

HANGING WITH THE HEATHS

And other Bugged Down Families



Temple University School of Environmental Design

A Directed Study in Horticulture by Cynthia Ahern

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I. INTRODUCTION

This project is an independent study of plant communities occurring in glaciated peatlands, including bogs, fens, and forested peatland habitats along with associated upland plant communities that may have an influence on the peatlands. The study focuses on peatlands formed as a result of glacial deposits left 17,000 to 9,000 years during the retreat of the Wisconsin Glacial Era that occurred between 28,000 and 12,000 years ago.

I became interested in bogs while visiting Maine in 2008 and during the *Summer Field Ecology* course I attended at Temple University in 2011 with Horticulture Professor Susan Mrugal. A field trip to the Tannersville Cranberry Bog left me wanting to spend more time learning about this unique and fascinating habitat, and I tagged along with her class field trips in the summer of 2012, and again in 2013 during this study. I chose the Tannersville Cranberry Bog as my point for comparison as it is designated as the southernmost low altitude boreal bog along the eastern seaboard, and I wanted to compare the species occurring at Tannersville with those in other bogs and peatlands, particularly in Maine where boreal bogs are more common.

The study officially began on May 17, 2013, with my first visit to the Tannersville Cranberry Bog, and included a total of twenty-five visits to eighteen different sites in four states and New Brunswick, Canada; with a final visit to Tannersville on October 30, 2013. Each visit was documented in detail, with a few of the smaller sites occurring in the same areas combined to a list of sixteen sites, including plant and animal species I was able to identify at each location. The study includes a number of locations in the New Jersey Pine Barrens to establish the differences between glaciated and non-glaciated peatland plant communities.

II. WETLANDS DEFINED

One might find it surprising to read the results found in a Google search for “bog definition”, and the answers certainly lead to the misconception and confusion as to what truly defines a bog. Some definitions include such words as wetland, marsh, swamp, fen, quagmire, slough, and wet and muddy ground, but do not go on to differentiate what designates a bog from a fen from a marsh. Wikipedia will have you believing that a bog might be comprised of salt water or brackish water, and basically generalizes all wetlands as a “one size fits all”. Upon searching “salt water bog”, the Wikipedia definition comes up as the top result, immediately followed by a site discussing marijuana use with “salt water in the bong”, and followed by “The Big Ketch Saltwater Grille”. These results are a bit disheartening to me due to the vagueness and misinformation in the definition of this type of wetland that provides critical habitat for specialized plant families and the ecology they sustain, and further, is threatened by climate change, development, and pollution.

The term wetland may refer to any number of habitat types where hydric soils are formed as the result of surface saturation from the water table being close enough to, or above the surface to support hydrophytic plants. Wetlands are found world-wide and may occur in many different geographical areas from high altitudes to sea level, may be comprised of tidal or non-tidal fresh, brackish, or salt water. While a bog is a wetland, wetland soils may not necessarily have the composition to be defined as a bog. A closer look at wetland types and their relative

biotic composition clearly lays out the difference between what is classified as a bog versus other wetland type.

MARSH

A marsh is comprised of herbaceous vegetation that makes up the majority of the plant composition, may be saturated or flooded periodically, and requires precipitation, run-off, and seasonal flooding to support the plant community. The soil composition of a marsh is predominantly mineral soil but may contain some organic matter. There are numerous types of marshes including tidal and non-tidal, fresh and salt water, and may also include wet meadow, wet prairie, prairie potholes, playa, and vernal pools. The John Heinz National Wildlife Refuge at Tinicum in Philadelphia, Pennsylvania and Palmyra Cove in Palmyra, New Jersey both contain tidal freshwater marshes. Tidal saltwater marshes are common along the back bays of beach communities up and down the Atlantic Coast and around the Gulf of Mexico. Many freshwater marshes have been lost to development, degrading local water quality a result of increased run-off, pollutants, and loss of critical habitat for wildlife.

SWAMP

Swamps are predominantly comprised of trees and shrubs tolerant of very wet soil with seasonal standing water, and are fed from surface water of lakes, streams and rivers. A swamp may be a mineral soil wetland or a type of peatland commonly referred to as a wooded fen or forested fen having minerotrophic soils containing some organic matter. A well-known example

of a swamp with mineral soil wetlands and peatlands is the Great Swamp National Wildlife Refuge in New Vernon, New Jersey, a mostly shrub type swamp with some areas of forested maple swamp and pockets of peatlands. Other well-known and important swamps include Corkscrew Swamp near Naples, Florida, a cypress swamp boasting the largest stand of old growth Bald Cypress in North America; and J. N. "Ding" Darling National Wildlife Refuge in Sanibel, Florida, home to a substantial Mangrove swamp community.

PEATLANDS

Peatlands are a wetland type, and the term peatland is often interchanged with different types of wetlands and may be confusing for those who do not understand wetland terminology. A peatland is characterized by naturally deposited soil to a foot or more in depth formed in saturated conditions and composed of eighty to ninety-five percent water and layers of poorly or incompletely decomposed organic matter (peat) including plant and animal remains, seeds and pollen. This natural process creates oxygen depleted conditions that slow, or at great depths of organic matter, stop the process of decomposition, allowing organic matter to remain largely intact and confined within its basin. "Peatlands are three-dimensional portions of the earth's landscape which are wetlands and have organic soils; they include the full depth of organic materials, regardless of origin, they include all waters within or on top of the organic materials; and they include all organisms living within or atop the organic materials and water." (Ian Worley, Professor Emeritus of Environmental Studies and Plant Biology, University of Vermont).

Most peatlands in the glaciated northeast (New England, most of New York, northeastern and northwestern Pennsylvania, northern New Jersey) were formed by melting ice as the Wisconsin Glacial Episode receded from the region 17,000 to 9,000 years ago. Peatlands formed as the result of poorly drained glacial sediment that deposited ice blocks, silt, and clay that created land forms like moraines, esker ridges, drumlins, kame and kettle topography, outwash, tunnel valleys and shallow ephemeral pools. Along the coast of Maine, rising sea levels created saturated conditions that slowed drainage from the land and allowed the formation of vast peatlands, inland areas of Maine and northern New York peatlands often formed from glaciofluvial streams and ponds. An example of a successional transformation from a kettle lake to peat bog to forested peatland is illustrated below.

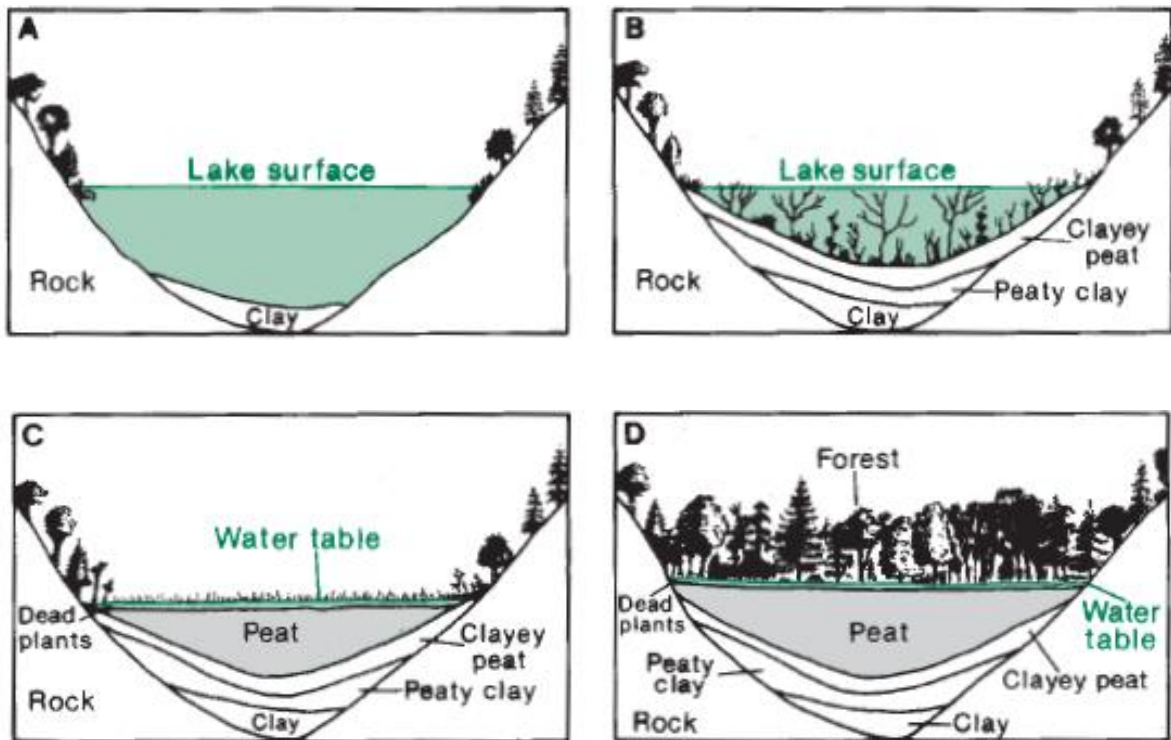


Image Source: Sevon, W. D., Fleeger, G. M., and Shepps, V. C., 1999, *Pennsylvania and the Ice Age* (2nd ed.): Pennsylvania Geological Survey

4th ser., Educational Series 6, 30

When ice blocks melted, deep depressions were left behind, creating a “kettle lake” (A). Isolated from groundwater, the kettle lake received water solely from precipitation, creating an oxygen poor environment only able to support specialized plants (B). Without the availability of mineral nutrient rich ground water, plants tolerant of oxygen poor and nutrient poor conditions began to colonize the kettle lakes, and as they died and partially decomposed, they slowly filled the lake. Sphagnum moss gradually took over, forming a mat that eventually covered the lake with an absorbent mat of vegetation (C&D).

About fifty percent of decomposed organic matter is humic acid, a major contributor to the low pH and preservation qualities of peat. Fifteen percent is bitumen, a natural hydrocarbon familiar as tar sands or oil sands (important to the energy industry, the highly controversial tar sands mining operations, only extractable by mining that requires stripping away land and destroying habitat) that will form coal over millions of years. Further discussion of acidic conditions and plant communities are discussed in detail in the Fens and Bogs section on page 11 and the Geographic and Physiographic Provinces section on page 20 of this report.

Paludification is another process that may form peatlands when uplands become submerged as a result of natural occurrences such as beaver dams or lateral expansion of raised peatlands, most common along coastal Downeast Maine and Fundy Coastal Ecoregion.

Peatland growth and expansion is confined by physical barriers such as rocks where peat is unable to accumulate (*Sphagnum* may grow on rocks, but unable to develop layers of peat) or by a basin where water is obtained in the form of precipitation or ground water from a stream, seep, or spring with nominal inflow or outflow. Peatlands may occur in boreal climates or in temperate regions; both climate and location influence the formation of peat in addition to

geological configuration, taking up to one hundred years for one inch of peat to form. Peat core analyses reveal preserved pollen grains that are thousands of years old and have helped researchers determine plant species that occurred through different geologic time periods and allowed them to distinguish drier times by the plants identified in the pollen grains.

Numerous terms may be used to describe peatlands and include boreal bog, bog, fen, forested fen, peat forest, swamp forest, cripple (cedar peatland or swamp), muskeg (in Canada and Alaska), heath (coastal Maine and New Hampshire), sponge (New Jersey Pine Barrens) and pocosin (southeastern United States). The word bog is theorized to have come from the Celtic term *bocc*, meaning soft. Peatlands may also be found within Mangrove forests and tidal marshes although there is a lack of information available and these peatlands are generally not included in data. Seventy-five percent of the world's peatlands occur in Russia and Canada, with Indonesia and the United States having the third and fourth largest areas of peatlands, the remainder distributed throughout many countries around world. The peatlands discussed from this point on will focus mainly on ombrogenous and oligotrophic boreal bog types and oligotrophic fens of the Northeastern United States and New Brunswick, but will also include areas in the New Jersey Pine Barrens to a lesser extent, mostly for comparison purposes.

III. FENS AND BOGS

Fens and bogs are basically grouped according to topography and landform, and include twelve forms of fens, and sixteen forms of bogs. These forms are categorized by tree, shrub, forb, and graminoid types, and further divided into groups based on the composition of plant

species and special features of the physiographic region. Further discussion will include the types of bogs and fens that I have visited throughout the northeast during this study.

Fens are classified as rich or poor depending upon the nutrient value they receive from precipitation, surface and groundwater or runoff, typical for most fens in the northeast. Fens may be oligotrophic or minerotrophic depending upon the nutrient content of the water, and the plant community varies based on the richness of nutrients. A nutrient rich fen (also referred to as eutrophic), is high in mineral nutrients with a pH of 6-8, and a fen poor in nutrients (or oligotrophic), has a pH lower than 6. Fens are commonly part of a larger wetland complex and may be sedge type, shrub type, or wooded type, and often include a bog community. Layers of peat found in fens are typically much shallower than in bogs and have more nutrients available to support a wider variety of plant life.

Plant species commonly occurring in fens include *Larix laricina* (Tamarack), *Thuja occidentalis* (Northern White Cedar), *Acer rubrum* (Red Maple), *Andromeda polifolia* (Bog Rosemary), *Aronia melanocarpa* (Black chokeberry), *Vaccinium corymbosum* (Highbush Blueberry), *Betula pumila* (Bog Birch), *Vaccinium macrocarpon* (Large Cranberry), *Myrica gale* (Sweet Gale), *Rhododendron viscosum* (Swamp Azalea), some sedges, *Sphagnum* spp., *Utricularia* spp. (Bladderworts), *Drosera intermedia* (Spatulate-leaved Sundew), *Meyanthes trifoliata* (Buckbean), *Maianthemum trifolium* (Three-leaved Solomon's Seal), *Geum rivale* (Water Avens), *Iris vesicolor* (Blue Flag Iris), *Symplocarpus foetidus* (Skunk Cabbage) and others. In non-calcareous rich fens, the absence of calcium carbonate allows more availability of nitrogen, potassium, phosphorus and other mineral nutrients providing favorable conditions for rare species including *Cypripedium reginae* (Showy Lady's Slipper), *Pogonia ophioglossoides*

(Rose Pogonia), *Liparis loeselii* (Bog Twayblade), *Toeplitzia racemosa* (False Asphodel), and *Lobelia kalmii* (Brook Lobelia).

Bogs are very complex and differ greatly from one to the next depending upon source and amount of water received, climate and physiographic region, attributes of surrounding wetlands and uplands, and other factors that make each site unique. A bog may range in size from less than twenty-five acres up to a thousand acres; smaller pockets are typically more frequent in the southern regions with larger expanses in northern regions. Bogs are usually part of larger wetland complexes or units comprised of zones with varying pH that are reflected by the plant communities present in each zone. Many of the same plants occur in transition areas and in more than one zone throughout the complex with varying pH, water source, raised hummocks and soggy hollows throughout the terrain. Woodland and Cyperaceae (sedge) fens along with other emergent species are fairly common, especially along the outskirts and perimeters of bogs and may connect one bog to another within the same complex. Submergent species and species with floating leaved habit are more likely in areas with open water. The fen perimeter often serves as a transition zone or a lag between ombrotrophic bog and mineral soil upland and may be variable from poor fen to mineral rich fen.

Plant growth in the form of a floating *Sphagnum* mat may extend from the edge of the shoreline and expand to the center of open water as illustrated on pages 9 and 10 in the example of a kettle bog. The mat is dominated by *Sphagnum* and heaths (Ericaceous species) like *Kalmia polifolia* (Bog Laurel), *Ledum groenlandicum* (Labrador Tea), *Vaccinium oxycoccus* (Small Cranberry), *Gaylussacia dumosa* (Dwarf Huckleberry) and may include *Drosera* species (Sundews), *Sarracenia purpurea* (Pitcher Plant), *Eriophorum* species (Cotton Grass), some *Carex* species (Sedge), lichens, and in northern latitudes and coastal Downeast Maine, *Rubus*

chamaemorus (Baked-Apple Berry), *Tricophorum cespitosum* (Deer's-hair Sedge) and the Ericaceous *Empetrum nigrum* (Black Crowberry). When peat becomes deeper and the mat thickens and stabilizes to form hummocks, trees and larger shrubs are able to take root in the mat, species commonly include *Acer rubrum* (Red Maple), *Thuja occidentalis* (Northern White Cedar), *Larix laricina* (Tamarack), *Picea mariana* (Black Spruce) and *Ilex mucronata* (Mountain Holly), *Pinus strobus* and *Quercus* species (Oaks) in more southerly climates, and *Chamaecyparis thyoides* (Atlantic White Cedar) along the Atlantic Coastal Plain.

Bogs are largely ombrotrophic (Greek ombros=rain; trophe = food), and nutrient-poor, deprived of calcium, phosphorus, and potassium, receiving water and nutrients strictly from precipitation as rain, snow, fog and mist in the form of dust and soil particles carrying magnesium, sodium, and organic matter from spores and pollen. Pollutants including nitrous and sulfuric acids and heavy metals may also be distributed by precipitation and air particles, and can jeopardize the critical and sensitive species occurring in bog habitats. Bogs in coastal regions also receive nutrients from salt spray, including phosphorus, sodium, and chlorine. A nutrient-poor environment results in oxygen depletion with an acidic pH of 4.2 or lower that form peat from the decomposition of *Sphagnum* species and other plants. Water is dark in color from the acidity in the water as a result of a high concentration of hydrogen ions that create humic acid from the peat, and from tannins of woody species including Hemlocks, Oaks, and Cedars. This acidity limits species and the growth of bacteria; nitrogen, calcium, and phosphorus are not released so the plants do not decay. These acids are washed away by groundwater and runoff in other wetland types, and to a lesser degree in fens, allowing them to support a more diverse plant community.

Bogs may be level or raised, open with water in the center referred to as the eye, or completely grown over with sphagnum mat. There is scientific debate regarding some bogs that are termed oligotrophic bogs with plant species composition that reflects those of plant communities typical of ombrotrophic bogs. Technically, these bogs are actually very poor fens that receive extremely low nutrient supply from runoff or ground water, and are most common in level bogs. The Tannersville Cranberry Bog is a prime example of this type of environment. A number of the bog types I experienced in my travels are described below.

Level bogs are comprised of various zones of vegetation that are determined by the nutrient levels of the water received. Level bogs may have a raised ombrotrophic area with dwarf shrub heath or forested bog in addition to oligotrophic areas of flat peatlands, and other areas of oligotrophic to minerotrophic fens. *Sphagnum* species are dominant, and *Picea mariana* (Black Spruce) and *Larix laricina* (Tamarack) common.

Level kettle type bogs, previously discussed on pages 9 and 10, are formed from circular or elliptical depressions left by glacial ice block melt. Kettle bogs, named for their kettle shape, are generally deeper than they are wide, and feature a floating *Sphagnum* mat or open water surrounded by a ring of *Sphagnum*. Peat may accumulate in the center to enough of a height above the surface of the mat to become isolated from groundwater, creating an environment of vegetation typically associated with ombrotrophic bog conditions. Outer areas of the mat still receiving mineral nutrients from groundwater often support a wider and more varied plant community typical of fens. A Quaking bog is a type of a kettle bog that shakes or sways when walking or jumping on the *Sphagnum* mat, the result of unstable tree and shrub roots established in raised hummocks.

Raised bogs are determined by climate and limited to high elevation geographical areas along coastal Downeast Maine, Maritime Provinces of Canada, and the Adirondack Mountains in New York, and are formed when peat accumulates and continues to rise above the level of the land surface. Growth may expand above the water table and on to adjacent upland, but this only occurs in areas with wet environment (fog) and high precipitation. High moisture combined with cool temperatures from ice pockets below the surface allow for cooler summer temperatures and result in a low evaporation rate that permits a longer growing season with a high amount of *Sphagnum* production. *Empetrum nigrum* (Black Crowberry), more common in northern latitudes in New England, New York and alpine areas, are found in many of the raised bogs along coastal Downeast Maine.

A **Coastal Plateau Bog** is a raised type, the surface usually flat or undulating and raised higher than the surrounding land, the perimeter with a definitive slope toward the lower mineral soil terrain with a well-defined lagg, often including a minerotrophic fen community. Open pools of water are rare on the plateau, and dominant species are *Trichophorum cespitosum* (Deer-hair Sedge), *Sphagnum* species (Sphagnum), *Empetrum nigrum* (Black Crowberry), and *Rubus chamaemorus* (Baked-Apple Berry) with dwarf shrubs and trees restricted to slopes of the plateau with little or no forest cover. Species more typical of southern climates may also occur in plateau bogs and include *Juniperus communis* (Common Juniper), *Symplocarpus foetidus* (Skunk Cabbage), and *Myrica pensylvanica* (Northern Bayberry). This type of bog reaches its southernmost limit at Acadia National Park along coastal Maine in Hancock County. The rare Crowberry Blue Butterfly uses Black Crowberry exclusively as its larval host plant, and is found in some coastal plateau bogs in Maine and New Brunswick.

Maritime sloped bogs scientifically called ‘Heath-Crowberry Maritime Slope Bogs’ are also referred to as ‘blanket’ bogs and occur along the Downeast coast of Maine. Coastal conditions and exposure create a cool, moist environment, and this type hosts a number of bog indicator species but is not considered a true peatland because the peat grows in a thin layer on rocky surfaces and is unable to accumulate layers of saturated peat. The plant community has dwarfed shrubs dominated by heaths with a low percentage of trees that are mostly dwarfed conifers, *Juniper communis* (Common Juniper), *Empetrum nigrum* (Black Crowberry), and *Rubus chamaemorus* (Baked-Apple Berry), with a dense cover of lichens and mosses. The Great Wass Preserve is a great example of this type, discussed on page 39.

Inland raised domed type bogs receive less moisture from fog and sea spray and experience greater precipitation from snow than raised coastal plateau bogs creating a very different plant community. A few characteristic of a domed bog of this type include fewer shrub thickets located on slopes (compared to most shrubs occurring on slopes in Coastal Plateau type), and a substantial presence of *Myrica gale* (Sweet Gale) and *Maianthemum trifolium* (Three-leaved Solomon’s seal).

IV. BOG CULTURE: PAST AND PRESENT

Bogs hold a significant key to historical climate, vegetation, wildlife and human cultures thanks to the preservation qualities of the acidic peat that provides a view to the past.

Peat was utilized in many ways throughout the history of the world. The Danish and Irish cut blocks of peat to provide heat for their homes and cooking, and Russians mined peat to use for fuel in electrical plants. Bog iron was mined throughout the New Jersey Pine Barrens and was worked in furnaces to create military weapons used during the Revolutionary War.

“Bog bodies” dating back to the late Iron Age (500 B.C. to 400 A.D.) have been recovered from northern European bogs; the mummified bodies are believed to have been discarded criminals, or offered as religious or spiritual sacrifices to Pagan or Celtic Gods. The high acidity and poor oxygen conditions of the peat helped to preserve these bodies through thousands of years. Bog bodies are not common in the areas of this study, and while there is the occasional report of a body recovered from a bog; most remains discovered in northeast bogs are identified as animals.

Other cultures cultivated bog plants for food and wine; the Finnish harvested *Rubus chamaemorus* (Baked-Apple Berry) to make wine, European settlers of northeastern United States cultivated cranberries and the region is still known as a top producer of commercial cranberry products today. Native Americans used *Sphagnum* and bog plants extensively for medicines, food, tools, children’s toys, and charms. *Sphagnum* was used in pillows, mattresses and diapers, and for a field surgical dressing in World War II. *Larix laricina* (Tamarack) for treating scurvy and bronchitis, to make rope, and beer, *Chamaedaphne calycuta* (Leatherleaf) was used to reduce fever and inflammation, and for tea, *Andromeda polifolia* (Bog Rosemary), *Gaultheria hispidula* (Creeping Snowberry), and *Ledum groenlandicum* (Labrador Tea) were used for tea, and the latter also for treating ulcers, burns, fever, and as a dye. *Kalmia angustifolia* had medicinal uses to cure headaches, backache, and colds, *Myrica gale* (Sweetgale) was used as a mosquito repellent, a dye, preservative, and charms, *Sarracenia purpurea* (Pitcher

Plant) for drinking cups, toys, and medicinally as a treatment for smallpox, kidney and lung ailments, and in sorcery. *Vaccinium corymbosum* (Highbush Blueberry) was not only eaten, but also used as treatment for insanity, pain during childbirth, and a blood cleanser, *Vaccinium macrocarpon* (Large Cranberry) for food and used to treat nausea, and *Eriophorum angustifolium* (Cotton Grass) for food. Sedges were once used for livestock feed, but not used now as modern use of heavy equipment makes access to soggy areas prohibitive.

Many bogs are gone forever as a result of being drained for use as agriculture fields in regions of central and northern New Jersey, Pennsylvania, the Finger Lakes region of New York, and especially in the Ontario area where very few acidic bogs remain today. The commercial bogs that we are most familiar with today produce food crops including blueberries and cranberries; Massachusetts and New Jersey are major commercial growers of cranberries, and New Jersey is a top producer of cultivated blueberries, while Maine is the largest producer of wild (Lowbush) blueberries. Black Crowberry with its large black fruit is prized for pies and preserves in Downeast Maine coastal communities. Peat is extracted for horticultural use with most horticultural peat originating from New Brunswick, Quebec, and North Carolina. Peat is also mined for its value as a clean-burning fuel, but the practice of peat extraction has become controversial and raises environmental concern, especially in Europe, due to habitat destruction and loss of biodiversity associated with mining peat that requires the draining and stripping of peatlands. Black spruce is an important source for the paper industry, while Tamarack, Northern White Cedar, and Atlantic Cedar are used to manufacture railroad ties, shingles, siding, and telephone poles because of their resistance to rot. *Rubus chamaemorus* (Baked-Apple Berry) is popular today for pies, *Ledum groenlandicum* (Labrador Tea) is still enjoyed as a beverage (use

sparingly due to toxins!), and *Myrica gale* has aromatherapeutic uses in scented pillows, and is also used as a natural flea repellent.

Calcareous peatlands are sometimes drained and stripped of marl (calcium rich chalky mud of silt and clay) for use as fertilizer in acidic agriculture fields, and is also added to mortar.

V. GEOGRAPHIC REGIONS AND PHYSIOGRAPHIC PROVINCES

ATLANTIC PLAIN

Southern New Jersey and the Long Island section of New York are situated at the northern end of the low lying Atlantic Plain, an area that includes the New Jersey Pine Barrens in New Jersey's Outer Coastal Plain province; within the Embayed Section, Coastal Plain province of the Atlantic Plain division of United States physiographic regions. This province is classified as non-glaciated since the Wisconsin Glacial Era did not extend this far south. Focusing on the New Jersey Pine Barrens, these peatlands were formed on elevated marine sediments as a result of rising sea levels during the last glacial retreat between 18,000 and 10,000 years ago and are relatively flat with some slopes and terraces. With an elevation of 0 feet to 391 feet above sea level at the highest point in the New Jersey province, the peatlands of the Atlantic Plain are typically shallow, especially in comparison to northern peatlands, with a high water table fed from streams, springs and aquifers making them more nutrient rich than northern peatlands. The soils here are porous and acidic, with pH from 3.6 to 5.5, composed of quartz or silica with low mineral content with aluminum and iron oxides and feldspars. The plant communities reflect the

warmer climate of the region, comprised of savannas that occur along streams with sedges and grasses, wooded cedar swamps and coastal marshes. In addition to the many rare and endemic species found here, as many as one hundred species reach their northern limit and approximately fifteen species reach their southern limit in the New Jersey Pine Barrens. Species common to this region that generally occur south of New England include *Chamaecyparis thyoides* (Atlantic White Cedar), *Magnolia virginiana* (Sweetbay Magnolia), *Myrica cerifera* (Southern Bayberry), and *Nyssa sylvatica* (Tupelo), *Woodwardia areolata* (Netted Chain Fern), *Xyris iridifolia* (Yellow-eyed Grass), *Tofieldia racemosa* (False Asphodel), *Lophiola americana* (Golden-crest), *Habenaria cristata* (Crested Fringed Orchid), *Myrica heterophylla* (Wax Myrtle), and the rarer *Narthecium americanum* (Bog Asphodel), *Schizaea pusilla* (Curly Grass Fern) and *Eriocaulon* species (Pipeworts). Many other species common in the peatlands of this region also occur in some northern New Jersey peatlands and may include *Chamaedaphne calyculata* (Leatherleaf), *Vaccinium macrocarpon* (Large Cranberry), *Vaccinium corymbosum* (Highbush Blueberry), *Gaylussacia baccata* (Black Huckleberry), *Kalmia latifolia* (Sheep Laurel), *Rhododendron viscosum* (Swamp Azalea), *Rhododendron maximum* (Rosebay Rhododendron), *Lyonia ligustrina* (Maleberry), *Clethra alnifolia* (Sweet Pepperbush), *Ilex glabra* (Inkberry), *Sarracenia purpurea* (Pitcher Plant), *Drosera* species (Sundews), *Woodwardia virginica* (Virginia Chain Fern), *Peltandra virginica* (Arrow Arum), *Toxicodendron vernix* (Poison Sumac), *Scirpus* species (Wool Grasses), and sedges. Forests in the Pine Barrens are commonly dominated by Pine-Oak or Oak-Pine forests depending on recent fires, and may have areas of dwarfed growth. Pines are dominated by *Pinus rigida* (Pitch Pine), with *Pinus echinata* (Shortleaf Pine), and *Pinus virginiana* (Virginia Pine); Oaks include *Quercus marilandica* (Post Oak), *Quercus*

velutina (Black Oak), *Quercus alba* (White Oak), *Quercus montana* (Chestnut Oak), *Quercus coccinea* (Scarlet Oak), *Quercus stellata* (Post Oak), and *Quercus ilicifolia* (Scrub Oak).

APPALACHIAN HIGHLANDS

Many of the peatlands I visited are located within the Appalachian Highlands division of United States physiographic regions and include sites in the Piedmont, Valley and Ridge, Appalachian Plateaus, and New England provinces, each region with unique qualities and distinct plant community types. Northern New Jersey experienced three of the last four major ice episodes compared to the relatively flat, non-glaciated Atlantic Plain, giving the region a sharp contrast with hills, ridges, and valleys.

Northern peatlands of glaciated New England and New York support a very different composition of species and usually have *Picea mariana* (Black Spruce), *Larix laricina* (Tamarack), *Thuja occidentalis* (Northern White Cedar), *Scheuchzeria palustris* (Rannoch-rush), *Eriophorum vaginatum* (Hare's Tail Cotton Grass), *Rhynchospora* species (Beak-rushes), *Carex trisperma* (Stunted Bog Sedge), *Carex pauciflora* (Few-Flowered Sedge), *Platanthera dilatata* (White Bog Orchid), *Salix serissima* (Autumn Willow), *Salix pedicellaris* (Bog Willow), *Betula pumila* (Bog Birch), *Ledum groenlandicum* (Labrador Tea). Forest communities vary depending on location, with northern hardwoods, mixed hardwood and conifer, spruce-fir, and other types discussed in more detail in the following sections describing each province, and on the individual sites beginning on page 27.

Piedmont and Valley and Ridge provinces in New Jersey

I have combined these provinces since the peatlands I visited in northern New Jersey are located in both provinces and have many similar plant species. The Piedmont province with elevations of 100 feet to 900 feet above sea level features a landscape of rolling hills, small streams, rivers, and ridges. The Valley and Ridge province has some similarities to the Piedmont landscape but has higher elevations of 400 feet to 1,800 feet above sea level, and higher uplands with steeper slopes and valleys, ridges may have rocky outcrops, and moist ravines are more typical here. Peatlands occur in glaciated areas of the Piedmont Lowlands Section of the Piedmont province and the Hudson Valley Section of the Valley and Ridge province. Many species in the aforementioned Atlantic Plain section also occur in glaciated peatlands of the Piedmont. Upland forests vary but are typically northern type mixed *Quercus rubra* (Red Oak), *Quercus alba* (White Oak), and *Quercus velutina* (Black Oak), with *Quercus montana* (Chestnut Oak) on dry slopes, *Fagus grandifolia* (American Beech) and *Acer saccharum* (Sugar Maple) on mesic slopes, and *Tsuga canadensis* (Eastern Hemlock) in damp ravines. The Great Swamp National Wildlife Refuge in the Piedmont Lowlands Section is discussed in detail on page 33, and the Kuser Bog in the Hudson Valley Section of Valley and Ridge is on page 31.

Peatlands in northern New Jersey may have boreal species with *Picea mariana* (Black Spruce) and *Larix laricina* (Tamarack) most frequent, and rarer *Ledum groenlandicum* (Labrador Tea) and *Andromeda polifolia* (Bog Rosemary). In the two sites I visited, *Picea mariana* (Black Spruce) was the only one of these species I observed, but these sites represent just a tiny percentage of peatlands in this area where the other species might be found.

Glaciated Appalachian Plateaus province in Pennsylvania and New York

A major part of my time during this study was spent in the Glaciated Low Plateaus Section at the Tannersville Cranberry Bog in Tannersville, Monroe County, Pennsylvania. Peatlands in this section are usually poor fens and many are less than one hundred acres or part of larger wetland complexes. Beavers may be responsible for creating some of the peatlands in this region; evidence of their activity clearly affects the Cranberry Creek that is dammed just above the Tannersville Cranberry Bog.

Both northern and southern species may occur in Pennsylvania, including *Chamaedaphne calyculata* (Leatherleaf), and uncommon boreal *Kalmia polifolia* (Bog Laurel) and *Rhododendron canadense* (Rhodora). Shrub thickets of *Vaccinium corymbosum* (Highbush Blueberry) are common. *Rhododendron maximum* (Rosebay Rhododendron), *Toxicodendron vernix* (Poison Sumac), *Toxicodendron radicans* (Poison Ivy), *Smilax* (Catbrier) are common on upland slopes.

New York has a great range of topography and habitats, but sadly, many peatlands in New York have been changed or destroyed by agriculture and development. Despite these changes, New York's lowlands hold some of the largest peatlands in the northeast, a result of numerous glacial retreats forming landscapes with marly deposits featuring kame and kettle, drumlins, eskers, large outwashes, with ephemeral lowlands. The Chicago Bog in Cortland is in the Southern New York Section has many features of the New York lowlands.

Adirondack province

Although I did not visit the Adirondacks, it is noteworthy to mention that this is the only area in the northeast outside of Maine where raised bogs occur.

New England province

With its many undeveloped expanses, Maine holds the largest area of peatlands in the northeast due to climate, latitude, and physical geography and hydrology, with a great variety of vegetation based on bog type and location. Many peatland types found here also occur in Canada, with five types reaching their southern limits in Maine. Coastal plateau raised type bogs and maritime slope 'blanket' bogs are restricted to the Downeast coastal area in the Seaboard Lowland Section; inland bog types include raised eccentric bogs, concentric raised dome type bogs, kettlehole bogs, raised level bogs, and patterned and unpatterned fens in the New England Upland Section. A number of these types are discussed in further detail on pages 15 to 17. *Rubus chamaemorus* (Baked-Apple Berry) and *Empetrum nigrum* (Black Crowberry) are at their southern limits in this region, and *Pinus banksiana* (Jack Pine) is found only in a few locations.

Forested lagg areas commonly have *Larix laricina* (Tamarack), less common *Betula pumila* (Bog Birch); and *Calamagrostis canadensis* (Bluejoint Grass) is common in grassy lags. Beech-Birch-Sugar Maple forest or Spruce-Fir forests are typical in mountainous commonly have boreal species *Picea rubens* (Red Spruce) and *Abies balsamea* (Balsam Fir). A few southern species may reach their northern limits in kettle bogs in the southern part of the state.

FUNDY COASTAL ECOREGION

The Fundy Coast Ecoregion spans the entire southern coastline of New Brunswick, Canada along the Bay of Fundy and includes a number of isles including Campobello, Grand Manan, Deer, and Machias Seal Islands. This region is the Canadian counterpart to Downeast

Coastal Maine and has very similar conditions with extreme tides, raised coastal plateau bogs, and maritime climate affected by the cold waters of the Bay of Fundy causing foggy conditions. This region experiences the highest tides worldwide.

Exploration on Machias Seal Island is very limited as this is a Migratory Bird Sanctuary and human presence is restricted to boardwalk paths leading to and from a visitor picnic area to bird blinds to observe the large Atlantic Puffin breeding colony. Visitors are not permitted to explore the island on foot and may only observe wildlife from the bird blind or visitor area.

The time I spent on Deer Island was limited to a rocky coastal area at dusk, so I am unable to provide documentation of peatlands on the island. I spent a considerable amount of time on Campobello Island, just two miles away across the Bay of Fundy via the Franklin Delano Roosevelt Memorial Bridge from Lubec, Maine to Campobello Island, New Brunswick, detailed on page 44.

INTERIOR PLAINS

The Zurich Bog, located in Arcadia, Wayne County, New York resides within New York's Erie-Ontario Lake Plains region of the United States' Eastern Lake section of the Central Lowlands province. The region has experienced numerous glaciations, and the landscape is a remnant of colder times. Although somewhat similar to the New York Lowlands section of the Glaciated Appalachian Plateau Province, this region appears to be a bit flatter and more defined by sandy outwash plains, glacial till, and drumlins with marly fens, minerotrophic marshes and ponds. Some Midwestern species may occur in fens in this region, and in larger wetland complexes,

poor fens may occur in interdrumlin peatlands, including a section in Zurich Bog described on page 47.

INDIVIDUAL SITE VISITS

TANNERSVILLE CRANBERRY BOG

The Tannersville Cranberry Bog located in Tannersville, Monroe County, Pennsylvania, is owned by the Nature Conservancy and Pocono Township, and managed by the Nature Conservancy and Monroe County Conservation District. The Nature Conservancy acquired the first 62.5 acres of the preserve in 1957, recognizing the value of the property to retain flood waters from the surrounding area during storms. Many additional land purchases and land gifts were added to the preserve through the years, and the property currently holds more than 1,000 acres of preserved land. A 1,450 foot floating wooden boardwalk allows safe access through the 150 acre wetland to the bog area that is accessible to the public only on guided walks due to the sensitive nature of the plant community. Public trails are blazed throughout the uplands of the preserve and are open for public hiking.

This property lies within the United States Department of Agriculture Growing Zone 6a, but the environment at the Tannersville Cranberry Bog is more like a missing piece from an ancient puzzle that has stood against time, hosting plant communities from glacial times. At nine hundred feet above sea level, the Tannersville Cranberry Bog is the southernmost lowest altitude boreal bog along the eastern seaboard and is a designated National Natural Landmark.

Formed at the end of the Wisconsin Glacial Era over 13,000 years ago, this former 715 acre kettle lake is now filled with approximately 60 feet of peat that has formed a nutrient poor fen with areas of bog-like qualities, home to rare and unusual plants normally present in boreal bogs and fens of Canada. The conditions in the Tannersville Cranberry Bog are due to the very minimal amount of groundwater received from the Cranberry Creek flowing along the edge of the peatland. The creek has been dammed by beavers and may contribute to the oligotrophic fen conditions along the Cranberry Creek, but has little effect on the very poor fen, with areas of low pH readings consistent with ombrotrophic bog conditions. Core analysis research reveals layers of history of a kettle lake, rich fen, poor fen, sphagnum bog. The closed eye of the bog is completely grown over by *Sphagnum* and is not accessible from the boardwalk, limited only to occasional visits by Monroe County Environmental Education Center staff to inventory plant species. This small complex has definitive zones, and pH readings are consistent with the plant communities that occur in each zone.

Monthly visits were made to this property with the intention of documenting the majority of species occurring here, and to observe each species in bloom and when in fruit. Visits were made on May 18, June 19, July 12, August 12, September 18, October 13, and October 30 of 2013.

Two boreal conifer species, *Larix laricina* (American Larch) and *Picea mariana* (Black Spruce) are the dominant trees in the bog, many to three hundred years old, but they are dwarfed due to the extreme conditions under which they are growing, rooting in hummocks and growing only about one foot every one hundred years. Due to the instability of the hummocks in the floating sphagnum mat, the conifers actually rock and sway when jumping on the boardwalk, classifying the Tannersville Cranberry Bog as a kettle type “quaking bog”.

Heaths comprise a large percentage of the plant composition of the Tannersville Cranberry Bog, featuring shrub thickets comprised mainly of *Vaccinium corymbosum* (Highbush Blueberry), *Chamaedaphne calyculata* (Leatherleaf), *Vaccinium macrocarpon* (Large Cranberry), *Kalmia angustifolia* (Sheep Laurel), *Rhododendron viscosum* (Swamp Azalea), some *Kalmia polifolia* (Bog Laurel), and a few *Andromeda polifolia* (Bog Rosemary), a rare plant in Pennsylvania. *Ledum groenlandicum* (Labrador Tea) is reported to be present here, but it was not observed during my visits. Sedges and other wetland shrubs and herbs are also present in more nutrient-rich sections of the fen.

Carnivorous plants are common in the Tannersville Cranberry Bog, and include many *Sarracinea purpurea* (Pitcher Plant) in areas with lower pH, and *Drosera rotundifolia* (Round-leaved Sundew) in the open, sunny low pH sections. *Drosera intermedia* (Spatulate-leaved Sundew) are also reported here, but due to the small size and distance I observed the plant from, it was difficult to determine if this species was also present along with *Drosera rotundifolia*.

A number of orchid species are listed on the Monroe County Environmental Education Center plant list for Tannersville Cranberry Bog, and include *Calopogon tuberosis* (Grass Pink), *Pogonia ophioglossoides* (Rose Pogonia), *Cypripedium parviflorum* (Yellow Lady Slipper), and *Platanthera blephariglottis* (White-fringed Orchid). There is raised concern that most of these species have not been observed or are increasingly rare in recent years and may have been shaded out by shrub and conifer growth. During my visits, I observed a single *Platanthera blephariglottis* (White-fringed Orchid), but none of the other orchids reported to occur on the property although with access limited to the boardwalk it is possible that they are located in a restricted area. Staff members have confirmed that they have not observed most orchid species that were previously recorded here. Other rare sun-loving bog species formerly found on this

site have also been crowded out by the succession of the shrub and conifer growth, including *Orontium aquaticum* (Golden Club), and *Lygodium palmatum* (Hartford Fern). Two experimental study areas, one large section and another small plot have been cleared of tree and shrub growth to allow more sunlight to reach these areas with the hope that the orchids will return in these sections.

Sedges, ferns, other herbaceous and shrub wetland species comprise the remainder of the plant community and include *Calla palustris* (Wild Calla), *Eriophorum angustifolium* (Cotton Grass), and *Toxicodendron vernix* (Poison Sumac). *Xyris iridifolia* (Yellow-eyed Grass), and the rare *Arceuthobium* spp. (Dwarf Mistletoe), parasitic to *Picea mariana* (Black Spruce) is reported to occur here but not observed on any of my visits.

During my visit on October 13, I took a number of pH and EC readings in various zones of the complex, and the readings were consistent with the plant species present. It should be taken into consideration that the readings were taken after heavy rains, and this may have affected the pH that read slightly higher than the numbers the Monroe Environmental Education Center staff had shared with me. At the beginning of the boardwalk in the lagg area dominated by sedges and ferns, the pH is 6.10, and the EC 130, the readings where the rich fen transitions to the heath shrub zone, the pH is 5.52 and the EC 100. The observation platform at Cranberry Creek with minerotrophic fen conditions has a higher pH of 6.34 and EC 120, and the final reading taken in the area nearest to the eye provided the lowest reading with a pH of 4.8 and EC 90. According to Monroe County Environmental Education Center staff, the pH readings closest to the eye average 3.5, and the readings at the Cranberry Creek observation platform average 5.5. These numbers make for an interesting comparison to similar sections at the Orono Bog Boardwalk in Maine where the lagg area has a pH of 6.6, and the open mat nearest the eye comes in at 3.8.

Many animals are found in the preserve including a number of rare and endangered species that include Snowshoe Hare, Bobcat, Black Bear, Coyote, River Otter, Gray Fox, and possibly the rare and endangered Bog Turtle, and Bog Copper Butterfly that requires cranberry as the host plant for its larval food. Many birds inhabit the bog, and include a number of breeders normally found in boreal climates such as Canada Warbler, Northern Waterthrush and Nashville Warbler. A complete species account is included at the end of this report.

DRYDEN KUSER NATURAL AREA – HIGH POINT STATE PARK

The Kuser Bog is a small 30 acre kettle bog within the 850 acre Dryden Kuser Natural Area of High Point State Park, located in Sussex County, New Jersey and managed by the New Jersey Department of Environmental Protection, Division of Parks and Forestry. I was able to make three visits to this bog, on June 9, June 29, and July 26 of 2013.

The mostly forested bog reaches depths to 20 feet and access is limited to the perimeter and open boardwalk area along the Cedar Swap Trail. I tried, unsuccessfully, to set up a time with a staff naturalist to assist me to reach areas of the bog that were not accessible from the trail, and to obtain further information about the species occurring in the wooded *Sphagnum* mat, but I never received a response to my inquiry, even after leaving numerous messages.

Chamaecyparis thyoides (Atlantic White Cedar), typically a coastal species, occurs here at 1,500 feet above sea level, and is thought to be at its highest elevation in the world at this site. Species typical of poor fen conditions may be observed from the boardwalk that extends through an open peatland fen with conifer species *Chamaecyparis thyoides* (Atlantic White Cedar) and

Picea mariana (Black Spruce), and rich with sedges and an impressive stand of *Iris versicolor* (Blue Flag Iris), *Calla palustris* (Wild Calla), and *Lysimachia terrestris* (Swamp Candles).

The slope around the perimeter of the bog is an ancient shoreline with wooded fen conditions carpeted with *Sphagnum* and struggling *Chamaecyparis thyoides* (Atlantic White Cedar) saplings constantly browsed by deer, *Tsuga canadensis* (Eastern Hemlock), *Rhododendron maximum* (Rosebay Rhododendron), *Kalmia latifolia* (Mountain Laurel), *Kalmia angustifolia* (Sheep Laurel), *Vaccinium corymbosum* (Highbush Blueberry), *Gaylussacia frondosa* (Dangleberry), and *Symplocarpus foetidus* (Skunk Cabbage), ferns and other herbaceous species. *Nyssa sylvatica* (Tupelo), *Acer rubrum* (Red Maple), *Pinus strobus* (Eastern White Pine), and a few *Betula allegheniensis* (Yellow Birch) occur in open areas with more sunlight. Numerous ephemeral ponds provide favorable conditions for frogs and salamanders to lay eggs.

Surrounding forested uplands with thin, rocky soils are dominated by Oaks with *Quercus rubra* (Red Oak), *Quercus alba* (White Oak), and *Quercus velutina* (Black Oak), and *Quercus montana* (Chestnut Oak) with *Pinus rigida* (Pitch Pine) on higher parts of the slope, *Sassafras albidum* (Sassafras), a few struggling *Castanea dentata* (American Chestnut), *Gaylussacia baccata* (Black Huckleberry) and *Vaccinium angustifolium* (Lowbush Blueberry), *Pteridium aquilinum* (Bracken Fern), *Dennstaedtia punctilobula* (Hay-scented Fern) and *Athyrium filix-femina* (Lady Fern).

GREAT SWAMP NATIONAL WILDLIFE REFUGE

The Great Swamp National Wildlife Refuge is a 7,768 acre wetland complex located in New Vernon, Morris County, New Jersey, owned and managed by the United States Fish and Wildlife Service. Designated a National Natural Landmark in 1966, Great Swamp lies just twenty-six miles west of New York City, and its wetlands are critical to the region where the surrounding area has been drastically altered by agriculture and urban development. Refuge water levels are managed to provide suitable habitat for certain species of wildlife. I visited this refuge with Eva Monheim and Sue Mrugal on July 24, 2013.

Situated on the site of the extinct glacial Lake Passaic, Great Swamp offers a mixed habitat of forested and shrub swamps, marshes, and fens that include oligotrophic and minerotrophic peatlands with many sedges, *Acer rubrum* (Red Maple), *Chamaedaphne calyculata* (Leatherleaf), *Rhododendron viscosum* (Swamp Azalea), *Typha latifolia* (Broadleaf Cattail), *Spiraea tomentosa* (Steeplebush), and *Cephalanthus occidentalis* (Buttonbush) . In more acidic areas, heaths dominate and include *Rhododendron viscosum* (Swamp Azalea), *Vaccinium corymbosum* (Highbush Blueberry), and *Gaylussacia frondosa* (Dangleberry).

ORONO BOG BOARDWALK ~ BANGOR, MAINE

This 616 acre wetland complex was designated as a National Natural Landmark in 1974, and is located in suburban Bangor only two miles from a shopping mall! The Orono Bog Boardwalk was founded in 2000 by Professor Ronald B. Davis and the University of Maine, and

is jointly managed by the University of Maine, City of Bangor, and Orono Land Trust. The Orono Bog Boardwalk provided the most comprehensive interpretive information of all the sites visited during this study, the material available was invaluable in helping to identify plant communities for comparison at the Tannersville Cranberry Bog and other locations. The species composition of this property and Tannersville had the most commonly shared species of all the sites I visited throughout the study. I traveled to this bog on August 14, 2013 as part of my “northern bog bonanza tour”.

The central half of the peatland is a raised bog, accessible by a 4,200 foot long floating wooden boardwalk. The land was formed 15,900 years ago as ice sheets melted and sea levels rose to cover the land depositing silt and clay from the bottom of sea. The land rose from the sea and small lakes formed the basin and areas of higher elevation with non-wetland vegetation for about 4,700 years until the climate became wetter, and at that time, wetland plants spread and established over the entire basin contributing to the landscape we see today with peat up to twenty-five feet deep.

This wetland complex is comprised of mixed forested fen transitioning through wooded conifer fen, heath shrub, mosses and evergreen shrub as described by interpretive signs and companion trail map along seven stations throughout the boardwalk:

1 – Mixed wooded fen: Broad-leaved Deciduous Forest with Scattered Evergreens

In this section, the lagg surrounding the peatland receives water from the upland and may experience dry periods during mid-summer months. Hummocks and hollows define this zone, with hummocks on old tree roots dominated by *Acer rubrum* (Red Maple), with *Fraxinus nigra* (Black Ash), *Thuja occidentalis* (Northern White Cedar), *Abies balsamea* (Balsam Fir), *Alnus*

incana (Speckled Alder), and *Ilex mucronata* (Mountain Holly). Herbs include *Symplocarpus foetidus* (Skunk Cabbage), *Osmunda regalis* (Royal Fern), *Osmunda cinnamomea* (Cinnamon Fern), and *Onoclea sensibilis* (Sensitive Fern). A surprise here was a single and very stunted *Cornus florida* (Flowering Dogwood), a species not expected this far north, and listed on the USDA Plants Database as occurring only in York County, the southernmost county in Maine, identified after showing photos to Eva Monheim. Vernal pools provide egg-laying opportunities for frogs without the hazard of being preyed upon by fish. Up to six feet of peat over mineral silt-clay beneath holds a canopy to 30 feet in height with a pH of 6.6 and EC 163. Nesting boreal species normally found much further north include Canada Warbler, Nashville Warbler, and Least Flycatcher.

2 – Conifer Wooded Fen – Black Spruce and Tamarack

This zone was created by a small lake that filled with 20 feet of mineral silt-clay beneath 4 feet of lake sediment and 16 feet of peat and has a pH of 4.4 and EC of 50. The canopy reaches 40 feet in height, and is dominated by *Larix laricina* (Tamarack) and *Picea mariana* (Black Spruce), a few *Acer rubrum* (Red Maple), and shrub species *Chamaedaphne calyculata* (Leatherleaf) and *Kalmia angustifolia* (Sheep Laurel). Slightly elevated, water drains from this section to the mixed wooded fen and lagg. Red Squirrel, Ruby-crowned Kinglet, Yellow-rumped Warbler, Red-breasted Nuthatch and Brown Creeper breed in this section.

3 – Upland Island – conifer forest with some broad-leaved Trees

This is the highest part of the ridge rising above the peat to form this island and has highly acidic mineral soil with a low pH of 4.2, and EC of 9. The young forest here was a logging site dating back to 1940, with *Betula populifolia* now dying out replaced by *Larix laricina* (Tamarack),

Picea mariana (Black Spruce), and *Acer rubrum* (Red Maple). with *Cornus canadensis* (Bunchberry) and moss groundcover. Black-Capped Chickadee, Red-Breasted Nuthatch, and Hermit Thrush breed in this community where the canopy reaches a height of 40 feet.

4 – Wooded Shrub Heath – Low shrubs with scattered dwarfed spruces and tamaracks

This is the central part of the peatland and is completely ombrotrophic and extremely infertile with a pH of 3.9 and EC 10, on a 10 foot base of peat with stunted trees up to one hundred years old. Mosses, shrubs and evergreens that retain more nutrients than other species are able to grow here and include a red *Sphagnum* species, *Ledum groenlandicum* (Labrador Tea), *Chamaedaphne calyculata* (Leatherleaf), *Kalmia angustifolia* (Sheep Laurel), *Sarracenia purpurea* (Pitcher Plant), and orchids blooming in late spring to early summer.

5 – Mosaic of moss lawns and wooded shrub heath hummocks

Water in this zone is just below the surface and is one of the lowest and wettest areas, with soggy hollows of moss ‘lawns’, covered by red and bright yellow-green *Sphagnum* species and hummocks up to a foot above the lawn. Stunted trees no more than 10 feet tall, and shrubs under 5 feet tall root in the raised hummocks including *Picea mariana* (Black Spruce), *Larix laricina* (Tamarack), *Chamaedaphne calyculata* (Leatherleaf), *Kalmia angustifolia* (Sheep Laurel), *Kalmia polifolia* (Bog Laurel), *Ledum groenlandicum* (Labrador Tea), *Vaccinium oxycoccus* (Small Cranberry), and *Eriophorum* species (Cotton Grass), and a different olive-brown *Sphagnum* species also grows on the hummocks. White-throated Sparrows breed here, and Northern Harriers take advantage of open areas to hunt. The peat base is 15 feet deep in this section, the pH here is highly acidic at 3.8, and the EC 40.

6 - Hydrological research station, seasonal pool, mosaics of moss lawns and wooded shrub heath hummocks.

This is a research area for studying water flow in peat for the purpose of predicting future climate change and effect on peatlands. Surface pools are present here most of year and may support rare dragonfly eggs and larvae. The peat reaches a depth of 20' atop mineral silt-clay in this section and is extremely poor with a pH of 3.8 and EC 10. Hummocks support *Picea mariana* (Black Spruce) up to 10 feet tall that air layer to produce clones and may be hundreds of years old with low, dense growth to provide good habitat for breeding Palm Warbler and Lincoln's Sparrow. Snowshoe hares are also present in this area.

7 – Mosaic of wooded shrub heath and forested bog.

This section is close to the outer limit of the ombrotrophic part of the peatland and is one of the more diverse areas with *Rhododendron canadense* (Rhodora) in flower mid to late spring and *Drosera rotundifolia* (Round-leaved Sundew) in the hollows. Lincoln's Sparrow, Palm Warbler, Nashville Warbler and Common Yellowthroat breed here, and Jumping Mouse and Leopard Frog are also noted here. The pH of 4.0 and EC 90 reflect the greater availability of nutrients here, and the canopy reaches up to 20 feet on a base of 20' peat over mineral silt-clay.

DOWNEAST MAINE AND THE BOLD COAST

The coastal area of Maine referred to as coastal 'Downeast Maine' includes coastal Hancock and Washington Counties from Mount Desert Island north to Eastport, and the Bold

Coast includes a 125 mile scenic stretch of rocky coastal from Millbridge (north of Acadia National Park) north to Eastport.

Acadia National Park, Mount Desert Island, Maine

The **Big Heath** is a 420 acre coastal plateau bog located within Acadia National Park on Mount Desert Island near Southwest Harbor, Maine, and is owned and maintained by the National Park Service. I visited this site and the following location, Long Pond Fire Road, on August 18, 2013.

The Big Heath is distinguished as the southernmost coastal plateau bog. Accessible along the main road and by a path along the perimeter, the center is open *Sphagnum* mat covered with *Empetrum nigrum* (Black Crowberry), *Trichophorum cespitosum* (Deer-hair Sedge), *Eriophorum vaginatum* (Tussock Cotton Grass), *Eriophorum virginicum* (Tawny Cotton Grass), *Rubus chamaemorus* (Baked-Apple Berry), dotted with dwarfed *Picea mariana* (Black Spruce) and *Larix laricina* (Tamarack), and the perimeter is mostly *Picea mariana* (Black Spruce). Sand pond depressions occur here, usually more common in northern latitudes. A lagg area along the roadside has a plant community consistent with rich fen characteristics and includes *Spiraea tomentosa* (Steeplebush), *Aronia melanocarpa* (Black Chokeberry), *Ilex verticillata* (Winterberry Holly), *Euthamia graminifolia* (Lance-leaved Goldenrod); and a dry, sandy strip between the peatland and the road has dwarfed *Gaylussacia dumosa* (Dwarf Huckleberry), *Vaccinium angustifolium* (Lowbush Blueberry), *Pteridium aquilinum* (Bracken Fern), and a *Rubus* species (Blackberry).

Long Pond Fire Road is a gravel road that lies near the base of Western Mountain within Acadia National Park, winding through mature mixed forest and open areas of marsh and

fen wetlands near Southwest Harbor. The road led to the discovery of a small poor fen with mostly open water and a floating *Sphagnum* mat with *Chamaedaphne calyculata* (Leatherleaf), *Kalmia angustifolia* (Sheep Laurel), *Gaylussacia baccata* (Black Huckleberry), *Sarracenia purpurea* (Pitcher Plant), *Sagittaria englemannia* (Engelmann's Arrowhead), dead and dying *Pinus strobus* (Eastern White Pine), *Eriophorum* species (Cotton Grass), and *Utricularia purpurea* (Purple Bladderwort); surrounded with evergreen species including *Thuja occidentalis* (Northern White Cedar), *Abies balsamea* (Balsam Fir), and *Picea rubens* (Red Spruce).

Great Wass Preserve ~ Beals, Maine

The Great Wass Preserve, acquired by the Nature Conservancy in 1978, is located on Great Wass Island and is notable for its orientation on the coast as it projects further out into the Gulf of Maine than any other island along the coast of Maine. I visited Great Wass Preserve on August 19, 2013, an absolute gem that quickly impressed me and is easily one of the best natural areas I have ever visited in all the years I have been enjoying nature.

The Gulf of Maine and the Bay of Fundy intersect at this location along the Fundian Fault, producing a foggy, cool maritime climate creating growing conditions that support a number of rare and unusual plants and several boreal species that reach their southernmost limit here. The peatlands occurring on the preserve range from ombrotrophic to minerotrophic, with a high frequency of lichens and very diverse habitat distributed throughout the preserve. Some community types include maritime spruce-fir forest, forested swamp, mixed hardwood, coastal raised plateau, maritime slope (blanket) bog, maritime fen, and a Jack Pine forest.

The bogs and fens are quite different and support a number of species not present at other sites. Coastal plateau bogs with *Empetrum nigrum* (Black Crowberry), *Trichophorum cespitosum* (Deer-hair Sedge), *Eriophorum vaginatum* (Tussock Cotton Grass), *Eriophorum virginicum* (Tawny Cotton Grass), *Rubus chamaemorus* (Baked-Apple Berry), and a small number of dwarfed *Picea mariana* (Black Spruce) and *Larix laricina* (Tamarack); and *Arethusa bulbosa* (Dragon's Mouth Orchid) is reported to occur here. The Crowberry Blue Butterfly is a rare species of special concern requiring *Empetrum nigrum* (Black Crowberry) as its larval host and is also recorded at this preserve.

A number of sedge-dominant fens occur in areas of the preserve, along with a maritime sedge fen with *Solidago sempervirens* (Seaside Goldenrod), and the rare *Iris hookeri* (Beachhead Iris) and *Plantago maritime* (Seaside Plantain) at the beach head.

The Jack Pine forest community is unique in this region, and possibly the only of its kind along the coast of Maine, growing on very thin soil atop exposed bedrock at higher elevations on the island. This Jack Pine community is able to reproduce without the aid of fire, usually required for reproduction of this species. Dominated by *Pinus banksiana* (Jack Pine), stunted *Picea rubens* (Red Spruce) and *Picea glauca* (White Spruce), and scattered dwarf heath shrubs are also associated with this plant community in addition to a substantial cover of *Cladonia* species (Reindeer Lichen). A similar habitat dominated by stunted and disfigured *Picea mariana* (Black Spruce), also occurs at higher elevations here, this type with a larger percentage of dense dwarfed shrubs, especially along the marginal slopes with *Vaccinium angustifolium* (Lowbush Blueberry), *Aronia melanocarpa* (Black Chokeberry), *Kalmia angustifolia* (Sheep Laurel), *Viburnum nudum* var. *cassinoides* (Witherod Viburnum) and others. Maritime blanket bogs also hold these shrub species and in addition to species mentioned above are *Ilex mucronata*

(Mountain Holly), and *Juniperus communis* (Common Juniper), and sedges, carnivorous plants, mosses and lichens on a “blanket” of *Sphagnum*. A maritime shrub zone has a higher percentage of *Myrica gale* (Sweetgale) in addition to other mixed shrubs.

Typical species within the maritime spruce forest include *Abies balsamea* (Balsam Fir), *Picea rubens* (Red Spruce), *Picea glauca* (White Spruce), *Taxus canadensis* (Canada Yew), and *Juniperus horizontalis* (Creeping Juniper) with *Cornus canadense* (Bunchberry) and Ericaceous subshrubs growing along the *Sphagnum* forest floor; while areas of forested swamp are dominated by *Thuja occidentalis* (Northern White Cedar), with a rich *Sphagnum* and herb layer including *Cornus canadensis* (Bunchberry), and *Coptis trifolia* (Goldthread).

Small rocky islands off the coast provide a suitable haul out site for Harbor Seals, an added bonus to the great variety of habitats on the preserve.

Boot Head Preserve and Hamilton Cove Preserve ~ Lubec, Maine

Boot Head Preserve and Hamilton Cove Preserve are both relatively recently acquired properties owned and maintained by Maine Coast Heritage Trust. The two preserves are only 1.5 miles apart on the same stretch of road along Maine’s Bold Coast in Washington County, yet despite the close proximity, there is considerable variation in plant communities with a wide range of plant and animals species, many unusual for this region.

Destined for sub-division, the 700 acre Boot Head Preserve was acquired in 1989, and the first land parcel of the 1,250 acre Hamilton Cove Preserve was acquired in 1993, with additional land purchases as recently as 2008. I visited both of these properties on August 21, 2013.

Hamilton Cove is situated along 1.5 miles of cobblestone shoreline, with rugged cliffs and high rocky ridges jutting out over the cove. Over twenty-five plant communities may be found at this preserve with influences from a stream that runs through the property, beaver dams, and human influences of grass barrens that are a historical remnant of land-clearing burns, along with damming for lumber mill and shipyard operations from the early 1800s.

Hamilton Cove is more diverse than Boot Head with multiple wetland types that contribute to the plant and animal diversity of the preserve, also having areas of young, successional growth, while Boot Head has more mature growth featuring a forested bog cedar swamp. Some of the plant communities found at Hamilton Cove include early successional hardwood areas with *Sorbus americana* (Mountain Ash) and *Alnus incana* (Speckled Alder); and successional forest with *Betula allegheniensis* (Yellow birch), *Picea rubens* (Red Spruce), and *Thuja occidentalis* (Northern White Cedar). Both properties have maritime spruce-fir forest, bog and fen wetlands with rare and endemic species including *Rubus chamaemorus* (Baked-Apple Berry), *Ledum groenlandicum* (Labrador Tea), *Rhodiola rosea* (Roseroot Sedum), and *Iris hookeri* (Beachhead Iris). Flycatchers, Gray Catbirds, Common Yellowthroats, Song Sparrows, and American Robins are attracted to build their nests in areas with *Alnus incana* (Speckled Alder) community, and enjoy feeding on the fruit of *Sorbus americana* (Mountain Ash) alongside other animals and Hermit Thrushes that nest in the associated mature forest. The grass barrens and dwarf shrub areas of the bogs are ideal for nesting Palm Warblers and Lincoln's Sparrows. Spotted Sandpipers nest along the cobble beaches in the associated beach plant community. Black Bear, Moose, Coyote, Snowshoe Hare and Bobcats also occur in this habitat.

West Quoddy Head State Park ~ Lubec, Maine

West Quoddy Head State Park is a 541 acre park located on the easternmost peninsula in the United States, with coastal maritime spruce-fir forest, rocky cliffs, and two coastal plateau bogs. One of the bogs in the park, Carrying Place Cove, is a National Natural Landmark, a 43 acre raised bog remarkable as it is affected by the extreme tides of the Gulf of Maine and Bay of Fundy and the bog has eroded to expose layers of peat that can be viewed from the beach. Unfortunately, the timing of my visit on August 21, 2013 was during high tide and I was unable to access the beach to view the eroded layers. The other bog is easily accessible via a boardwalk trail leading through the bog and has interpretive signage describing the formation of the bog and the plants living in the bog. Similar to other raised bogs in the area, this site holds a now familiar account of species, dominated by dwarfed shrubs and *Sphagnum* lawn with *Trichophorum cespitosum* (Deer-hair Sedge), *Eriophorum angustifolium* (Cotton Grass), *Rubus chamaemorus* (Baked Apple Berry), *Empetrum nigrum* (Black Crowberry), *Vaccinium oxycoccus* (Small Cranberry), *Ledum groenlandicum* (Labrador Tea), *Viburnum nudum* var. *cassinoides* (Withered Viburnum), *Kalmia polifolia* (Bog Laurel), *Rhododendron canadense* (Rhodora), few *Picea mariana* (Black Spruce), *Larix laricina* (Tamarack), and the carnivorous *Sarracenia purpurea* (Pitcher Plant), and *Drosera intermedia* (Spatulate-leaved Sundew). *Cladonia* species (Reindeer Lichen), *Cornus canadense* (Bunchberry), *Gaultheria hispidula* (Creeping Snowberry), *Gaultheria procumbens* (Winterberry) grow on the hummocks and *Ilex mucronata* (Mountain Holly) is found in the oligotrophic lagg area upon entering the boardwalk. The bog is reached by a trail through the surrounding maritime spruce-fir forest with *Abies balsamea* (Balsam Fir), *Picea rubens* (Red Spruce), *Picea glauca* (White Spruce), *Taxus canadensis* (Canada Yew), and *Juniperus horizontalis* (Creeping Juniper), with *Clintonia borealis* (Blue

Bead Lily), *Coptis trifolia* (Goldthread), *Cornus canadense* (Bunchberry), *Gaultheria procumbens* (Winterberry), and *Aralia nudicaulis* (Wild Sarsaparilla) growing upon the *Sphagnum* forest floor.

The “boreal bog regulars” can be found nesting in the bog and adjacent forest with Lincoln’s Sparrow, Palm Warbler and Least Flycatcher, and Golden-crowned Kinglet, Red-breasted Nuthatch, Black-capped Chickadee, along with Bald Eagles nesting in established spruces.

EAGLE HILL BOG ~ ROOSEVELT CAMPOBELLO ISLAND, NEW BRUNSWICK, CANADA

Roosevelt Campobello International Park was once the summer home of Eleanor and Franklin Delano Roosevelt, and is jointly owned, staffed, and maintained by Canadian and United States Citizen as a memorial to Roosevelt and as a symbol of the close relationship between Canada and the United States. I spent the entire day of August 20, 2013 exploring Campobello Island, with a stop at the Eagle Hill Bog located within the park.

The Eagle Hill Bog was formed 10,000 years ago by a pond leftover from a glacial depression, and is very shallow as far as bogs are concerned, with an average depth of 4.5 feet over bedrock and clay. This bog has an interesting history, once used as a logging road until the 1950s, as the peat stayed frozen for a longer time providing passage for lumber transported through the bog by sled. This site also has a different topography from others, and while it is a

coastal raised plateau type, it formed from a pond with a ridge through the center, resulting in taller shrubs along the center ridge.

The bog is ombrotrophic in the thick *Sphagnum* mats, with oligotrophic conditions along the perimeter in the zonal transition and lagg areas where typical species include *Sorbus americana* (Mountain Ash), *Ilex mucronata* (Mountain Holly), and *Viburnum nudum* var. *cassinoides* (Witherod Viburnum). The shrubby bog is dominated mostly by Ericaceous species including *Vaccinium oxycoccus* (Small Cranberry), *Andromeda polifolia* (Bog Rosemary), *Kalmia polifolia* (Bog Laurel), *Kalmia angustifolia* (Sheep Laurel), *Chamaedaphne calyculata* (Leatherleaf), *Ledum groenlandicum* (Labrador Tea), *Rhododendron canadense* (Rhodora), *Empetrum nigrum* (Black Crowberry), *Gaultheria procumbens* (Winterberry), *Vaccinium angustifolium* (Lowbush Blueberry) and *Myrica gale* (Sweet Gale), with *Cladonia* and *Usnea* (Reindeer and Old Man's Beard Lichens) and *Cornus canadensis* (Bunchberry) in areas raised above the saturation level. Palm Warblers and Lincoln Sparrows are commonly observed in the open areas, and Yellow-bellied Flycatcher, Least Flycatcher, Nashville Warbler, and Canada Warbler take advantage of the many shrub thickets for nesting.

The mixed upland forest ascends to Eagle Hill, a rocky outcrop, where it overlooks the bog and offers spectacular views of the Bay of Fundy, offering a chance to view offshore species from a bog. A mix of mature upland forest and young forest areas that were formerly logged with *Betula papyrifera* (White Birch), and *Acer pensylvanica* (Striped Maple) offer a of variety nesting opportunities for many species of birds that include Swainson's Thrush, Hermit Thrush, Magnolia Warbler, and Black-throated Green Warbler.

FINGER LAKES REGION ~ NEW YORK

While working on this bog study, I took advantage of an opportunity to work on another unrelated project giving me a reason to make an impulsive trip to the Finger Lakes where I could work on both projects. While in the Finger Lakes region, I was able to visit two bogs, adding yet more diversity to the spectrum of this study with species heavily influenced by calcareous soils characteristic to the area. Both properties shared some similarities in their surrounding uplands with landscapes typical of this region with kame and kettle topography, drumlins, eskers, and marly ponds, but the bogs were each unique in their composition. The day of October 6, 2013 was unseasonably warm following heavy rains, and provided comfortable temperatures for exploring these peatlands.

Chicago Bog ~ Cortland, Cortland County, New York

The Chicago Bog is owned and maintained by Lime Hollow Center for Education & Culture, a local educational center focusing on the nature and culture of the area. This property is located in the Southern New York Section of the Glaciated Appalachian Plateaus Province in the eastern part of the Finger Lakes region.

The Chicago Bog is the only bog I visited having a large open eye, surrounded by a massive *Ledum groenlandicum* (Labrador Tea) in the shape of a donut on the *Sphagnum* mat. This location is viewed from the shore of the lagg area, and species are difficult to determine without taking a kayak into the bog. A number of *Vaccinium corymbosum* (Highbush Blueberry) thickets and an abundance of *Eriophorum angustifolium* (Cotton Grass) in the *Sphagnum* mat were dominant, along with *Pinus strobus* (Eastern White Pine) on the hummocks.

The bog is accessible via the Phillips Memorial Trail traversing through kame and kettle landscape, with uplands at 1200 feet elevation looking down on a sizable ephemeral marl pond, and then gently ascending toward the bog. The trail to the bog hosts a number of lime-loving plants including *Jeffersonia diphylla* (Twinleaf) and *Hepaticophyta* (Liverworts), and the nature center mentions a large population of *Trillium* (Trillium) that might be worth a return visit to see in the spring. The sloped Northern Hardwoods Forest upland is dominated by *Fagus grandifolia* (American Beech), *Acer saccharum* (Sugar Maple) and *Betula lenta* (Sweet Birch), leveling off at the base and replaced by a moist area dominated by *Tsuga canadensis* (Eastern Hemlock) with an understory with *Viburnum acerifolium* (Mapleleaf Viburnum), *Gaultheria procumbens* (Winterberry), and a view to the open eye kettle quaking bog where *Pinus strobus* (Eastern White Pine) grows on the hummocks and in a huge stand on the opposite side of the bog.

The lagg around the bog contains indicator species of a rich fen, supporting *Scirpus cyperinus* (Woolgrass) with many invasive species growing at the edge of the pond including *Rhamnus cathartica* (European Buckthorn). A high number of invasives were also present throughout the forested areas, noticeable especially after the absence of non-natives while visiting the northern sites.

A remarkable number of Red Eft and tree frogs were active due to unseasonably warm weather and the availability of seasonal ponds resulting from a wet summer.

Zurich Bog ~ Arcadia, New York

The Zurich Bog, part of a 650 acre peat wetland complex, is a National Natural Landmark for the unique plant and animal associations found in the wetland, and is owned and maintained by the Bergen Swamp Preservation Society in Arcadia, Wayne County, New York.

I was able to spend a few hours exploring this fantastic preserve, observing a great variety of species throughout the zones of the complex.

The wetland complex is partially accessible by a plank board trail that circles down to an open *Sphagnum* bog surrounded with swamp and bog peat forests and upland drumlin forest, and is long and narrow with a small drumlin in the bog, the only site having this type of configuration.

The swamp forest is dominated by *Taxus canadensis* (Canada Yew), *Acer rubrum* (Red Maple), *Ulmus americana* (American Elm), with a forest floor covered with many ferns including *Onoclea sensibilis* (Sensitive Fern), *Osmunda cinnamomea* (Cinnamon Fern), *Thelypteris palustris* (Marsh Fern), *Osmunda regalis* (Royal Fern). *Cornus racemosa* (Gray Dogwood) and *Lindera benzoin* (Spicebush) are dominant descending toward the bog forest, followed with a stand of *Pinus strobus* (White Pine), *Tsuga canadensis* (Hemlock) and a carpet of *Polytrichum* species (Haircap Moss) and *Hepaticophyta* (Liverworts) in the transition zone. The bog forest is covered by *Picea mariana* (Black Spruce), *Taxus canadensis* (Canada Yew), *Thuja occidentalis* (Northern White Cedar), *Ilex mucronata* (Mountain Holly), *Myrica pensylvanica* (Northern Bayberry), *Gaultheria procumbens* (Wintergreen), *Maianthemum canadense* (Canada Mayflower), and *Coptis trifolia* (Goldthread) on a rich *Sphagnum* forest floor. The open bog zone is a *Sphagnum* mat with shrub species *Ledum groenlandicum* (Labrador Tea), *Chamaedaphne calyculata* (Leatherleaf), *Kalmia angustifolia* (Sheep Laurel), *Kalmia polifolia* (Bog Rosemary), *Aronia melanocarpa* (Black Chokeberry), *Vaccinium angustifolium* (Highbush Blueberry), *Gaylussacia baccata* (Black Huckleberry), *Myrica gale* (Sweet Gale), *Carex* and *Rhynchospora* species (Sedges), *Eriophorum vaginatum* var. *spissum* (Hare's Tail Cotton Grass), *Sarracenia purpurea* (Pitcher Plant) and dormant *Drosera intermedia* (Spatulate-leaved

Sundew), and *Drosera rotundifolia* (Round-leaved Sundew). The swamp forest winds through *Larix laricina* (Tamarack) and *Picea mariana* (Black Spruce) to the upland forested drumlin with *Pinus strobus* (Eastern White Pine), *Fagus grandifolia* (American Beech), *Betula papyrifera* (Paper Birch), *Prunus serotina* (Wild Black Cherry), *Liriodendron tulipifera* (Tuliptree), *Polystichum acrostichoides* (Christmas Fern), *Botrychium virginianum* (Rattlesnake Fern), and other dormant lime-loving species including *Trillium* (Trillium) (from the preserve species list). The floating moor was roped off for a study and not accessible but a glimpse of the *Sphagnum* mat caught *Typha latifolia* (Broadleaf Cattail) and sedges, and the preserve list includes *Decodon verticillata* (Swamp Loosestrife), *Sagittaria latifolia* (Broadleaf Arrowhead) and other species indicative of minerotrophic conditions.

PEATLANDS OF THE NEW JERSEY PINE BARRENS

With over a million acres, the Pine Barrens of New Jersey deserve more attention than a few short sections in this report, but is worth the abbreviated tour for the sake of comparison that clearly defines the differences and some similarity of species occurring in non-glaciated peatlands and glaciated boreal peatlands. Wharton, Bass River and Brendan T. Byrne (Lebanon), and Belleplain State Forests are all situated within the Pine Barrens and are owned and managed by New Jersey Department of Environmental Protection. Many other county, federal, and privately owned properties are preserved and protected in the Pinelands National Reserve.

I was able to visit a number of bogs during the summer months to observe the variety of species found in this region, however, these ‘bogs’ are actually fens, swamps and savannas that

receive ground water from the underlying Cohansey Aquifer and local rivers and streams. The Atlantic Plains section on pages 20 to 22 describes the soils and plants characteristic to this region, so I will generalize and discuss the highlights of each site rather than dedicate a section to each site.

I visited a number of areas throughout the Pine Barrens on foot and by kayak, and found the composition of species varied a great deal from the species observed in northern boreal bogs. Typical of every site is *Sphagnum* with sedges, *Drosera intermedia* (Spatulate-leaved Sundew), *Drosera rotundifolia* (Round-leaved Sundew), *Drosera filiformis* (Threadleaf Sundew), *Sarracenia purpurea* (Pitcher Plant), *Chamaedaphne calyculata* (Leatherleaf), orchids and wildflowers, open ponds with *Nymphaea odorata* (Fragrant Water Lily), *Utricularia* species (Bladderworts), swamp edges with *Chamaecyparis thyoides* (Atlantic White Cedar) and shrubs including *Gaylussacia baccata* (Black Huckleberry), *Gaylussacia frondosa* (Dangleberry), *Gaylussacia dumosa* (Dwarf Huckleberry), *Rhododendron viscosum* (Swamp Azalea), *Kalmia angustifolia* (Sheep Laurel), *Clethra alnifolia* (Sweet Pepperbush), *Lyonia lucida* (Fetterbush), *Lyonia mariana* (Steeplebush), *Vaccinium corymbosum* (Highbush Blueberry), and *Vaccinium macrocarpon* (Large Cranberry). Upland forests are dominated by *Pinus rigida* (Pitch Pine) and mixed *Quercus* species (Oak species), *Ilex opaca* (American Holly), *Ilex glabra* (Inkberry), and *Pteridium aquilinum* (Bracken Fern).

Webb's Mill Bog is a cedar swamp and fen in Ocean County, New Jersey, and is part of the Greenwood Wildlife Management Area owned and managed by the New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife. In addition to many of the species in the aforementioned paragraph, this site is extraordinary for its great number of *Calopogon tuberosis* (Grass Pink), *Pogonia ophioglossoides* (Rose Pogonia), *Narthecium*

americanum (Bog Asphodel) and *Lophiola aurea* (Golden Crest) that I enjoyed during my visit on July 5, 2013.

The highlights of the savannas and fens along **Quaker Bridge Road in Wharton State Forest** during my August 5, 2013 visit were without a doubt the orchids, including a high occurrence of *Platanthera blephariglottis* (White-fringed Orchid) and the rare *Platanthera integra* (Southern Yellow Orchid), reaching the northern limit of its range. I was sworn to total secrecy regarding the exact location of this site as this species is rare and endangered in New Jersey.

Kayaking the Wading River in **Wharton State Forest** in Burlington County, and **Menantico Ponds Wildlife Management Area** near Millville in Cumberland County offered a different view of the Pine Barrens, rich with open sedge fens and a variety of submerged species along with my only look at the rare *Eriocaulon septangulare* (Seven-angled Pipewort). I chose to include this information in the report, and although I actually went on these kayaking trips during the summer of 2012, the trips were focused on observing Pine Barrens ecology and helped shape the species list for this region.

PLANT FAMILIES OF THE PEATLANDS

It is already established that environmental conditions in oligotrophic and ombrotrophic bogs and fens are challenging and limited to species tolerable of low pH, low oxygen and

saturated habitat. Many species found living in these conditions have developed survival strategies over thousands of years of evolution, possessing creative ways to obtain nutrients in a poor environment, such as the symbiotic relationship between *Myrica gale* (Sweetgale) with nitrogen nodules on its roots and *Alnus incana* (Speckled Alder). A number of plant families and individual species have developed unique survival techniques that allow them to live in poor conditions.

SPHAGNUM

Sphagnum mosses are a large genus occurring worldwide, abundant in northeastern peatlands, and an indicator of minerotrophic and ombrotrophic conditions. Growth is variable depending on location and conditions and is influenced by shade, minerals, flooding and drought, and may range from under a centimeter a year up to 20 centimeters per year.

Some species produce spores, but most reproduction is vegetative dispersal by wind, waterfowl and other animals. *Sphagnum* has two types of leaf cells; small cells with chloroplasts to produce food and color, and large, specialized thick-walled, empty cells lacking cytoplasm in mature leaves and stems to allow water retention and give strength and rigidity to the plant. *Sphagnum* species can hold up to twenty-five times their weight in water and are important in maintaining wet conditions to support hydric plants. Unlike other plants, the upper leaves of *Sphagnum* absorb water and the submerged part of the plant dies from the bottom allowing for slow decomposition due to low oxygen and high acidic conditions. Active growth and reproductive parts are usually above water, and *Sphagnum* has the ability to hold ions, the

leaves taking up calcium, sodium and other minerals exchanging hydrogen ions that contribute to the acidity in peat.

CONIFERS

Two species of conifers are associated with ombrotrophic bogs and oligotrophic bogs and fens, *Picea mariana* (Black Spruce) and *Larix laricina* (Tamarack). *Picea mariana* (Black Spruce) is an indicator of ombrotrophic conditions, while *Larix laricina* (Tamarack) is linked to oligotrophic peatlands. Both species have dense wood and narrow growth rings that indicate slow growth.

Picea mariana (Black Spruce) is well adapted to wet, acidic soils and is an indicator of bog conditions. In bogs, this species has a gnarly-looking appearance with shallow roots that grow down then out to form air layer clones in a circle around the base of the main trunk to ensure its survival. When growing outside of a bog environment in Black Spruce forests or maritime forest communities, the growth habit is tall and full, typical of the classic conifer shape. The branches provide protection and nesting opportunities, while the dark cones offer important food for many species of birds and mammals. White-tailed Deer and Moose do not enjoy this species and will only eat saplings out of desperation.

Larix laricina (Tamarack) is a deciduous conifer that is adapted to wet conditions and is found in oligotrophic fens and bogs, and in spruce-fir forest communities in northern climates. Cones are small and purplish-brown with soft, flexible needles that turn a brilliant gold then drop in the fall. Many species of birds nest in this tree, and Spruce Grouse, finches and other birds;

Red Squirrel, Snowshoe Hare and other small rodents feed on the cones and twigs. This is my favorite tree to hug!

ERICACEAE ~ HEATHS

Heaths are the plants of the Ericaceae Family, a large family known for their ability to survive in nutrient poor soils at high elevations, northern latitudes, and in peatlands, including bogs, rocky slopes, boreal and arctic regions. All are woody shrubs or subshrubs, some evergreen, ranging in height from the 30 foot *Rhododendron maximum* (Rosebay Rhododendron) to the tiny, trailing *Vaccinium oxycoccus* (Small Cranberry) at less than 8 inches in height. Many species are bog indicators, while others are found in associated forests.

Ericaceous species offer fragrant, showy, blooms, brilliant fall colors, and an abundance of edible berries; a number of species have specially adapted protective leaves that may be thick, tomentose, or glaucous. In addition, a number of species including *Chamaedaphne calyculata* (Leatherleaf), *Kalmia* species (Laurels) and *Ledum groenlandicum* (Labrador Tea) secrete a neurotoxin, acetylandromedol, in their leaves which is deadly to livestock and discourages deer and other browsers from eating the leaves. Many species have a symbiotic association with mychorrizal fungi growing on their roots, and it is thought that this aids the development of berry crop and may offer some immunity to bacteria and viruses.

Chamaedaphne calyculata (Leatherleaf), is the most common heath in the northeast, able to tolerate various degrees of water depth and movement, and a constant in peatlands. Other species expected in bogs include *Ledum groenlandicum* (Labrador Tea), *Kalmia polifolia* (Bog Laurel), *Kalmia latifolia* (Sheep Laurel), and *Gaultheria hispidula* (Creeping Snowberry),

Vaccinium vitis-idaea (Mountain Cranberry), *Vaccinium macrocarpon* (Large Cranberry), and *Vaccinium oxycoccus* (Small Cranberry).

Kalmia latifolia (Sheep Laurel) is also referred to as Lambkill and is common and widely distributed, easily recognized as it blooms on the stalk above previous year's leaves. *Kalmia polifolia* (Bog Laurel) is much rarer, with thinner leaves that roll slightly under, and terminal flowers that distinguish it from *Kalmia latifolia* (Sheep Laurel).

Ledum groenlandicum (Labrador Tea) is very common in northern climates, but rarely occurs south of glaciated areas of New York. The leaves roll under and are tomentose beneath, starting out white early in the season and becoming a burnt orange color later in the season from storing tannins in the leaves that are obtained from the peat. This survival strategy allows the plant to absorb moisture from the air with minimal drying from sun.

Vaccinium corymbosum (Highbush Blueberry) and *Gaylussacia baccata* (Black Huckleberry), reach a height of 10-15 feet, are common in northeastern deciduous forests and produce plentiful berries, important food for many species of birds and mammals.

Rhododendron canadense (Rhodora) is related to other azaleas, but with a two-part flower rather than the tubular flower of other *Rhododendron* species and was originally assigned to a different genus. One of the earliest shrubs to bloom with large flowers and glaucous leaves, this species is common in northern regions with less frequency south of New England.

Vaccinium oxycoccus (Small Cranberry) and *Vaccinium macrocarpon* (Large Cranberry) prefer very wet soils; *Vaccinium oxycoccus* (Small Cranberry) prefers soils with a lower pH and is an indicator of ombrotrophic bog conditions. Cranberry fruits do not rot because they are

preserved by the acids in the soil and if not eaten by wildlife, will remain viable on the stem through the following season.

CARNIVOROUS PLANTS

Carnivorous plants occur worldwide with over 400 species; many are tolerable of poor, saturated conditions and have developed special adaptations to allow them to survive in difficult environments. Carnivorous plants may be active or passive, depending on their method of trapping prey, *Sarracinea* (Pitcher Plant) and *Drosera* (Sundew) species are considered passive as the prey is attracted to the plant then becomes trapped, while *Utricularia* (Bladderwort) species are considered active, using a sucking mechanism to capture prey.

Pitcher Plants

Sarracinea species (Pitcher Plants) have specially adapted leaves with curled edges to form a 'pitcher' that enables the plant to hold water. The leaves of *Sarracinea purpurea* (Pitcher Plant) grow from a basal rosette and are flared with nectar glands and bright veins to attract insects with fragrance and bright colors. Once attracted to the leaves, sticky, downward facing hair-like cells on the leaves stick to the feet of the prey and lead them to the pitcher where they are unable to escape and drown. The walls and bottom of the pitcher have specialized glands with enzymes that allow the plant to digest its prey aided by bacteria that helps break down and digest insects and small animals. The plant is able to obtain nutrients including nitrogen and phosphorus that are not available from the acidic soil. Insects are thought to have a symbiotic

relationship with the plant and may contribute to the plant's reproductive cycle and stop the digestive enzyme from producing after production of seed. A number of these insects are discussed on page 61.

Sundews

Sundews occur in peatlands worldwide, with a handful of species possible in peatlands of the northeast, the two most common are *Drosera rotundifolia* (Round-leaved Sundew) and *Drosera intermedia* (Spatulate-leaved Sundew), the latter found more often in saturated coastal environments that are richer in nutrients. (Linear-leaved Sundew) restricted to minerotrophic peatlands in northern Maine, and *Drosera filiformis* (Threadleaf Sundew) prefers wet sandy soils in coastal regions from southeast Massachusetts to southern New Jersey.

Sundews may have originated in the tropics, and grow very slowly in cool sphagnum with a faster rate of growth in summer, becoming dormant and disappearing beneath sphagnum when weather becomes cooler (no longer present at Tannersville in October), where underground roots and dormant leaf buds overwinter to emerge the following spring.

Sundews obtain nutrition by capturing prey in glandular hairs located on leaves that secrete a sticky sugary liquid that appear like dewdrops and act as a glue to trap insects in the hairs. A specialized growth adaption allows the hairs to quickly grow new cells that fold around the body of the insect, while short hairs on the inner surface of the leaves secrete mucilage with anesthetic and digestive enzymes to immobilize and digest prey. Nutrients are absorbed through the leaves and dispersed throughout the plant, and once the prey is digested, the hairs on the leaves re-open. Leaves are only able to act as a trap a few times during their lifetime, and do not react when a non-living object such as a dust particle drops on the hairs.

Bladderworts

Bladderworts occur world-wide except in Antarctica, and include a number of aquatic to semi-aquatic species which occur in the northeastern United States. The two most common types that are found in semi-aquatic habitat are *Utricularia cornuta* (Horned Bladderwort) and *Utricularia subulata* (Zig-zag Bladderwort), while the *Utricularia purpurea* (Purple Bladderwort) occurs in areas of open water.

Bladderworts do not have roots, and the stems and leaves are difficult to see unless the plant is in flower at the surface. They feed on small aquatic organisms and small fish and tadpoles, attracting them by secreting a sugary substance, then trapping the prey through a unique “vacuum” system. The bladders act like a stomach and are able to capture, store, and digest food, with a door-like opening that functions as a sucking mechanism to take in prey along with water, then vacuum seals to trap the prey with a membranous flap called a velum, and pumps out water after digesting its prey. Nutrients are provided to the plant through its digestive system with specialized digestive enzymes and bacteria secreted in the bladder glands.

ORCHIDACEAE ~ ORCHIDS

There are 20,000 to 30,000 species of orchids occurring worldwide, and most are epiphytic tropical species, with just a small percentage of terrestrial species, having a limited number occurring in North America. A small percentage of species are found in peatlands, many in boreal regions, and may be classified as uncommon to rare, threatened, and endangered. A few of the more common species include *Calopogon tuberosis* (Grass Pink), possibly the most frequent, and *Pogonia ophioglossoides* (Rose Pogonia), *Arethusa bulbosa* (Dragon’s Mouth

Orchid) often associated with open sphagnum and sedge communities. *Platanthera blephariglottis* (White Fringed Orchid) and *Platanthera dilatata* (White Bog Orchid) are not as common, and a number of southern species reach their northern limits in New Jersey, including the rare *Platanthera integra* (Southern Yellow Orchid). Orchids are extremely sensitive to environmental conditions and location and may not always be present in the same location from year to year, but may reappear after being absent for a number of years.

The seeds of Orchidaceae are incredibly tiny and lack endosperm, and orchids are parasitic on fungi, acquiring nutrition from the fungi, and depend on pollinators for reproduction.

Orchid flowers are three-parted, with reproductive organs contained in a single “column” comprised of male stamens attached to the female pistil where pollen is produced and retained deep inside the flower, awaiting the arrival of an insect to complete pollination. Sepals are large and attractive, and may have unique modifications such as the enlarged labellum (pouch) of *Cypripedium* species (Lady’s Slipper) or upward facing labellum of the *Calopogon tuberosis* (Grass Pink) and are sweetly scented to attract pollinators that brush against the column where pollen sticks to them and is transported to another flower.

Orchids are especially vulnerable to illegal collecting and loss of habitat, and botanists may be secretive about sharing the location of some species.

CYPERACEAE ~ SEDGES

Cyperaceae is a large family with numerous genera and species, and a major contributor to the formation of peat, with species occurring in all types of peatlands. Sedges are dominant in

plant communities of fens, wet pastures and marshes, and vary considerably depending on nutrients, water movement, climate, and geology, distribution of plant and animal species, and topography. Cyperaceae species are monocots with some similarities to grasses but do not have sheaths and are identified as sedges by the triangular stem with leaves attached on the stem, individual species are identified by the flowers and seeds and are very difficult to identify, some requiring magnification with a microscope to determine the species. Of all the plants I encountered during this study, I am still not confident with my identification of sedges!

Open peatland fens support the greatest variety of sedges that may grow in tussocks, or form mats from rhizomatous or interwoven roots that provide stability for other plants. Leaves are short-lived and allow for massive underground growth and high seed production, and are important contributors to the colonization of *Sphagnum*. Sedges are good indicators of pH in a wetland complex, with most species occurring in minerotrophic fens and laggs, with fewer species found in oligotrophic fen and ombrotrophic bogs. *Eriophorum* species (Cotton Grass) and *Rhynchospora* species (Beak-rush) are most common in high pH bog conditions.

LICHENS

Cladonia species (Reindeer Moss) is not actually a moss but lichen, named for its association as a popular food for Reindeer (Caribou), Moose and other grazers. Lichens are comprised of fungus and algae that co-exist together to maintain the necessary nutrients for survival; the fungus provides mineral nutrition and water and prevents drying out, while the algae produce organic material and vitamins. Lichens are epiphytic and energized by the sun (phototrophic) to produce food, and have a broad range of species, and many are sensitive to environmental

conditions. Lichens are able to grow in dry areas in the bog and are an indicator of a low water table when they are the dominant ground cover, allowing for decomposition of dead plants and insects to provide a higher level of nutrients. Plants requiring more nutrients are able to grow in the lichens, and species like *Cornus canadensis* (Bunchberry), *Maianthemum trifolium* (Three-leaved Solomon's Seal), *Maianthemum canadense* (Canada Mayflower), and *Trientalis borealis* (Starflower), can survive in this area of the bog. *Cladonia rangiferina* and other species may live over 250 years and may be an indicator of a mature bog.

ANIMALS

ARTHROPODS AND INVERTEBRATES

A considerably low diversity of insects occurs in peatlands as they are unable to survive in the acidic environment, but there are a few exceptions that are can live in conditions with a pH as low as 3.5 and include Whirligig Beetles and Water Boatmen.

Butterflies may be observed nectaring at flowers in bogs, and a number of species are bog specialists, laying their eggs on host plants found in a bog community including Bog Copper (*Vaccinium* species), Jutta Arctic (*Carex* and *Eriophorum* species), Bog Elfin (*Picea mariana*), and a frequent visitor to bogs, the Bog Fritillary (*Salix* and *Viola* species).

Sarracenia purpurea is the larval host plant for *Exyria rolandiana* (Noctuidae Moth species), and *Wyeomia smithii* (Pitcher Plant Mosquito), lays its eggs in the water at the bottom

of the pitcher, the larvae unaffected by the digestive enzymes of the plant. *Sarcophaga* species (Flesh Fly species) larvae are also found inside the pitchers, feeding on the remains of trapped insects, and a species of wasp nests inside the pitcher, apparently immune to the enzymes. These insect species may have a symbiotic relationship with the plant, providing bacteria to help digest the exoskeleton of insects that cannot be digested by the plant's enzymes.

Other insects and arthropods common in bog environments include many species of Odonata (Damselflies and Dragonflies), and assorted Ground Beetles (important decomposers), some spiders and mites (including Fishing Spider), and snails, slugs, and crayfish in areas of higher pH and slow moving water. I observed a snail attached to a bladder of *Utricularia* species (Bladderwort), presumably feeding on the minerals from the bladder received from ingesting insects.

FISH

Fish are not able to survive in bogs due to toxic conditions from low oxygen and low pH, although a limited number of species occur in richer fens having a pH of 6.0 or higher that allow eggs to develop. A few species that can survive these conditions include Salmon, Lake and Brook Trout and Largemouth Bass in northern fens, and Banded and Mud Sunfish, Chain Pickerel, Pirate Perch, and Eastern Mudminnow and a few others in fens of the New Jersey Pine Barrens.

AMPHIBIANS

Some amphibians may be found in peatlands, but due to the sensitivity of their eggs to acidic conditions, they may experience defects and are unable to survive in an environment with a pH of 4.0 or lower. Ephemeral ponds provide suitable habitat for egg-laying, and species may include Eastern Red-Spotted Newt (juvenile form most familiar as the Red Eft), Red Salamander, American Toad, Green Frog, Wood Frog, Northern Leopard Frog, Spring Peeper, Gray Tree Frog, Carpenter Frog, and the rare and endangered Pine Barrens Tree Frog. The Wood Frog is a boreal species, and the only species mentioned that can successfully reproduce in highly acidic bog water.

REPTILES

A number of turtle and snake species are found in peatlands, with a higher number of species occurring in southern peatlands with fewer occurrences in the north and at high elevations. New Jersey supports a higher number of species, while Maine has few species. Common species include Painted Turtle, Snapping Turtle, Ribbon Snake, Garter Snake, Redbelly Snake, and Northern Water Snake, and in the New Jersey Pine Barrens, an endemic population of Northern Pine Snake. The Spotted Turtle, a species of Special Concern, may be observed in ponds, and muddy wetlands with emergent plants. The Critically Endangered, rare Bog Turtle has been recorded in a number of sites, and is seriously threatened by loss of habitat.

BIRDS

Many birds take advantage of the habitat provided in bogs and associated habitats, and a high number of species may be found throughout bog complexes, a number of which are threatened or of special concern.

Shrub thickets attract nesting Palm Warbler, Canada Warbler, Northern Waterthrush, Savannah Sparrow, White-throated Sparrow, Lincoln's Sparrow, Nashville Warbler, Common Yellowthroat, and Least Flycatcher, while open *Sphagnum* lawns provide hunting grounds for birds of prey including Northern Harrier, Red-shouldered Hawk, Barred Owl and Short-eared Owl. In areas with dense *Picea mariana* (Black Spruce) and *Larix laricina* (Tamarack), warblers and flycatchers nest and find protection during migration. Nesting species include Yellow-rumped Warbler, Tennessee Warbler, Blackburnian Warbler, Red-breasted Nuthatch, Brown Creeper, and Yellow-bellied Flycatcher. Adjacent spruce-fir forests provide prime nesting sites for Bald Eagles and boreal species such as Boreal Chickadee, Gray Jay, Black-backed Woodpecker and Spruce Grouse, the latter spending summers nesting in uplands then moving to bog habitat in the fall. Mallards and Pied-Billed Grebe take advantage of peatlands with open ponds, and in sedge fens, Wilson's Snipe, Sora, Marsh Wren, Red-winged Blackbird, and Belted Kingfisher may be discovered nesting.

MAMMALS

A number of mammals may be present in bogs and other peatlands and include White-tailed Deer, Moose, Elk, Caribou, Grey Wolf, Mountain Lion (Cougar). Moose and White-tailed Deer wade in ponds and eat aquatic plants and browse peatland shrubs and small trees, using

evergreen heaths for protection during the winter. Moose and deer trails may be observed in peatlands, and during the winter, they protect themselves from the elements by hiding in evergreen shrubs. *Thuja occidentalis* (Northern White Cedar) is a favorite of White-tailed Deer, as we have noted in our local community.

Beavers are more common in areas with trees and tall shrubs and occur frequently in fens and laggs, at times creating peatland by damming waterways, known as paludification.

Fewer species of small mammals occur in bogs as a result of the limited species of plants; fairly common species include Red Squirrel, Flying Squirrel, bats, shrews, lemmings, moles and voles. Northern Bog Lemmings reach their southern limit and are threatened in Maine, but remain stable in Canada, providing a source of food for Snowy Owls and other predators. (I had to comment on this since we are currently experiencing an astounding winter irruption of Snowy Owls here in the United States, partially due to an abundance of lemmings during nesting season that provided a plentiful food source, allowing a higher than average number of Snowy Owl young to survive.) When small mammals are abundant, raptors and other predators including Bobcats, Fishers, Weasels, and Coyotes may be present. The endangered Canada Lynx also preys on small mammals, but has a preference for Snowshoe Hares that live in dense bog thickets.

IX. THREATS

A number of factors threaten the survival of peatlands and the sensitive species that inhabit acidic wetland environments. Education is the key to ensuring survival of these precious lands and unique plant and animal communities.

Development has long been a source of wetland destruction, and it is only in recent years after a great deal of irreversible habitat destruction, loss of species, and the resulting excessive flooding that the importance of wetland protection and preservation has come to light. While efforts are underway to protect and restore many wetlands, many landscapes have been forever altered by development.

Pollution goes hand in hand with development, and the increased presence of humans abusing the environment with excessive use of toxic chemicals including lawn fertilizers, weed and insect control, and detergents, combined with the use of road salt contribute to the die-off of sensitive species that may occur in peat wetland communities. Many of the plant and animal species living in peatlands are highly sensitive to pollution, and a number of species are actually used to determine water quality. Invasive species are lurking everywhere, waiting for a chance to establish in cleared areas that are strongly influenced by development and pollution. Invasive species are not adapted to environments with low pH, however, storm water run-off carrying excessive nutrients and heavy metals are capable of raising pH levels to threaten the survival of entire plant communities, while at the same time providing free transportation for seeds and transplants of invasive species.

Fracking is now a forerunner in the debilitation of our environment, especially in Pennsylvania and New York, and despite the facts that have been presented proving fracking to be highly dangerous and detrimental to the environment and human health, the energy companies and their political cronies are still selling their Kool-Aid to uneducated landowners.

Climate change is a very real threat to boreal bogs and fens; the warming trend will wreak havoc on these landscapes as sea levels are raised, forcing coastal communities to shift inland, therefore reducing and destroying upland habitat. Temperature rise will create warmer conditions in boreal bogs allowing frozen peat to thaw faster and raising the rate of decomposition, causing a higher percentage of carbon released into the atmosphere with further warming that will result in extinctions on a massive scale.

Human intrusion and illegal harvesting of rare and endangered species pose a danger to fragile plant communities, especially species such as orchids with a low rate of reproduction. Another hazard to consider is the possible introduction of invasive species (seeds) transported on the soles of shoes. It only takes ONE SEED. Reptiles and amphibians are at risk of being collected as pets and removal can impact the species population, especially with rare and endangered species like the Bog Turtle.

It is a matter of extreme urgency that we educate the public of the important role our peatlands play in sequestering and filtering water and providing clean air; these sensitive habitats must be protected before it is too late to preserve them. Many properties have been recently purchased and protected by lands trust and conservation organizations, but until more people understand the impact of their actions and continue to allow the destruction of habitat, we are all

in jeopardy of losing something that took tens of thousands of years to develop, only to be destroyed in moments with the sweep of a bulldozer.

X. CONCLUSION

Conclusion seems like a harsh word to me at this point, defined as “the end or finish of an event or process.” (Google definition), and I prefer to refer to this study as the Beginning. When I chose the topic of bogs for my study, I was not expecting it to spark such a wild interest, a topic so interesting to me that I did not want to stop researching information for this report.

Throughout my life, there have been very few subjects that I have become completely enthralled with the way I have by the biotic communities found within the peatlands where I spent time observing and documenting species living in an environment so unfamiliar and uncommon to me. This conclusion is only a conclusion in the sense that I have completed this particular study as an independent project for a horticulture course, and my study will continue long after I close this document.

May 17, 2013 was first “official” visit to Tannersville Cranberry Bog to kick off this work, and my most recent (not final) visit was on October 30, 2013. A number of visits were made to other bogs and fens as described in the sections designated for each individual site. Throughout this project, I was able to identify and record a total of 442 species, with the focus on vascular plant species, but also included non-vascular plants, mammals, birds, reptiles and

amphibians, and arthropods. I considered including species of fungi, but opted to simply mention them in symbiotic relationships since this kingdom deserves so much more attention and time. Many other species occur within these sites, but those included in this paper are the species I actually observed, recorded and researched, more await my future visits! The species breakdown is as follows: 282 species of vascular plants (including 123 tree, shrub, subshrub, and 159 herbaceous), 9 species of non-vascular plants (there were many, many more!), 8 species of mammals, 15 species of reptiles and amphibians, 96 species of birds, and 31 species of arthropods and 1 gastropod!

My analysis of the species composition is based upon a number of factors including physiographic region, peatland type, and associated plant communities within the wetland complex, slope and upland woods.

The total number of **vascular plants** per site from highest to lowest: Tannersville Cranberry Bog (112), Orono Bog Boardwalk (97), Kuser Bog (96), Great Swamp National Wildlife Refuge (72), Zurich Bog (71), Boot Head/Hamilton Cove Preserves (60), Great Wass Preserve (57), Webb's Mill Bog (52), Kayaking New Jersey Pine Barrens (49), Eagle Hill Bog (45), Quaker Bridge 1 (45), Chicago Bog (39), Quoddy Head State Park (37), Quaker Bridge 2 (29), Acadia Big Heath (23), Acadia Long Pond Fire Road (18). Only one genus occurred in every site visited, a *Sphagnum* species, followed by *Flavoparmelia* species (lichen), occurring in 62% of the sites. Looking at the numbers, I believe without a doubt that the species diversity depicts the physical attributes of each site. Tannersville Cranberry Bog had the highest overall species across the board, due in part to being able to visit the property throughout the course of the growing season that allowed the inclusion of spring ephemeral species, but also as a boreal habitat snuggled in to a diverse plant community typical of the region. Kuser Bog and Great

Swamp National Wildlife Refuge also saw a high number of species, with Great Swamp needing further exploration in the future. The second highest number of species was recorded at Orono Bog Boardwalk, located in the southern part of central Maine, an area where many southern species reach their northern limits with a mix of northern hardwoods and conifers and combined with bog and fen species. The Orono Bog Boardwalk has the most similarities to the Tannersville Cranberry Bog although it is four times the size of Tannersville, and provides a good comparison of similar wetland zones. The Zurich Bog in New York is a large preserve with many plant communities and calcareous soils with lower acidity giving the property the ability to support a higher diversity of plant species. Boot Head and Hamilton Cove Preserves, and Great Wass Preserve both have a higher diversity of plant species with multiple plant communities occurring in their sites, both hosting rare and unusual species. The Pine Barrens locations in New Jersey offer a wide variety of species as they have numerous plant communities and are also the northern limit for many southern species and the southern limit for some northern species, mostly herbaceous. The Eagle Hill Bog on Campobello Island has an interesting mix of upland and associated fen communities, giving the site a broader diversity of species than other similar sites in the region. The Chicago Bog in New York, and Quoddy Head State Park in Maine are relatively small properties compared to other sites visited, and a lower number of species reflects the limitations of each site. Acadia's Big Heath is adjacent to the Seawall and is limited to the maritime conditions, while the fen found along Long Pond Fire Road is very small compared to all other locations and the lower number of species reflects the size of the site.

On average, individual **woody plant species (123)** occurred in 23% of the sites, with highest to lowest number of species: Tannersville Cranberry Bog (54), Kuser Bog (48), Zurich

Bog (40), Orono Bog Boardwalk (39), Boot Head/Hamilton Cove Preserves (33), Eagle Hill Bog (31), Great Swamp National Wildlife Refuge (30), Great Wass Preserve (30), Quaker Bridge 1 (29), Kayaking Pine Barrens (28), Webb's Mill Bog (21), Quoddy Head State Park (20), Chicago Bog (18), Quaker Bridge 2 (16), Acadia Big Heath (10), Acadia Long Pond Fire Road (6.) Nine species of woody plants were frequent in 50% or more sites include *Chamaedaphne calyculata* (Leatherleaf) in 14 sites, *Acer rubrum* (Red Maple) in 11 sites, *Gaultheria procumbens* (Winterberry) in 10 sites in associated uplands, *Picea mariana* (Black Spruce) in 9 sites, *Prunus serotina* (Wild Black Cherry) in 9 sites, *Vaccinium corymbosum* (Highbush Blueberry) in 9 sites, *Vaccinium oxycoccus* (Small Cranberry) in 9 sites, *Larix laricina* (Tamarack) in 8 sites, *Kalmia angustifolia* (Sheep Laurel) in 8 sites. Five of the species are Heaths, and the remainder of the species closely associated with bogs and poor fen conditions. *Prunus serotina* (Wild Black Cherry) was the most frequent species in upland forests, but did not occur on any sites north of Orono, Maine. While I was surprised at first, considering the young age of many of the forests in Pennsylvania, New Jersey, and New York from clear cutting for agriculture and settlement, this makes perfect sense, especially since this species provides an important food source for many species of birds and Black Bears, as a larval host plant and source of nectar for butterflies and pollinators, and is frequently spread by wildlife. *Abies balsamea* (Balsam Fir), *Picea glauca* (White Spruce), and *Picea rubens* (Red Spruce), were the most common species in northern forests of Maine and New Brunswick.

In addition to species discussed in the aforementioned paragraph, species having a southern preference including *Rhododendron viscosum* (Swamp Azalea), *Nyssa sylvatica* (Tupelo), and *Chamaecyparis thyoides* (Atlantic White Cedar), did not occur at all in northern peatlands, and *Clethra alnifolia* (Sweet Pepperbush) and *Ilex verticillata* (Winterberry) were not

observed north of Bangor, Maine. In northern sites, *Rhododendron canadense* (Rhodora) and *Myrica gale* (Sweetgale) were frequent in oligotrophic sections and *Ilex mucronata* (Mountain Holly) common in richer lagg areas were absent from southern peatlands. *Viburnum nudum* var. *cassinoides* (Witherod) abundant in northern sites, occurred only occasionally in southern peatlands.

Herbaceous plant species (159) were naturally more frequent in number and species, with individual species occurring in 17% of the sites, with highest to lowest number of species: Tannersville Cranberry Bog (58), Orono Bog Boardwalk (58), Kuser Bog (48), Great Swamp National Wildlife Refuge (42), Webb's Mill Bog (31), Zurich Bog (31), Boot Head/Hamilton Cove Preserves (27), Great Wass Preserve (27), Chicago Bog (21), Kayaking New Jersey Pine Barrens (21), Quoddy Head State Park (18), Quaker Bridge 1 (16), Eagle Hill Bog (14), Quaker Bridge 2 (13), Acadia Big Heath (13), Acadia Long Pond Fire Road (12). 11 species of plants were frequent in 50% or more sites and include: *Sarracenia purpurea* (Pitcher Plant) in 15 sites, *Carex* species (Sedge species) in 14 sites, *Pteridium aquilinum* (Bracken Fern) in 10 sites in associated uplands, *Maianthemum canadense* (Canada Mayflower) in 10 sites, *Drosera intermedia* (Spatulate-leaved Sundew) in 10 sites, *Eriophorum angustifolium* (Cotton Grass) in 9 sites, *Osmunda cinnamomea* (Cinnamon Fern) in 9 sites, *Trientalis borealis* (Starflower) in 9 sites, *Drosera rotundifolia* (Round-leaved Sundew) in 8 sites, *Coptis trifolia* (Goldthread) in 8 sites, *Triadenum virginicum* (Marsh St. Johnswort) in 8 sites. Although four of these species are considered upland species, three (*Maianthemum canadense*, *Trientalis borealis*, and *Coptis trifolia*) are very common growing on hummocks in bogs in addition to their occurrence in associated peat woodlands; and *Pteridium aquilinum* is the most frequent fern occurring in forest

uplands associated with peatlands. Three of the species are carnivorous plants (*Sarracenia purpurea*, *Drosera intermedia*, and *Drosera rotundifolia*) and are expected in acidic conditions, and the remaining species (*Carex*, *Eriophorum angustifolium*, *Osmunda cinnamomea*, and *Triadenum virginicum*) are typical of fens and bogs.

I noticed a sharp decline in the presence of invasive plants in northern sites, most likely a combination of unfavorable conditions with low pH throughout the region and few areas that are highly developed.

Birds are abundant in bog and fen environments, although not always visible, with 96 species of birds recorded during the study. As an avid birder, the species account is not as complete as I would have liked it to be, and a number of factors play into what I consider to be inconsistency in numbers, with individual species occurring in 21% of the sites. Factors to consider include season, time of day, and migration, all having an effect on the species present during different visits. During early nesting season, birds are more vocal and active as they establish and protect territory making them easier to observe, but they become very quiet and secretive when feeding young fledglings later in the season in an effort to protect the young from predators. During migration, the mission is to conserve energy for travel, with many Neotropical species traveling thousands of miles to their wintering grounds with weather contributing to the abundance or lack of birds that may literally be gone with the wind, taking advantage of favorable fronts for more efficient flight. In the mid to late summer heat, birds are also quiet from late morning through late afternoon, another energy conserving strategy. The following list of species may not truly reflect the species that occur on each site, and the Eagle Hill Bog with the second highest number (37 species) is a perfect example as it reflects a fallout of migrants arriving overnight awaiting the next weather front. Similarly, visits to locations reflecting lower

than expected numbers may have been visited during a lull in migration when an abundance of species were not present or during mid-day hours when all was quiet in bird land. Tannersville naturally has the highest species account since this site was visited monthly during spring and fall migration, and throughout nesting season. The total for species of birds from highest to lowest are Tannersville Cranberry Bog (55), Eagle Hill Bog (37), Kuser Bog (34), Kayaking New Jersey Pine Barrens (34), Great Swamp National Wildlife Refuge (26), Boot Head/Hamilton Cove Preserves (26), Great Wass Preserve (22), Chicago Bog (17), Webb's Mill Bog (13), Orono Bog (11), Acadia Big Heath (11), Acadia Long Pond Fire Road (11), Quoddy Head State Park (11), Quaker Bridge 1 and 2 combined (10), Zurich Bog (9). 11 species were most frequent occurring in 50% or more of the sites with American Goldfinch in 14 sites, Common Yellowthroat in 12 sites, Black-capped Chickadee in 11 sites, Gray Catbird in 10 sites, Cedar Waxwing in 9 sites, Golden-crowned Kinglet in 9 sites, American Crow in 9 sites, Blue Jay in 9 sites, Downy Woodpecker in 9 sites, Mourning Dove in 8 sites, and Song Sparrow in 8 sites.

The most common species came as no surprise, most nesting in or feeding on conifer species that are present in almost all sites, while species like Gray Catbird, Common Yellowthroat, and Song Sparrow prefer to nest in thickets. If I had the opportunity to visit the northern sites during breeding season rather than during migration season, I would expect to find a higher number of boreal breeders and Neotropical migrants; many had already departed for wintering grounds, including Palm Warbler, Lincoln's Sparrow, Least Flycatcher, Canada Warbler, Northern Waterthrush, Blackburnian Warbler, and Nashville Warbler, the latter four notable breeders at Tannersville Cranberry Bog and Kuser Bog.

8 species of **mammals** were observed during the study, with Red Squirrel most frequent, followed by American Beaver. The Red Squirrel's preference for spruces and other conifers, and the American Beaver's association with wetlands and paludification of peatlands provide validation of their presence. Many species are active during evening or early morning hours when humans are not present, and with highly developed hearing, become invisible in the presence of humans, sometimes leaving clues when they are close by in the way of fresh scat and footprints. Tannersville Cranberry Bog had the most species observed with 4, including fresh River Otter scat that was probably less than 10 minutes old. Kuser Bog logged in with 3 species and included still-steaming Black Bear scat, followed by 2 species at Great Wass Preserve, and only a single species observed at other sites. Thick vegetation contributes to the scarcity of mammal species that can disappear at the sound of a human whisper, but their presence is well marked if time is taken to look for clues.

15 species of **reptiles and amphibians** were found during visits, with Red Eft (juvenile terrestrial form of the Eastern Red-spotted Newt), and Eastern Ribbon Snake most common. Freshwater ponds, and slow-moving water with a muddy bottom provides favorable egg-laying conditions for Eastern Red-spotted Newt, and bogs with their associated wetland complexes (in areas of higher pH) and ephemeral ponds offer prime real estate for this common species. Eastern Ribbon Snakes are often observed sunning themselves atop shrub thicket species such as *Chamaedaphne calyculata* and prefer a wetland environment. The presence of reptiles and amphibians may be variable as they are cold-blooded species that depend on warm conditions, and are less common in cooler climates in northern latitudes, and I did not observe any cold-blooded species north of Acadia National Park during this study. Tannersville Cranberry Bog had 12 species; Kuser Bog 5, Zurich Bog 5, Chicago Bog and New Jersey Pine Barrens each had

4, Great Swamp National Wildlife Refuge 3, and Orono Bog Boardwalk and Acadia Long Pond Fire Road with 1 species each.

Although I did not focus on insects and other arthropods, there were fewer species present in areas of high acidity with 31 species of arthropods (combined Insecta, Arachnida, and Diplopoda) identified. 18 of the species noted are Odonata (Damselflies and Dragonflies) and include the rare and imperiled Rusty Snaketail observed at Kuser Bog. The diversity of Odonata was not unexpected since this order is heavily dependent upon clean water habitat for their life cycle, and may be used as an indicator of water quality. I only included species I was able to photograph and identify; many others were also present throughout the study. Butterflies observed were mostly associated with lagg and wooded units of the complexes, however a number of species were observed nectaring at blooms in the bogs, although none of the species observed use any of the plants in the bog as a larval host plant. Whirligig Beetles, one of a few insects able to tolerate high acidic conditions, were present while kayaking in the New Jersey Pine Barrens.

My final thoughts are of mixed sadness and accomplishment; this project has been a highlight of my adult life and I am sorry to see the end of what has been a truly wonderful learning experience. On a happier note, I feel a great sense of pride and achievement knowing that all the observations and research I performed confirm much of the professional research already completed, and I feel that I was able to support the information with hard evidence. To be continued...

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