the pitchers that prevent rainwater from collecting. Southern pitcher plants are rich in beauty and style. They vary from the large white-topped (Sarracenia leucophylla) and yellow pitcher (Sarracenia flava) plants that form trumpet-like pitchers to the hooded pitcher (Sarracenia minor) plant with light windows, and the parrot pitcher (Sarracenia psittacina) plant with prostrate colorful pitchers with ant-sized openings.

Infidelity in southern pitcher plants is common. Where a southern peat land has multiple pitcher plant species, interspecies pollinations occur and hybrid seed is produced. Pitcher plant hybrids add to the diversity and color of the parental species in these southern wetlands. The intricate design of pitcher plant hybrids adds to the mystery and beauty of the wetland community.

Figure BLADDERWORT BLADDERS. Bladderworts are submergent aquatic plants of nutrient poor bogs, swamps, and marshes. Trap doors on the bladders are opened and the trap expands drawing in prey when trigger hairs are touched.

There are several species of bladderwort that occupy nutrient impoverished open waters of bogs and lakes in North America (Figure Bladderwort). A few species such as the grass-leaved bladderwort actually grow on the sphagnum lawn rather than in open water. Deep water bladderworts have a primary whorl of branches near the water surface with smaller branches and small spherical bladders that range in size from 0.2 to 6 mm. The bladders represent a small, suction-type of trap that is particularly adept at collecting mosquito larvae, daphnia, and other small aquatic animals.

The negative pressure within the bladder draws the sides in to form concave depressions on either side. A small opening is closed by a thin trap door attached by a one-way hinge. The trichomes or bristles surrounding the door aide in funneling prey towards the trap. Four smaller trigger hairs attach to the hinge of the trap door.   Several glandular trichomes near the trap door secrete a mucilaginous matrix over the trap. The exact function of the mucilage is unknown, but it may (1) serve as an attractant for prey, or (2) have an important role in resetting a sprung trap.

Animal contact with the bladder trigger hairs results in a rapid change in the action potential (water potential) of the hinge and a shape change in the trap door. Rapid loss of turgor in hinge cells allows the door to rapidly swing inward. As the door changes shape the trap rapidly expands by 40-50% and prey are immediately drawn into the bladder and permanently trapped in less than 30 milliseconds. The trap resets as water is withdrawn over a period of 2-4 hours. The exact mechanism of prey death, breakdown, and nutrient absorption is not well documented, but it has been established that enzymatic activity occurs within the bladder. Paramecia die within 75 minutes of capture in live traps, but remain alive in freshly removed traps. Mosquito larvae appear to be the most abundant prey, but many species of zooplankton are found in the bladders as well.

The mechanism of bladderwort trap resetting has been described in some detail. Respiratory inhibitors and microinjection of salt ions into the trap reduce the rate of trap resetting. These observations suggest that metabolic energy is required and perhaps a water potential gradient is necessary to remove water during the resetting process. Water is extruded across the cells of the trap door to the region just beneath the door cuticle. A chloride ion gradient exists across cell membranes which results in a lower water potential of the door cells. Thus, water flows passively into the cells from the lumen and then by bulk flow to the outside of the trap door. The mucilage on the outer surface of the trap door may provide a buffer that allows ion pumps to create a concentration gradient to the region below the cuticle.

Round-leaf sundews are common in northern bogs, but other sundew species frequent peatlands of the Atlantic and Gulf coast. Sundew leaves are decorated with reddish glandular hairs smothered in a drop of glistening mucilage. Unlike the passive trap of pitcher plant and the active trap of bladderwort, sundews form an adhesive trap through the sticky viscous polysaccharide secretion of the glands. The ultraviolet reflection and glitter of the mucilage in contrast to the dark foliage may create the allure of a nectar rich reward for insects. Instead, landing on the glands is a fatal mistake. The fleeing action brings insects into contact with more glands. This action ultimately cements their fate to the sundew leaf.

Insect movement triggers a painfully slow response of all the glandular hairs of the leaf. Within a few minutes of mechanical stimulation, the hairs begin to move towards the prey and within an hour, the prey is firmly attached to many tentacles of the leaf that has now folded on top of the prey. Sundew glands secrete enzymes to digest proteins and the exoskeleton of insect prey. Sundew leaves have been shown to absorb nitrogen-rich amino acids following prey digestion. Like pitcher plants and bladderwort, digestion may be aided by the rich bacterial flora that lives on the mucilage of the sundew tentacles. Small flies, mosquitoes, and ants are common prey of the round-leaf sundew in northern bogs.

Ecological History. The cold, anoxic, acidic bog conditions prevent decomposition and allow organic matter to sediment in a serial manner. The oldest layers start just above the clay basement of the bog and the freshest near the surface. Each layer traps and preserves microfossils of pollen and diatoms. If the peat sediment can be dated through radiocarbon dating or through assuming a constant deposition rate of 2-3 centimeters per 20 years, then we can examine the community ecology of the bog and surrounding forest over the past 12,000-18,000 years. Analysis of pollen in bog sediments reveals the arrival time of each tree species to that region and the composition of the surrounding forests (Figure Glacial Communities).

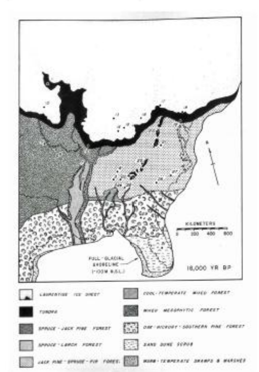
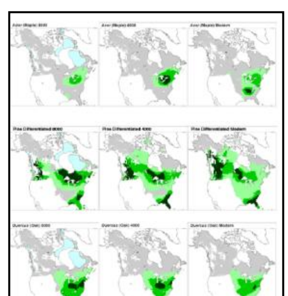


Figure Glacial Communities. Distribution of forest types in eastern North America near the glacial maximum as indicated by palynological records. Figure has been photocopied from Delcourt—Forests in Peril. A narrow zone of tundra like plants existed along the southern edge of the glacial front and along high elevations in the Appalachians. Much of the east was covered in coniferous forests with relictual communities of broadleaved evergreen and deciduous forests in river valleys of the southeast.

To complete the landscape picture of North America at the peak of glaciation, palynologist had to probe the depths of organic rich sediments from swamp, marsh, and bog-like communities across eastern North America. Details of these exciting adventures are wonderfully described by Hazel Delcourt in Forests of Peril. This text summarizes Hazel and Paul Delcourt's field and laboratory research over four decades to gain insight into historical refugia and range expansion of forests following glaciation. Together they trudged through muck and plant tangles that very few of us would ever consider visiting.

The rate of colonization is likely dependent on many biotic traits and the movement of optimal climatic conditions (Figure Post-glacial Migration). For example, pines produce an abundance of lightweight pollen and seeds that are capable of long distance wind-dispersal. Pine pollen is abundant in 20,000 year old deposits from the southeastern United States. White, red, and jack pine were capable of migrating



quickly northward following glacial melt. These pines were tolerant of the cool dry conditions that were becoming more abundant. By 8,000 years ago, these pines had reached their current range in the northwestern and north central North America. Southern savannah pines have continued to predominate much of Florida and regions of southern Georgia and South Carolina.

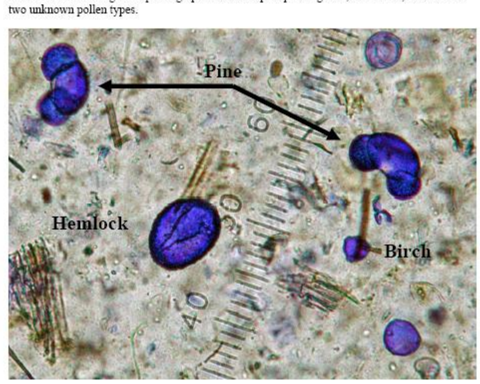
Maples prefer warm moist conditions. Although they are capable of long-distance pollen and seed dispersal, the floral structure and pollen is more conducive to insect pollination and the seeds are considerably larger and heavier than pine. Maple was likely present in moist riverine communities of the south east and lower Midwestern United States at the peak of glaciation. The northward march of maple was slower and narrower in distribution than pine. Maple finally reached a northeastern range 8,000 years ago, but currently maintains two centers of diversity in the Great Lake region and southern Appalachian Mountains.

Oaks likely occupied glacial refugia in the lower Midwest and southeast much like maple. Unlike maple, oak has heavy seeds that initially disperse by gravity, but then are available for secondary dispersal by mammals and birds. It is surprising that oak recolonized the north at a faster rate than maples which have smaller wind-dispersed seeds. Some have speculated that the fast rate of recolonization was due to blue jays caching seeds and acorns. Blue jays have been observed to engulf and store several oak acorns in their crop while flying some distance to cache the seeds.

The National Climatic Data Center is the depository for pollen records across North America (http://www.ncdc.noaa.gov/paleo/ftp-pollen.html). The data are easily sorted, accessed, and viewed from thousands of pollen records world-wide. Pollen diagrams are easy to generate. One such diagram from Green Lake Michigan (Lawrenz,R.W.; data contributor; Figure Pollen Diagram) nicely illustrates different arrival times and dominance by spruce, birch, pine, maple, and hemlock. The initial cool moist climate of Michigan favored spruce and fir immediately following the retreat of the glacier 12,000 years ago. The cool dry climate followed, 11,000 years before present, and the regional community was dominated by pine. Warm, mesic species such as birch, maple, and hemlock arrived 5,000 years before present and continue to persist today.

Palynological studies of bog and lake sediments are easily accomplished (Figure Bog Pollen). The biggest challenge is collecting samples using a probe or sampling borer, but only small amounts of material are necessary. Identification of pollen can be difficult, but groups such as hemlock, oak, birch, pine, spruce, and fir are all relatively easy to learn. Interpretation of pollen abundance diagrams can be cross examined to the animated pollen maps provided by researchers at Brown University in collaboration with the University of Oregon. The maps provide great detail on the rate of species spread and colonization starting about 20,000 years before present.

Figure. Fossil pollen extracted from a depth of 1meter and approximately 1,250 years old from a central New York bog. The photo graph shows two pine pollen grains, a hemlock, a birch and two unknown pollen types.



Human history. The names of ancient European bog people bare the formality of their home bog and the sex. They include Tollund Man, Grauballe Man, Old Croghan Man, Gundhildhe Woman, and Windeby Girl who later turned out to be a boy. The bog chemistry mortified their Iron Age corpses with exquisite detail of hair, facial stubble, wrinkles, fingernails, and finger prints. Sphagnum phenolics tanned their skin in orange-brown hues and preserved their internal organs.

Despite their age, modern science has administered more medical tests to the bog people than most Americans receive at their annual physical. Radiocarbon dating, CT scans, x-rays, heavy metal analysis have uncovered the secrets of food preferences, medical conditions, and insight into their death. Life was difficult during the Iron Age. Humans were malnourished and plagued by intestinal worms and diseases as indicated by abnormal bone growth and examination of intestines. They ate grains, seeds, fruits and occasionally meat, but more often than not their stomach held scant shards of seed chaff, a few grains, and small amounts of peat. Fungal spores in the stomach of Tollund Man suggest that he may have suffered from the European form of ergot poisoning. Grains stored in cool moist conditions are prone to fungal infection by <u>Claviceps</u> <u>purpurea</u>. Alkaloids of this fungus cause vascular constriction, burning pain, and gangrene in the extremities in a condition that is commonly called St. Anthony's fire.

The death of bog people has received considerably more speculation than scientific certainty. Although the slit throats, cranial concussions, and neck-bound nooses provide the details on how they died, archaeologist are left with guesswork on why these individuals were selected to die and sentenced to eternity in the bog. Were they criminals, sacrifices to deities, or members of disdained royal families? One bog man ate a last meal of milk and cereal, and the removal of his nipples at the time of death may indicate he had elite status in his community. The poor health of other bog people suggests that they were sacrificed during meager times. Their deaths were brutal, planned and conducted with little ceremony.

While North America does not possess a dearth of bog people, peat lands have provided some spectacular finds of early Holocene mammals. Ice age mastodons have been found in bogs of Ohio and New York. Although the bodies are not preserved with the same detail, the specimens have provided nearly compete skeletons, fragments of skin and hair, and fragments of other mammal skeletons from the past. The Ohio mastodon provided scientists with DNA fragments worthy of analysis and comparison with extant members of the elephant lineage. Another mastodon from Alaska yielded large quantities of mitochondrial DNA and provided a nearly intact genome for a comprehensive analysis. The research scientists concluded that mastodons diverged from the related elephants between 24 and 28 million years ago.

Bog bodies have been uncovered in the Windover pocosins of central Florida. Like bogs, pocosins are mineral poor and acidic. In 1982, the first of 168 human burials was located on land being drained and developed for a housing community. Radiocarbon isotopes dated the bodies at more than 8000 years of age. Unlike European bog people, skin and soft-tissue organs had decomposed, but the brain cases still contained tissue. Pollen sediments and seed analysis indicated that central Florida was a hospitable environment that provided many food resources for the occupants at the time. In addition, the intact condition of the skeletons and careful placement of bodies in the peat suggests that this was a planned cemetery for natural deaths, rather than executions.

Bogs hold considerable economic and ecological importance. Cranberries are a major agricultural crop in Wisconsin, Maine, Massachusetts, and New Jersey. Although the current agricultural setting is different from a natural bog, growers still utilize wetland like conditions and flooding to assist in the harvest of cranberries. These tart fruits are essentially sour unripe blueberries as suggested by the genus name (<u>Vaccinium</u>). The anthocyanins and organic acids of cranberries provide a healthy snack and drink known to help prevent infections and heart disease.

In Europe, barley is still smoked over peat logs early in the process of making high grade scotch. The smoke of peat imparts a rich, woodsy aroma and flavor that gives Scotch whisky its unique character. Dried peat does provide a source of heat energy in many regions of Great Britain. Dried blocks of peat may be pressed directly into the wall forms of homes as an excellent insulation.

Reportedly, ancient North Americans used fresh dried Sphagnum as the first disposable diaper. Sphagnum is clean, natural, and highly absorbent. The sterile nature of Sphagnum promoted its use as a medical dressing in battlefields of World War I when few other medical implements and dressings were available. It has been stated that one can safely drink water wicked above the water level by Sphagnum. However, after examining the plethora of springtails, nematodes, and rotifers inhabiting the Sphagnum ranks, one may reconsider drinking from this moss except in dire times. Many early Adirondack cabins used Sphagnum to pack and glaze the space between logs. The mossy packing contracts and expands with humidity to allow air flow in hot dry conditions, and prevent drafts during cool, moist weather. The hydrogen ion exchange capacity of Sphagnum works well to preserve logs and prevent their destruction by insects.

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