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Fact Sheets for Wetland Systems in New Hampshire

A Final Report to
NH Department of Environmental Services

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Advancing Wetland Assessment, Classification, and Permit Review in NH

Overview of the NH Natural Heritage Bureau's Purpose and Policies

The NH Natural Heritage Bureau (NHB) finds, tracks, and facilitates the protection of New Hampshire's rare plants and exemplary natural communities. As a bureau within the NH Department of Resources and Economic Development's Division of Forests & Lands, NHB works with landowners and land managers to help them protect New Hampshire's natural heritage while meeting their land-use needs.

The New Hampshire Native Plant Protection Act (RSA 217A) authorizes NHB to collect and analyze data on state lands about the status, location, and distribution of rare or declining native plant species and exemplary natural communities and maintain that information in a comprehensive database.

The Natural Heritage database contains information about more than 7,000 plant, animal, and natural community occurrences in New Hampshire.

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Cover photo: ***Montane level fen/bog*** on Mount Monadnock (photo by Bill Nichols).

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WETLAND SYSTEMS

New Hampshire's wetland systems are part of a larger system classification developed by the NH Natural Heritage Bureau (Sperduto 2004a, 2004b)[1]. Systems are particular associations of natural communities[2] that repeatedly co-occur in the landscape and are linked by a common set of driving forces, such as landforms, flooding, soils, and nutrient regime. They are at an appropriate scale for many conservation applications, including:

- Mapping and predictive modeling.
- Correspondence to wildlife and wildlife habitats.
- As broad coarse-filter[3] targets in conservation planning.
- Tracking locations and comparing entire sites, particularly when natural communities may be difficult to map.
- As a more appropriate level of vegetation classification for users that have relatively little experience with plants.
- Appropriate scale for wetland condition assessments (e.g., Level 2 Ecological Integrity Assessments).

These wetland system fact sheets include photographs and information on ecology, distribution, stressors, relationship to other classifications, and more. Rare (endangered and threatened) plant species listed in this document are noted by an asterisk (*). All pH values were measured using a calibrated water pH meter. See Appendix 1 for an explanation of global and state conservation status rank codes, Appendix 2 for an explanation of state listing codes, and Appendix 3 for key to wetland systems in New Hampshire.

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[1] Sperduto, D.D. 2004a. Upland Natural Community Systems of New Hampshire. NH Natural Heritage Bureau, Department of Resources and Economic Development, Concord, NH.

Sperduto, D.D. 2004b. Wetland Ecological Systems of New Hampshire. NH Natural Heritage Bureau, Department of Resources and Economic Development, Concord, NH.

[2] Natural communities are recurring assemblages of plants and animals found in particular physical environments (see Sperduto and Nichols (2011) for more information). Natural community names throughout this document appear in bold/italicized print.

[3] Systems serve as efficient "coarse filters" for protecting a broad array of species, including obscure species that are little-known or not readily identifiable. This coarse-filter approach to conservation has been a key motivation in the development of the NH Natural Heritage Bureau system classification (Sperduto 2011). In turn, this classification has been used by partners who have protected many ecologically significant sites in New Hampshire.

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ALPINE/SUBALPINE BOG SYSTEM (S1)

Alpine/subalpine bog system on Shelburne-Moriah Mountain in Shelburne (photo by Ben Kimball).

OVERVIEW: A small patch, circular to irregular shape system occurring in concavities on ridges and on moderate to steep slopes over bedrock in alpine/subalpine zones from 2,900–4,900 ft. elevation. Permanently saturated to seasonally saturated soils are poorly to moderately decomposed peat over bedrock, generally less than 75 cm deep. Some combination of limited drainage, cold wet climate, late melting snowpacks, low evapotranspiration rate, and self-maintaining *Sphagnum* mats contribute to peat accumulation. Water source is topogenous to soligenous (surface runoff to groundwater seepage influenced).

Native plant species composition is dominated primarily by lowland bog plants found in poor level fen/bog systems, but are distinguished from them by the presence of alpine and subalpine species. The following are species characteristic of alpine/subalpine bog systems but absent or rare in poor level fen/bogs of lowlands: *Empetrum nigrum* (black crowberry), *Rubus chamaemorus* (baked-apple-berry)*, *Trichophorum cespitosum* (tufted clubsedge), *Vaccinium uliginosum* (alpine blueberry), and *Vaccinium vitis-idaea* (mountain cranberry). Note: Endangered or threatened plant species are noted by an asterisk (*).

VEGETATION PATTERNS: Dwarf shrub and moss/liverwort lawns characterized by the following natural communities: ***Alpine/subalpine bog*** (S1), ***subalpine sloping fen*** (S1), and ***wooded subalpine bog/heath snowbank*** (S1S2). Many examples of this system contain both ***alpine/subalpine bogs*** (very poorly drained concavities and occasionally on slopes) and ***wooded subalpine bog/heath snowbanks*** (sloping to level ground, less wet, more black spruce and balsam fir, but still with thick, peaty organic soils). The former type has several wet-site bog species that are absent in ***wooded subalpine bog/heath snowbanks***. The ***wooded subalpine bog/heath snowbanks*** occur as a border zone around wetter bogs or in association with late melting snowbank areas, and have more black spruce and balsam fir. ***Subalpine sloping fens*** are boggy peat mats on the brow of some high elevation cliffs that are subject to sloughing off the cliff-edge, and contain the state watch *Calamagrostis pickeringii* (Pickering's reed grass).

In parts of the White Mountains, alpine/subalpine bog systems form a mosaic with subalpine heath - krummholz/rocky bald systems that have collectively been referred to as "heath balds" (Fahey 1976; Doyle 1987). These "heath balds" occur mostly below 4,000 ft. elevation on flat to gently sloping ridgetops of the Mahoosuc, Carter-Moriah, and Baldface Ranges. Smaller examples are found in several other scattered locations. Otherwise alpine/subalpine bog systems are found either within the higher elevation alpine tundra mosaic in the Presidential Range, or embedded as patches within high-elevation spruce - fir forest systems.

DISTRIBUTION IN NEW HAMPSHIRE: Restricted to the White Mountains.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Acadian-Appalachian Alpine Tundra; Acadian-Appalachian Subalpine Woodland and Heath-Krummholz. These ecological systems include alpine and subalpine bogs embedded within the surrounding upland matrix.

STRESSORS/THREATS: Stressors that may alter vegetation and soil and degrade the ecological integrity of bogs in alpine and subalpine habitats include increased nutrient inputs and trampling from hikers. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants.

GOOD EXAMPLES: Shelburne-Moriah Mountain (Shelburne).

BLACK SPRUCE PEAT SWAMP SYSTEM (S2S3)

Black spruce peat swamp system at South Bay Bog in Pittsburg (photo by John Burns).

OVERVIEW: Black spruce peat swamps occur in closed or stagnant depressions and open headwater basins with limited drainage. They're often in depressions in glacial outwash or ice-contact deposits or broad lake basins away from the influence of lake water. These swamps are small to large patch (occasionally extensive) and circular to irregular in shape. They often form an exterior zone around open peatlands or sometimes in mosaics with more open peatlands. Soils are permanently saturated to seasonally flooded, moderately deep to very deep, moderately decomposed peat. Black spruce peat swamps are topogenous (surface runoff influenced), oligotrophic to weakly minerotrophic, and with pH values generally in 3s to mid 4s (occasionally higher).

This system corresponds to acidic, nutrient-poor wooded peatlands dominated by boreal conifers and heath shrubs, particularly *Picea mariana* (black spruce) and to a lesser extent *Larix laricina* (eastern larch) and other conifers.

VEGETATION PATTERNS: The main community is ***black spruce swamp***, which has a transcontinental boreal distribution with extensions south into northern and central New Hampshire. This community often surrounds open peatlands or can dominate peatland basins that have no open communities. Black spruce dominated areas sometimes transition to ***acidic northern white cedar swamps*** on peat or ***red spruce swamps*** on mineral soil, or ***northern white cedar - balsam fir swamps*** on minerotrophic peats. Patches of tall shrub peatland thickets (fens with <25% tree cover) are common as part of the swamp mosaic. Where these tall shrub fens become extensive, they should be considered part of an adjacent open peatland system.

Diagnostic natural communities are ***black spruce swamp*** (S3), ***highbush blueberry - mountain holly wooded fen*** (S3S4), and ***mountain holly - black spruce wooded fen*** (S3). Peripheral or occasional natural communities are ***acidic northern white cedar swamp*** (S1), ***alder wooded fen*** (S3S4), ***larch - mixed conifer swamp*** (S3), ***northern white cedar - balsam fir swamp*** (S2), and ***red spruce swamp*** (S3).

This system is often found in association with poor level fen/bogs, kettle hole bogs, and lowland spruce - fir forest/swamp systems. When this system surrounds an open bog or fen system, the two communities that typically mark the transition to open peatland system are ***leatherleaf - black spruce bog*** and ***highbush blueberry - mountain holly wooded fen***. The frequency and size of this system generally diminishes to the south in New Hampshire where temperate peat swamp and coastal conifer peat swamp systems are more common, and where ***black spruce swamps*** usually form narrow borders around bogs.

DISTRIBUTION IN NEW HAMPSHIRE: Broadly distributed in central and northern New Hampshire, much less common in lowland southern New Hampshire.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Boreal-Laurentian Conifer Acidic Swamp and Treed Poor Fen.

STRESSORS/THREATS: Development threats include fragmentation, habitat displacement and degradation, invasion of non-native species, alterations of flood regimes, and impacts to water quantity and quality (including pollution, eutrophication, and reduction through withdrawal). Impervious surfaces and other alterations to surrounding landcover can affect hydrology and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Logging of forested wetlands may impact hydrologic patterns and alter habitat for forest-restricted species. Regionally, there has been a tendency towards younger, second-growth swamp forests in the region. Logging of adjacent uplands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Naturally acidic, low-nutrient wetland types are particularly susceptible to alteration by elevated nutrient inputs. Residential and industrial pollution, including road, sewage, and agricultural runoff, are sources of nutrients and pollutants that may result in eutrophication. The management implication is to increase the size of buffer areas and limit or control certain activities near these wetland types. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Cypress Brook (Beans Purchase), Norton Pool (Pittsburg), Stearns Branch vicinity (Success), Trudeau Road vicinity (Bethlehem), Bear Brook State Park (disjunct example in Allenstown/Deerfield), and South Bay Bog (Pittsburg).

BRACKISH RIVERBANK MARSH SYSTEM (S1)

Brackish tidal riverbank marsh system along Garvin Brook in Dover (photo by Bill Nichols).

OVERVIEW: The brackish tidal riverbank marsh system occurs along tidal riverbanks and near mouths of low-gradient coastal rivers feeding estuaries where salinities are oligo- to meso-haline (0.5–18 parts per thousand [ppt]). They can form large, linear patches several to 50 m wide by 50–2,000+ m long with linear zonation parallel to riverbanks. Much of the high and low marsh soil along stream and river mouths entering the Great Bay complex and the narrow margins around the bay consists of organic materials 16 to 50" thick overlying silty materials. Some stretches of riverbank consist of marine silt or clay, and gravelly or cobbly material is found along upper sections of large streams corresponding to this system.

Numerous rare plants that occur in brackish riverbank marsh systems but not in salt marsh systems are diagnostic. *Spartina alterniflora* (smooth cordgrass) typically dominates the physically stressful low marsh. As salinity decreases, *Bolboschoenus robustus* (sea-coast tuber-bulrush) and *Typha angustifolia* (narrow-leaved cat-tail) become more prominent and may dominate the low marsh in some examples. A variable mix of graminoids and forbs characterize the high marsh zone.

VEGETATION PATTERNS: ***Low brackish riverbank marshes*** typically occur in zones between mean sea level and mean high tide along moderate to steep brackish river- and stream-banks. The hydroperiod (duration and frequency of tidal flooding) in ***low brackish riverbank marshes*** roughly corresponds to that found in the

low salt marsh, whereas soil water salinity is more equivalent to brackish marshes (0.5–18 ppt). Fresh water can form a lens on top of the salt water, causing salinity to fluctuate widely with the tides. ***High brackish riverbank marshes*** typically occur as narrow zones along moderate to steep brackish river- and stream-banks flooded less than daily (e.g., between the mean high water mark and the upper reaches of spring tides). The hydroperiod of ***high brackish riverbank marshes*** corresponds to that found in the ***high salt marsh***, whereas soil water salinity is more equivalent to brackish marshes (0.5–18 ppt). Where slopes are gentler, the low and high marshes may cover broader areas. ***Brackish marsh***, another type of estuarine marsh occurring in oligo- to meso-haline soil water settings, may occur intermittently along the upper edge of the high brackish riverbank marsh.

This system may grade into sparsely-vegetated intertidal and subtidal systems toward the channel, and upland forest (landward) or fresh water stream borders (upstream).

DISTRIBUTION IN NEW HAMPSHIRE: Restricted to tidal sections of primarily Great Bay coastal rivers and large streams below the lowest dams.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Northern Atlantic Coastal Plain Brackish Tidal Marsh; Acadian Estuary Marsh.

STRESSORS/THREATS: Stressors from climate change include loss of marsh from sea level rise, precipitation changes, and warmer temperatures that accelerate peat breakdown. Other human-related stressors include impacts from invasive species, insufficient tidal flow, channelization, freshwater runoff, filling, pollution, and cultural eutrophication.

GOOD EXAMPLES: Reference condition examples are unknown in New Hampshire. An example with “fair” condition is Garvin Brook (Dover).

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CALCAREOUS SLOPING FEN SYSTEM (S1S2)

Calcareous sloping fen system in Monroe (photo by Ben Kimball).

OVERVIEW: Calcareous sloping fens occur in headwater positions, openings in northern white cedar swamps, steep terraces of rivers or streams, and side slopes of hills. They also are found in small basins, kettles, or catchments with seepage influence and stream margins flowing through marshes or swamps in areas with calcareous bedrock. Certain expressions of these systems often occur where disturbance maintains vegetation in an early successional state, such as beaver meadows and grazed pastures or hay fields. While some examples are nearly level, most have gentle to prominent slopes.

These fens are small patch with irregular to uniform zonation and often with rivulets or small open pools. Soils are permanently saturated, well decomposed shallow to moderately deep peat. Peat depth varies with landscape setting; deeper peat accumulation occurs in basins and gentle slopes relative to steeper slopes or periodically disturbed areas such as terraces along major rivers or old pastures. Water source is soligenous (groundwater seepage influenced) with considerable minerotrophic year-round seepage through base-rich or carbonate-bearing bedrock types; pH values range from 6.7 to 8.2 (average 7.2).

Calcareous sloping fens structurally range from graminoid - moss carpets to sedge - medium height sparse shrublands. The diagnostic natural community is ***calcareous sedge - moss fen*** (S2).

VEGETATION PATTERNS: ***Calcareous sedge - moss fens*** are dominated by a distinct assemblage of low sedges and other graminoids over a carpet of "brown" mosses and several uncommon to rare peat mosses. Scattered willow and dogwood shrubs are often present. These peatlands are among the most botanically diverse in New Hampshire and contain many calciphilic plants (species that grow best in calcium-rich soils) in addition to more common wetland species. There are often numerous orchids and other uncommon herbs interspersed among the graminoids and shrubs; these orchids and herbs are absent in oligotrophic to moderately minerotrophic peatland systems (such as medium and poor level fen/bogs and kettle hole bogs). Many of these species are rare, and restricted to these systems.

This system is most often associated with montane/near-boreal minerotrophic peat swamp system, and occasionally drainage marsh - shrub swamp or spruce - fir forest/swamp systems.

DISTRIBUTION IN NEW HAMPSHIRE: North and northwest of the White Mountains and northern Connecticut River valley.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Alkaline Fen.

STRESSORS/THREATS: Alterations of hydrology, both direct (e.g., connectivity changes, draining, channeling/ditching, diversions, and damming) and indirect (e.g., road construction and vegetation removal on adjacent slopes), can significantly degrade the ecological integrity of peatlands. Lowering the water table, or conversely increasing surface water inputs, can lead to shifts in species composition and community types. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Some type of disturbance is required to maintain the open fen vegetation structure (e.g., grazing, flooding, windthrow, or fire).

GOOD EXAMPLES: Stewartstown and Monroe (all are on private property).

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COASTAL CONIFER PEAT SWAMP SYSTEM (S1S2)

Coastal conifer peat swamp system at Locke Pond in Rye (photo by Ben Kimball).

OVERVIEW: The coastal conifer peat swamp system occurs in stagnant, closed or open headwater basins with limited drainage, often in depressions in glacial outwash or ice-contact deposits or broad lake basins away from the influence of lake water. They occur as small to large patches, circular to irregular in shape, and either uniform or forming exterior zone around open peatlands (sometimes in mosaics with more open peatlands). Soils are permanently saturated to seasonally flooded, deep, moderately well decomposed peat. Water source is topogenous (surface runoff influenced). This system is oligotrophic to weakly minerotrophic. Some inland examples of this system are very acidic (pH values as low as 3.4); seasonally flooded portions of these systems that transition to emergent marshes have higher pH values (4.4 to 6.5).

This system is dominated by *Chamaecyparis thyoides* (Atlantic white cedar), and occasionally *Pinus rigida* (pitch pine). Coastal plain and southern species are more common in this wetland system than in more inland, northern, or higher elevation temperate peat swamps. These include *Clethra alnifolia* (sweet pepperbush), *Rhododendron maximum* (giant rhododendron)*, and *Sphagnum flavicomans* (peat moss). Note: Endangered or threatened plant species are noted by an asterisk (*).

VEGETATION PATTERNS: The system is characterized by one or more of the five Atlantic white cedar natural communities or the pitch pine - heath swamp. Atlantic white cedar or pitch pine dominates some or all of a peatland basin, mixing in some areas with ***red maple - Sphagnum basin swamps***. Patches of tall shrub peatland thickets (fens with <25% tree cover) are common as part of the swamp mosaic. Where these tall shrub fens become extensive, they should be considered part of an adjacent open peatland system.

Diagnostic natural communities are ***Atlantic white cedar - leatherleaf swamp*** (S1), ***Atlantic white cedar - giant rhododendron swamp*** (S1), ***Atlantic white cedar - yellow birch - pepperbush swamp*** (S2), ***highbush blueberry - mountain holly wooded fen*** (S3S4), ***inland Atlantic white cedar swamp*** (S1), ***pitch pine - heath swamp*** (S1S2), ***red maple - Sphagnum basin swamp*** (S4), ***seasonally flooded Atlantic white cedar swamp*** (S2), and ***sweet pepperbush wooded fen*** (S2). Peripheral or occasional natural communities are ***black gum - red maple basin swamp*** (S3), ***black spruce swamp*** (S3), and ***highbush blueberry - winterberry shrub thicket*** (S4).

This system is often found in association with poor level fen/bogs, kettle hole bogs, and in stagnant headwater basins in isolation of other peatlands or open wetlands. Structurally, it is similar to the temperate peat swamp system (which is largely hardwood dominated, more common, and ranges further northward, inland, and to higher elevations).

DISTRIBUTION IN NEW HAMPSHIRE: Found in coastal New Hampshire with disjunct occurrences in the highlands of southwest New Hampshire, the Merrimack Valley, and the Lakes Region.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Northern Atlantic Coastal Plain Basin Peat Swamp.

STRESSORS/THREATS: Development threats include fragmentation, habitat displacement and degradation, invasion of non-native species, alterations of flood regimes, and impacts to water quantity and quality (including pollution, eutrophication, and reduction through withdrawal). Impervious surfaces and other alterations to surrounding landcover can affect hydrology and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Logging of forested wetlands may impact hydrologic patterns and alter habitat for forest-restricted species. Regionally, there has been a tendency towards younger, second-growth swamp forests in the region. Logging of adjacent uplands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Naturally acidic, low-nutrient wetland types are particularly susceptible to alteration by elevated nutrient inputs. Residential and industrial pollution, including road, sewage, and agricultural runoff, are sources of nutrients and pollutants that may result in eutrophication. The management implication is to increase the size of buffer areas and limit or control certain activities near these wetland types. The importance of beaver flowages for supporting a variety of habitats for wetland-dependent flora and fauna is well established. However, impacts to natural community types previously unimpacted by beavers may be on the rise. Wetland loss from human encroachment increases the likelihood that the remaining wetland basins will be converted to beaver flowages. Larger beaver populations may further intensify the problem. The recent loss of many Atlantic white cedar and black gum swamps in the southeastern portion of the state where human encroachment is greatest may be examples of this possible trend. Combinations of different types of stressors together with their scope and severity determine the degree to which a system’s ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Loverens Mill (Antrim), Manchester Cedar Swamp (Manchester), Cedar Swamp Pond (Kingston), White Lake State Park (Tamworth), and Locke Pond (Rye).

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COASTAL SALT POND MARSH SYSTEM (S1)

Coastal salt pond marsh system at Odiorne Point State Park in Rye (photo by Sara Cairns).

OVERVIEW: In New Hampshire, the coastal salt pond marsh system is known only from a single, viable site in a partially protected, supratidal coastal basin. Soils are Pawcatuck mucky peat over fine to coarse mineral and rocky substrates. Ponded water ranges was nearly fresh (weakly oligohaline) to higher salinity following salt water intrusion during storm events when sea water washes over the cobble berm (also possibly by intrusion through porous berm sediments). Other water sources include freshwater runoff and precipitation. Temporarily to seasonally flooded on higher ground to semi-permanently flooded in low elevation areas. Much of the ponded area that exists early in the growing season draws down later in the summer, exposing mud flats in low areas. Water levels can also rise rapidly after a storm.

Vegetation is highly variable both temporally and spatially, likely the result of the dynamic nature of the hydrologic and salinity processes governing the system. Many of the plant species occurring in the coastal salt pond marsh system can be found in fresh or brackish wetlands, but when growing together indicate brackish conditions. Other plant species that found only in freshwater habitats are restricted here to higher ground along the wetland's upper edge, where plant diversity is highest.

VEGETATION PATTERNS: The system occupies a coastal basin that is separated from the ocean by a ***maritime cobble beach*** and ***maritime shrub thicket***. The ***coastal salt pond flat*** occurs adjacent to the emergent marsh but in lower lying areas that are seasonally to semi-permanently flooded. Plants develop from rhizomatous perennials creeping into this community from the emergent marsh at higher elevations or emerge from buried or recently deposited seeds as inundated areas are exposed. The ***coastal salt pond emergent marsh*** occurs between the flat and meadow marsh in saturated to semi-permanently flooded settings with seasonably variable water levels. Water levels in shallower portions of the emergent marsh range from a few to several centimeters for most of the growing season. Later in the growing season, the soil surface may be exposed for the remainder of the summer. In deeper sections of the emergent marsh, 0.5 m or more of water may semi-permanently inundate the ground. These soils are exposed only during drier periods. The ***coastal salt pond meadow marsh*** is semi-permanently saturated to seasonally flooded and is located on higher ground adjacent to the emergent marsh. Flooding typically occurs during the spring or high-runoff and precipitation events, but in most years, the water table remains at or below the surface for much of the growing season. In addition to the three preceding rare communities, a narrow and discontinuous band of ***highbush blueberry - winterberry shrub thicket*** occurs along the upper edge of the ***coastal salt pond meadow marsh***.

This system is associated with upland communities landward and the maritime rocky shore system, salt marsh system, sparsely vegetated intertidal system, and subtidal system seaward.

DISTRIBUTION IN NEW HAMPSHIRE: The single site known is adjacent to a high-energy maritime shoreline along immediate coast.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Atlantic Coastal Plain Northern Salt Pond Marsh.

STRESSORS/THREATS: Human-related stressors include impacts from invasive species, altered hydrology, sea level rise, freshwater runoff, filling, pollution, and cultural eutrophication. The Massachusetts Natural Heritage & Endangered Species Program states, "Overwintering populations of Canada geese may provide sufficient nutrient enrichment to change the character of the ponds, allowing algae and pondweeds not native to the ponds to grow and reduce the habitat available to the plants of the pondshore community."

GOOD EXAMPLES: Reference condition examples do not occur in New Hampshire. The only example of this system located in New Hampshire occurs at Odiorne Point State Park (Rye) – its condition is "good to fair."

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DRAINAGE MARSH - SHRUB SWAMP SYSTEM (S5)

Drainage marsh - shrub swamp system at Great Meadows along the Exeter River in Kensington/Exeter (photo by Ben Kimball).

OVERVIEW: The drainage marsh - shrub swamp system occurs in open basins (i.e., those that have an outlet) and along small, low-gradient, seasonally flooded streams (mostly first- and second-order), lower energy sections of rivers and major streams, and ponds and lakes. It forms medium (to large) patches, often broad-linear in shape with inlets and outlets, and irregular or linear zonation (parallel to stream corridors and pond/lake margins).

The very poorly to poorly drained soils are sandy and silty mineral materials and/or well decomposed muck (often shallow organics over mineral soil). This system is moderately to strongly minerotrophic; pH values are mostly in 5s and 6s. Water source is primarily limnogenous (influenced by lake, pond, or stream water); secondarily surface runoff (topogenous) and groundwater seepage (soligenous). Most examples exhibit a broad flood regime gradient from permanently flooded or intermittently exposed (aquatic beds) to semi-permanently flooded (emergent marshes) to seasonally flooded conditions (meadow marshes, shrublands, and wooded swamps).

Species and community composition are influenced to some extent by stream and soil characteristics (i.e., mineral vs. organic soils) and geography, although many of the natural communities in this system have wide geographic ranges. Most of the variation among examples relates to diversity of flood regime conditions and effects of beaver activity on community composition.

VEGETATION PATTERNS: There is considerable variation among examples of this system in terms of diversity of communities, flood regimes, and successional states present, but there is relatively little geographic variation across the state. Periodic beaver activity sets successional states back towards deeper water communities (pond, aquatic beds, and/or emergent marsh), while beaver dam abandonment and subsequent pond drainage shifts the successional track back towards meadow marsh and more wooded states. Some abandoned beaver meadows consist of sedge meadow marshes characterized by minerotrophic peat mosses and marsh herbs on well decomposed muck and often with standing snags indicative of raised water levels. These peaty marshes likely succeed to shrub or swamp states with continued drainage.

Diagnostic natural communities are ***aquatic bed*** (S5), ***bayonet rush emergent marsh*** (S2), ***cattail marsh*** (S4), ***emergent marsh*** (S5), ***herbaceous seepage marsh*** (S3), ***lake sedge seepage marsh*** (S3), ***sedge meadow marsh*** (S4), ***short graminoid - forb meadow marsh/mudflat*** (S4), ***tall graminoid meadow marsh*** (S4), ***alder alluvial shrubland*** (S3), ***alder - dogwood - arrowwood alluvial thicket*** (S4), ***buttonbush shrubland*** (S4), ***highbush blueberry - winterberry shrub thicket*** (S4), ***meadowsweet alluvial thicket*** (S3S4), ***mixed alluvial shrubland*** (S4), ***mixed tall graminoid - scrub-shrub marsh*** (S4S5), and ***seasonally flooded red maple swamp*** (S4S5).

The drainage marsh **-** shrub swamp system can occur with the medium level fen system (particularly along sluggish drainages or within inlets away from the influence of streams) and is sometimes transition to oligotrophic peat swamp or minerotrophic swamp systems.

DISTRIBUTION IN NEW HAMPSHIRE: Widespread throughout New Hampshire.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Freshwater Marsh; Laurentian-Acadian Wet Meadow/Shrub Swamp.

STRESSORS/THREATS: Historic and contemporary land use practices have impacted the hydrologic, geomorphic, and biotic structure and function of many marshes. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in amount and pattern of herbaceous wetland habitat. If the alteration is long term, wetland systems may reestablish to reflect new hydrology and composition (e.g., cat-tail can be an aggressive invader). Human land uses both within the marshes as well as in adjacent upland areas can reduce connectivity between wetland patches and upland areas. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can also have a substantial impact on wetland condition. For example, land uses in the watershed have the potential to contribute excess nutrients into the system which could lead to the establishment of non-native species and/or dominance of “weedy” native species. Combinations of different types of stressors together with their scope and severity determine the degree to which a system’s ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Broad Brook Headwaters (Pisgah State Park, Chesterfield), Mountain Brook (Pawtuckaway State Park, Deerfield and Nottingham), and Great Meadows (Kensington and Exeter).

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FOREST SEEP/SEEPAGE FOREST SYSTEM (S4)

Forest seep/seepage forest system at St. Gaudens National Historic Site in Cornish (photo by Ben Kimball).

OVERVIEW: The forest seep/seepage forest system occurs at groundwater discharge areas in upland forests, bases of steep slopes, and slopes where slowly-pervious soil layers force groundwater to the surface. They form small patches, points, or narrow-linear zones perpendicular (e.g., slope-bases) or parallel to flow direction such as seepage runs. Seasonally to permanently saturated soils are usually silty or loamy, sometimes sandy, with a shallow muck layer, subacid to circumneutral (mid 5s to >7), and poorly to very poorly drained. This system is moderately to strongly minerotrophic.

VEGETATION PATTERNS: This is a broadly defined, spatially small wetland system that corresponds to forest seeps, seepage runs along headwater streamlets, and to their somewhat larger counterparts of northern New Hampshire, seepage forests. These tend to be small, isolated, sloping seepage wetlands up to about 5 acres in size, with most examples being much smaller (<0.25 ac). Seepage forest examples are found primarily in northern New Hampshire; examples further south tend to be small patch forest seeps. Diagnostic natural communities are ***acidic Sphagnum forest seep*** (S3S4), ***circumneutral hardwood forest seep*** (S3), ***northern hardwood - black ash - conifer swamp*** (S3), ***northern hardwood seepage forest*** (S3), and ***subacid forest seep*** (S3S4). A peripheral or occasional natural community is ***alder seepage thicket*** (S3).

This system is most often embedded within upland forests, although they occasionally occur at the border of various other wetland types. They have some floristic similarities to other minerotrophic swamp systems, but they have a more limited set of vascular plants in any given example, and are more variable from one seep to another. They are well demarcated, however, by a set of seepage and other minerotrophic plants that, as a group, primarily occur in seeps.

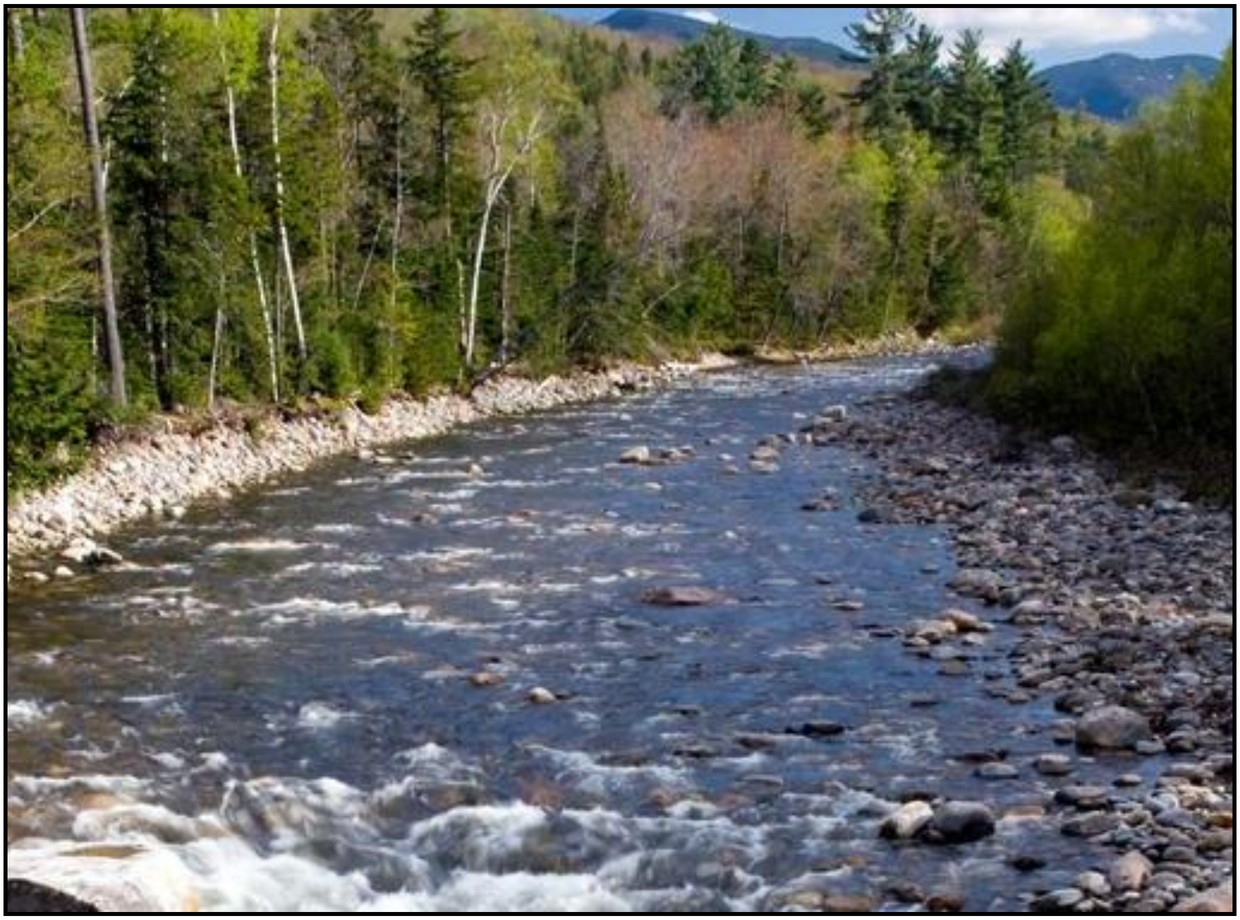
DISTRIBUTION IN NEW HAMPSHIRE: Broad distribution in the state, but more common and larger examples found in northern New Hampshire.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: North-Central and Northeastern Seep.

STRESSORS/THREATS: This system can be impacted by logging, agriculture, development, invasives, and altered hydrology. Impervious surfaces and other alterations to surrounding landcover can affect hydrology and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Good examples of ***northern hardwood seepage forest*** occur at Scott Brook Headwaters (Pittsburg) and Dry Brook (Lincoln). Good examples of ***acidic Sphagnum forest seeps*** occur along entrenched streams draining into Indian Stream (Pittsburg). Good examples of the ***circumneutral hardwood forest seep*** occur at Black Mtn. (Benton), Crommet Creek vicinity (Durham), and St. Gaudens National Historic Site (Cornish).

HIGH-GRADIENT ROCKY RIVERBANK SYSTEM (S3)



High-gradient rocky riverbank system along the Peabody River near Gorham (photo by Ben Kimball).

OVERVIEW: This system occurs along high-gradient sections of rivers and large streams below the bankful flood-stage of river marked by transition to floodplain (when floodplain is present). The high-gradient rocky riverbank system is large patch (typically 5+ m wide and up to miles long) with linear zones parallel to riverbanks or patchy zonation corresponding to intermittent cobble bar deposits.

Soils are primarily bedrock, boulders, stones, and some cobble with interstitial sand and gravel (degradational environments in which fine sediments are transported downstream at high or low river stages, leaving boulders and bedrock as the dominant channel substrate). The system is temporarily to seasonally flooded by river water (limnogenous).

The high-gradient rocky riverbank system is sparsely vegetated; ice and flood scour are pronounced. Rare or uncommon northern and subalpine plants are found in this system along northern rivers (not found in low energy settings or southern New Hampshire).

VEGETATION PATTERNS: Alder alluvial thickets and other herbaceous to wooded communities occur on slightly higher riverbanks. Outcrops are present in some examples; riverside seeps are rare. Diagnostic natural communities are ***acidic riverbank outcrop*** (S3), ***acidic riverside seep*** (S1), ***alder alluvial shrubland*** (S3), ***boulder - cobble river channel*** (S3), ***calcareous riverside seep*** (S1), ***circumneutral riverbank outcrop*** (S1), ***cobble - sand river channel*** (S3S4), ***herbaceous riverbank/floodplain*** (S4), and ***riverweed river rapid*** (S2S3).

This system typically borders upland forests on till or high river terraces and does not occur along river sections with well-developed floodplains. Occasionally it is adjacent to the upper reaches of montane/near-boreal floodplain systems.

DISTRIBUTION IN NEW HAMPSHIRE: Most common in the White Mountains and north, and scattered along upper reaches and intermittent steep-gradient sections of minor and major rivers throughout much of the state.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Floodplain Forest.

STRESSORS/THREATS: High-gradient riverbanks have been impacted by development, invasives, hydrologic alterations, clearing of natural buffers, and trampling from hikers, fisherman, and boaters. Impervious surfaces and other alterations to surrounding landcover can affect flow and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Diamond Gorge (Second College Grant) and Peabody River (Gorham).

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KETTLE HOLE BOG SYSTEM (S2)

Kettle hole bog system at Heath Pond Bog in Ossipee and Effingham (photo by Ben Kimball).

OVERVIEW: Kettle hole bogs are found where big chunks of glacial ice were stranded and partially buried in glacial outwash or other coarse ice-contact deposits. The ice chunks subsequently melted, leaving ponds in holes in the ground, with no hydrologic inlets or outlets. Over millennia, peat has progressively filled in the kettle holes from the edges inward toward the pond center; most still have a central bog pond with a floating mat border, while some have covered the kettle surface entirely with peat and filled in the pond.

The system is small patch and circular to irregular in shape with more or less concentric vegetation zonation. Soils are permanently saturated, deep, poorly decomposed peat. This system is oligotrophic due to very limited terrestrial runoff influence from their small watersheds and coarse, porous soils, and to the dominance of precipitation as the primary water source; pH values $\leq$4.0 (often higher in the nearshore zone).

The vegetation is dominated by species indicative of oligotrophic conditions including scattered, stunted *Picea mariana* (black spruce), numerous dwarf heath shrubs [*Chamaedaphne calyculata* (leatherleaf), *Vaccinium oxycoccos* (small cranberry), *Kalmia angustifolia* (sheep laurel), *K. polifolia* (bog laurel)], lawns (wet, floating lawns dominated by low, turfy mats of the leafy liverwort *Cladopodiella fluitans*, which turns black and looks like mud from a distance), *Utricularia* spp. (bladderworts), and *Rhynchospora alba* (white beaksedge).

VEGETATION PATTERNS: There is often a moat separating the peat mat from the surrounding upland, which is largely a result of increased decomposition due to elevated nutrient levels from upland runoff as well as periodic, seasonal drawdown of the water table. A typical community sequence from the upland border towards the center of the kettle hole is ***marshy moat*** (when present), tall shrub fen or ***black spruce swamp***, followed by a dense ***leatherleaf - black spruce bog*** zone, then a floating, reddish-colored open moss carpet (*Sphagnum rubellum*) with extremely dwarfed shrubs, and patches of *Sphagnum* pools with *Sphagnum cuspidatum* and the liverwort *Cladopodiella fluitans*.

Diagnostic natural communities are ***highbush blueberry - mountain holly wooded fen*** (S3S4), ***leatherleaf - black spruce bog*** (S3), ***liverwort - horned bladderwort fen*** (S3), ***marshy moat*** (S4), and ***Sphagnum rubellum - small cranberry moss carpet*** (S3). Peripheral or occasional natural communities are ***large cranberry - short sedge moss lawn*** (S3) (*Sphagnum cuspidatum* variant), ***leatherleaf - sheep laurel shrub bog*** (S2S3), and ***water willow - Sphagnum fen*** (S3).

Kettle hole bogs often occur in isolation of other wetland systems. They can also be surrounded by peat swamp systems (temperate, coastal conifer, or black spruce types) or occur adjacent to poor level fen/bog systems and, less frequently, medium level fen systems.

DISTRIBUTION IN NEW HAMPSHIRE: Broadly distributed but concentrated in the central and southern portions of the state where kettle holes are more abundant.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: North-Central Interior and Appalachian Acidic Peatland; Atlantic Coastal Plain Northern Bog.

STRESSORS/THREATS: Threats include fragmentation, habitat displacement and degradation, invasion of non-native species, trampling, alteration of hydrology, and impacts to water quality. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Hydrologic alterations, both direct (e.g., connectivity changes, draining, channeling/ditching, diversions, and damming) and indirect (e.g., road construction and vegetation removal on adjacent slopes), can significantly degrade the ecological integrity of peatlands. Lowering the water table, or conversely increasing surface water inputs, can lead to shifts in species composition and community types. Logging in and near peatlands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Increased nutrient inputs (e.g., from nearby roads, agriculture, development, or logging) can cause this system to shift away from its natural range of variability, leading to an increase in fen and marsh species and creating opportunity for invasive plants and "weedy" native species. The related management implication is to increase the size of buffer areas and to limit or control certain activities near these wetland types. Buffers reduce the impact of disturbances outside the system and ensure that other characteristics and processes within the community remain intact. Buffers help protect natural communities from the deleterious effects of increased nutrients, reduced water quality, altered water quantity, invasion by exotic species, windthrow, loss of secondary plant or animal habitat, and future deleterious changes in surrounding land use that may increase threats over the long term. Nutrient-poor systems, such as most types of peatland, may require larger setbacks than other systems because of their high susceptibility to changes in nutrient concentrations.

GOOD EXAMPLES: Philbrick-Cricenti Bog (New London) and Heath Pond Bog (Ossipee, Effingham).

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LOW-GRADIENT SILTY-SANDY RIVERBANK SYSTEM (S3)

Low-gradient silty-sandy riverbank system along the Blackwater River in Salisbury (photo by Ben Kimball).

OVERVIEW: This system occurs on river banks and channels along low gradient sections of rivers and large streams (with or without well-developed adjacent floodplain). They can form extensive narrow-linear patches (several meters wide and miles long) with linear zones parallel to river or patchy zonation corresponding to intermittent bar deposits. Soils are primarily alluvial sands, loams, and silt loams and temporarily to permanently flooded by river water (limnogenous).

VEGETATION PATTERNS: ***Aquatic bed*** and ***emergent marsh*** communities are common, whereas these are typically absent or not well developed in higher energy settings of moderate- and high-gradient sections of river. These communities are typically indicated by a higher density of vegetation and emergent marsh forbs, including species absent from high-energy environments. Sandy or silty channel bars are occasional, but gravel and cobble bars are relatively rare or absent in this depositional environment. Adjacent floodplains typically have red or silver maple floodplain forest communities, but examples of this system may lack well-developed wooded floodplain forests. Instead they may have extensive alluvial alder floodplains along large streams that are flooded at least annually, or they may transition rapidly to upland. Shrubbier portions may also be characterized by dogwoods and Viburnums, and sometimes a diverse assemblage of other shrubs.

Diagnostic natural communities are ***cobble - sand river channel*** (S3S4), ***mesic herbaceous river channel*** (S4), ***twisted sedge low riverbank*** (S3S4), ***alder alluvial shrubland*** (S3), ***alder - dogwood - arrowwood alluvial thicket*** (S4), ***bluejoint - goldenrod - virgin's bower riverbank/floodplain*** (S3S4), ***herbaceous riverbank/floodplain*** (S4), ***meadowsweet alluvial thicket*** (S3S4), ***aquatic bed*** (S5), ***bayonet rush emergent marsh*** (S2), ***cattail marsh*** (S4), ***emergent marsh*** (S5), and ***short graminoid - forb meadow marsh/mudflat*** (S4). A peripheral or occasional natural community is ***dry river bluff*** (S2S3).

This system is most often associated with temperate minor river and major river silver maple floodplain systems, and rarely montane/near boreal floodplains that occur on large streams.

DISTRIBUTION IN NEW HAMPSHIRE: Broadly distributed throughout the state.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Floodplain Forest; Eastern Boreal Floodplain; Central Appalachian River Floodplain; Northeastern Erosional Bluff.

STRESSORS/THREATS: Riverbank systems have been impacted by development, river channelization, invasives, clearing of natural buffers, hydrologic alterations, and dam construction. Impervious surfaces and other alterations to surrounding landcover can affect flow and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Pine River (Ossipee and Effingham) and Blackwater River (Salisbury).

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MAJOR RIVER SILVER MAPLE FLOODPLAIN SYSTEM (S2)

Major river silver maple floodplain system along the Merrimack River (photo by Ben Kimball).

OVERVIEW: This system is characterized by forests on floodplains (above bankful) along moderate-gradient and low-gradient sections of major rivers. They form large linear patches with broad to meandering linear and semi-circular zones parallel to riverbanks or corresponding to floodplain terracing and oxbow, slough, or overflow channel formations. Flooding is affected by snowmelt from the White Mountains that peaks a bit later in the spring than melting snowpacks along tributaries. This floodplain system may require major periodic flood events with historical return intervals for long term maintenance of floodplain forests on medium and high terraces.

The temporarily flooded alluvium soils range from well drained coarse sands on levees, to poorly drained silts and mucks in floodplain sloughs, vernal pools, and other depressions. As water levels rise over riverbanks, sediment is transported from upstream and deposited where water slows and spreads out across the floodplain terraces. The system is moderately to strongly minerotrophic.

VEGETATION PATTERNS: Forest canopies are dominated by mature *Acer saccharinum* (silver maple), which forms a tall, arching, cathedral-like ceiling above the level floodplain adjacent to the river channel. Whereas shrubs are poorly represented, vines tend to be abundant, especially in canopy gaps and along forest edge transitions to other communities. Floodplain forests of this system often form a mosaic with more open floodplain communities. Shrub thickets and herbaceous meadows may occur on low floodplains and adjacent riverbanks. Aquatic beds, emergent marshes, and shrub thickets in oxbows may also occur and are typically flooded annually. ***Riverwash plain and dunes*** occur on a few sandy pointbar floodplains of the Merrimack River and are kept open by some combination of infrequent scouring by major floods and subsequent shifting windblown sands.

The ***silver maple - wood nettle - ostrich fern floodplain forest*** type is most common along the Connecticut River, while the ***silver maple - false nettle - sensitive fern*** type is most common on the Merrimack, Ashuelot, Contoocook, and Suncook Rivers. This type exhibits different dominant herbs and generally more grasses and sedges. On smaller rivers, silver maple floodplain forest communities may be reduced to a narrow band or relatively small portion of the floodplain system compared to other forest types or disappear altogether. Red maple and other floodplain forest types predominate when silver maple disappears.

Diagnostic natural communities are ***alder alluvial shrubland*** (S3), ***alder - dogwood - arrowwood alluvial thicket*** (S4), ***aquatic bed*** (S5), ***bluejoint - goldenrod - virgin's bower riverbank/floodplain*** (S3S4), ***emergent marsh*** (S5) – in oxbows, ***herbaceous riverbank/floodplain*** (S4), ***silver maple - false nettle - sensitive fern floodplain forest*** (S2), and ***silver maple - wood nettle - ostrich fern floodplain forest*** (S2). Peripheral or occasional natural communities are ***buttonbush shrubland*** (S4) – in oxbows, ***red maple floodplain forest*** (S2S3), ***riverwash plain and dunes*** (S1), and ***sugar maple - silver maple - white ash floodplain forest*** (S1S2).

This system is most often adjacent to the low-gradient silty-sandy riverbank system and sometimes the moderate-gradient sandy-cobbly riverbank system. It frequently transitions to river terraces dominated by upland forest types, occasionally including rich and semi-rich forests.

DISTRIBUTION IN NEW HAMPSHIRE: Primarily along main-stems of Connecticut and Merrimack Rivers; occasionally on lower reaches of major tributaries.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Floodplain Forest.

STRESSORS/THREATS: Floodplain systems along major rivers are a regionally imperiled habitat and have been fragmented and impacted by agriculture, timber harvesting, development, river channelization, dam construction, and invasives. The flat, relatively productive soils are prime for alternative land use, especially higher terraces that are no longer regularly flooded. Historical flood regimes, the natural processes that create and sustain floodplain systems, have been altered by dam control of major rivers, eliminating or lengthening the flood return interval on medium and high floodplains. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: New Hampshire appears to lack reference condition examples due to human-related impacts. A good example (B ranked) occurs at Franklin Falls Reservoir–ACOE (New Hampton to Franklin). A good example of a natural community that is diagnostic of the system is the silver maple - false nettle - sensitive fern floodplain forest at NHTI and SPNHF Headquarters (Concord).

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MEDIUM LEVEL FEN SYSTEM (S3S4)

Medium level fen system at Ossipee Lake Natural Area in Ossipee (photo by Ben Kimball).

OVERVIEW: Medium level fens mostly occur along stream and lake borders where the nutrient levels and seasonal fluctuations of water levels are greater than in poor level fens, but less than in emergent marshes (thus allowing peat to accumulate over the long term). They also occur in open headwater basins and drained depressions in glacial outwash or ice-contact deposits.

This system is small to large patch and irregularly circular or linear with irregular or banded zonation parallel to stream or pond border. Streams often pass through the peatland (has inlet and outlet). Soils are permanently saturated, deep, poorly to moderately well-decomposed peat. Water source is topogenous (surface runoff) and limnogenous (lake, pond, or stream) with limited soligenous (groundwater seepage) influence. This system is more minerotrophic influenced (weakly to moderately minerotrophic with pH values generally in low 4s to mid 5s) than poor level fen/bogs due to the effects of upland runoff, exposure to lake and stream water, or limited groundwater seepage.

In shrubby areas, vigorous patches of *Myrica gale* (sweet gale), *Spiraea alba* var. *latifolia* (meadowsweet), and sometimes *Chamaedaphne calyculata* (leatherleaf) are prominent and usually more than 20" (50 cm) in height (leatherleaf tends to be shorter in poor level fen/bogs). *Ilex verticillata* (common winterberry), *Toxicodendron vernix* (poison-sumac), *Acer rubrum* (red maple), and *Larix laricina* (American larch) indicate weakly to moderately minerotrophic conditions in areas that have tall shrubs and trees (these species are sparse or absent in poor fens). Robust, tall sedges, like *Carex lasiocarpa* (wire sedge), *Carex utriculata* (swollen-beaked sedge), and *Carex stricta* (tussock sedge), are also common, and may dominate large areas individually or in mixtures with other species. Moat areas along the upland margin and lawns, carpets, and pools near water bodies often support aquatic peat mosses and herbs such as *Sphagnum torreyanum*, *S. cuspidatum*, *S. pulchrum*, *Carex canescens* (hoary sedge), *Vaccinium macrocarpon* (large cranberry), *Rhynchospora alba* (white beaksedge), and *Dulichium arundinaceum* (three-way sedge). Also, many species of kettle hole and poor level fen/bog systems may be found in medium level fens.

VEGETATION PATTERNS: Mosaic of open, sedge-dominated fens, dwarf to medium-height shrublands, and open moss lawns, carpets, and pools. Tall shrub fens are also common. A typical natural community sequence from the upland border towards the center of the basin, channel, or water-margin is as follows: a moat; a tall shrub fen zone; a dense medium-height shrub zone with sweet gale; sedge fen; and open moss carpet areas closest to the water's edge. Moss carpets or lawns are typically not present or well developed in fens along streams, but are more common in lake border or floating mat settings.

Diagnostic natural communities are ***bog rosemary - sedge fen*** (S3), ***large cranberry - short sedge moss lawn*** (S3), ***sweet gale - meadowsweet - tussock sedge fen*** (S4), ***wire sedge - sweet gale fen*** (S3), ***alder wooded fen*** (S3S4), ***highbush blueberry - sweet gale - meadowsweet shrub thicket*** (S4), ***sweet pepperbush wooded fen*** (S2), and ***winterberry - cinnamon fern wooded fen*** (S4). Peripheral or occasional natural communities are ***alder - lake sedge intermediate fen*** (S2S3), ***floating marshy peat mat*** (S3S4), ***marshy moat*** (S4), ***montane level fen/bog*** (S2), ***sedge meadow marsh*** (S4), and ***water willow - Sphagnum fen*** (S3).

In large peatland basins, this system can co-occur with poor level fen/bog systems. It is typical for medium level fen peatlands to have small portions dominated by oligotrophic conditions and communities. When these areas are limited in extent or constitute a small proportion of the wetland, they are considered inclusions within the medium level fen system; when they are more extensive or constitute a substantial proportion of the wetland, the peatland may best be treated as having both poor and medium level fens systems within the same site. Conversely, poor level fen/bogs can have areas with more minerotrophic influence with medium level fen communities.

DISTRIBUTION IN NEW HAMPSHIRE: Broadly distributed in New Hampshire.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: North-Central Interior and Appalachian Acidic Peatland; Boreal-Laurentian-Acadian Acidic Basin Fen.

STRESSORS/THREATS: Threats include fragmentation, habitat displacement and degradation, invasion of non-native species, trampling, alteration of hydrology, and impacts to water quality. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Hydrologic alterations, both direct (e.g., connectivity changes, draining, channeling/ditching, diversions, and damming) and indirect (e.g., road construction and vegetation removal on adjacent slopes), can significantly degrade the ecological integrity of peatlands. Lowering the water table, or conversely increasing surface water inputs, can lead to shifts in species composition and community types. Logging in and near peatlands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation.

GOOD EXAMPLES: Betty Meadows (Northwood), NW of Lake Umbagog (Errol), Little and Big Church Ponds (Livermore/Albany), Bradford Bog (Bradford), Berry Pond (Moultonborough/Sandwich), and Ossipee Lake Natural Area (Ossipee).

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MODERATE-GRADIENT SANDY-COBBLY RIVERBANK SYSTEM (S3)

Moderate-gradient sandy-cobbly riverbank system along the Pemigewasset River near Plymouth (photo by Ben Kimball).

OVERVIEW: This system occurs on river banks and channels along moderate-gradient, moderate to high-energy sections of rivers and large streams. They can form extensive narrow-linear patches (typically 5+ m wide and up to miles long) with linear zones parallel to riverbanks or patchy zonation corresponding to intermittent bar deposits. The temporarily to seasonally flooded soils are primarily alluvial sand, gravel, and cobble. Ice and flood scour are important annual disturbances, producing sparse to moderate cover of herbs and shrubs on coarse substrates. Thus the natural communities in this system on average are sparsely vegetated.

VEGETATION PATTERNS: The moderate-gradient sandy-cobbly riverbank system lacks well-developed emergent marsh vegetation characteristic of low-gradient riverbank systems and extensive deposits of boulders and rock that are characteristic of high-gradient rocky riverbanks. It has a higher abundance of coarse deposits (gravel to cobble) compared to low-gradient silty-sandy riverbanks. Rapids or riffle sections are common among the depositional bars. This system includes extensive alder thickets on large northern streams or small rivers that are flooded at least annually and are without floodplain forests. Floodplain forests (primarily silver maple, sugar maple, and balsam fir types) are often adjacent to this riverbank system.

Diagnostic natural communities are ***boulder - cobble river channel*** (S3), ***cobble - sand river channel*** (S3S4), ***dwarf cherry river channel*** (S2), ***hudsonia - silverling river channel*** (S1), ***mesic herbaceous river channel*** (S4), ***riverweed river rapid*** (S2S3), ***twisted sedge low riverbank*** (S3S4), ***willow low riverbank*** (S3), ***acidic riverbank outcrop*** (S3), ***acidic riverside seep*** (S1), ***alder alluvial shrubland*** (S3), ***bluejoint - goldenrod - virgin's bower riverbank/floodplain*** (S3S4), ***calcareous riverside seep*** (S1), ***circumneutral riverbank outcrop*** (S1), ***herbaceous riverbank/floodplain*** (S4), and ***mixed alluvial shrubland*** (S4).

This system is associated with all three floodplain systems or may occur without a well-developed forested floodplain along upper reaches of large mountain streams with annually flooded shrub floodplains. Montane/near-boreal floodplain systems are almost always associated with this riverbank system (but not vice versa).

DISTRIBUTION IN NEW HAMPSHIRE: Broadly distributed throughout the state.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Floodplain Forest; Central Appalachian Stream and Riparian.

STRESSORS/THREATS: Riverbank systems have been impacted by development, river channelization, invasives, clearing of natural buffers, hydrologic alterations, and dam construction. Impervious surfaces and other alterations to surrounding landcover can affect flow and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Albany Intervale (Albany, Livermore, and Waterville Valley), Dead Diamond River (Second College Grant, Atkinson & Gilmanton, and Pittsburg), and (Second College Grant, Dixs Grant, and Dixville).

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MONTANE/NEAR-BOREAL FLOODPLAIN SYSTEM (S2)

Montane/near-boreal floodplain system flanking a gravel barren along the Saco River (photo by Dan Sperduto).

OVERVIEW: This system occurs on floodplains (above bankful) along moderate-gradient sections of rivers and large streams. They can form large broad-linear patches (<1–50+ acres) with meandering linear and semi-circular zones parallel to riverbanks or corresponding to floodplain terracing and oxbow, slough, or over-flow channel formations. Soils are sandy alluvium (loamy sand, sandy loam, silt loams, and occasionally sand over gravel or cobble). The hydroperiod is temporarily flooded with a flashy flood regime (high intensity, short-duration floods from mountain runoff events).

The most diagnostic natural communities are sugar maple and balsam fir floodplain forests, and occasionally red maple floodplain forest. When silver maple floodplain forests are present they typically form a narrow border and are not the dominant forest type. Moderate gradient sandy-cobbly riverbanks are typically adjacent to these floodplains, although some examples occur on higher- or lower-gradient sections of river. Some smaller, northern river floodplains contain balsam fir floodplain/silt plains and alder thickets that lack sugar maple floodplain forest communities.

VEGETATION PATTERNS: Examples along larger rivers with ***sugar maple - ironwood - short husk floodplain forest*** contain mixes of *Acer saccharum* (sugar maple), *Ostrya virginiana* (ironwood), and other common upland trees. Shrubs are generally not dominant, except at forest edges. Compared to average northern hardwood forests, the herb layer is often more lush – commonly with a high total coverage, and a species composition indicative of semi-rich conditions. ***Sugar maple - silver maple - white ash floodplain forest*** can occur on lower adjacent floodplains, marked by the appearance of *Acer saccharinum* (silver maple) and more mesic site plants. ***Balsam fir floodplain/silt plain***s have a somewhat less floristically rich flora that lacks ironwood and contains more softwoods, and common wet-site herbs of northern NH.

Diagnostic natural communities are ***balsam fir floodplain/silt plain*** (S2), ***sugar maple - ironwood - short husk floodplain forest*** (S1), ***sugar maple - silver maple - white ash floodplain forest*** (S1S2), ***alder alluvial shrubland*** (S3), ***bluejoint - goldenrod - virgin's bower riverbank/floodplain*** (S3S4), ***herbaceous riverbank/floodplain*** (S4), and ***mixed alluvial shrubland*** (S4). A peripheral or occasional natural community is ***silver maple - false nettle - sensitive fern floodplain forest*** (S2).

Moderate gradient sandy-cobbly riverbanks are typically adjacent to these floodplains, although some examples occur on higher- or lower-gradient sections of river.

DISTRIBUTION IN NEW HAMPSHIRE: Primarily found on flashy northern rivers in the White Mountains or north country, and occasional in north-central New Hampshire.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Floodplain Forest; Eastern Boreal Floodplain.

STRESSORS/THREATS: Floodplain systems have been fragmented and impacted by agriculture, timber harvesting, development, river channelization, and dam construction. Impervious surfaces and other alterations to surrounding landcover can affect flow and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Indian Stream (Pittsburg).

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MONTANE/NEAR-BOREAL MINEROTROPHIC PEAT SWAMP SYSTEM

Near-boreal minerotrophic peat swamp system at Hurlbert Swamp in Stewartstown (photo by Ben Kimball).

OVERVIEW: The near-boreal minerotrophic peat swamp system occurs in headwater basins and broad drainageways, extensive flats, pond and lake basins, and adjacent gentle slopes. This system forms small to large patches (sometimes extensive), circular-oval or irregular in shape, and with uniform vegetation patterns or sometimes with sedgy or shrubby openings or surrounding open peatlands.

The permanently saturated to seasonally flooded soils are deep to moderately deep, well-decomposed peat, grading to mineral soils in sloped swamp margins. The peat or muck in the ***northern white cedar - balsam fir swamps*** are usually over a meter in depth and well decomposed; soils in ***northern hardwood - black ash - conifer swamps*** consist of shallow, well decomposed muck over silty material. Soil water pHs range from 4.9–7.5. The system is moderately to strongly minerotrophic. Water source is topogenous and soligenous (surface runoff to groundwater seepage influenced).

These are diverse swamp systems that harbor many vascular plants (>200 species) and bryophytes (>65 species), particularly those preferring circumneutral conditions. Abundant to frequent northern conifers and hardwoods includes northern white cedar, *Abies balsamea* (balsam fir), *Larix laricina* (American larch), and

Picea spp. (spruces); *Fraxinus nigra* (black ash), *Betula alleghaniensis* (yellow birch), and *Acer rubrum* (red maple).

VEGETATION PATTERNS: At least two swamp types are typically present: ***northern white cedar - balsam fir swamps*** tend to occur on organic soils (muck and peat >16 in.); and ***northern hardwood - black ash - conifer swamps*** are often found toward the swamp margins on level to sloping mineral soil (shallow organic layer 0–16 in.). The sloping mineral soil margins can also transition to ***northern white cedar seepage forest***. In contrast to more acidic black spruce peat swamps, this swamp system is strongly influenced by minerotrophic groundwater seepage. On sites with a moderate degree of mineral enrichment, the ***larch - mixed conifer swamp*** may be present. Overall, the swamps are conifer-dominated or mixed hardwood - conifer dominated. ***Alder wooded fens*** are often part of this system, and can mark the transition to open peatland systems or alder alluvial shrublands along large streams. ***Calcareous sedge - moss fens*** occur in a few swamps, in openings where calcareous groundwater discharge is prominent.

Diagnostic natural communities are ***larch - mixed conifer swamp*** (S3), ***northern white cedar - balsam fir swamp*** (S2), ***northern hardwood - black ash - conifer swamp*** (S3), and ***northern white cedar seepage forest*** (S2). Peripheral or occasional natural communities are ***acidic northern white cedar swamp*** (S1), ***alder seepage thicket*** (S3), ***alder wooded fen*** (S3S4), ***calcareous sedge - moss fen*** (S2), ***northern hardwood seepage forest*** (S3), and ***northern white cedar - hemlock swamp*** (S2).

Medium level and rich sloping fens are often associated with this swamp system, and in large wetland basins may co-occur with the montane/near-boreal hardwood - conifer minerotrophic swamp system.

DISTRIBUTION IN NEW HAMPSHIRE: Occurs north and northwest of the White Mountains; there are a few cedar swamps south of the White Mountains, which contain the ***northern white cedar - hemlock swamp*** community. Northern white cedar swamps have a northeastern-boreal distribution in North America (Great Lakes to Canadian Maritimes), and extend into northern New Hampshire, mostly north of the White Mountains.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Acadian-Appalachian Conifer Seepage Forest; Laurentian-Acadian Alkaline Conifer-Hardwood Swamp.

STRESSORS/THREATS: Development threats include fragmentation, habitat displacement and degradation, invasion of non-native species, alterations of flood regimes, and impacts to water quantity and quality (including pollution, eutrophication, and reduction through withdrawal). Impervious surfaces and other alterations to surrounding landcover can affect hydrology and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Logging of forested wetlands may impact hydrologic patterns and alter habitat for forest-restricted species. Regionally, there has been a tendency towards younger, second-growth swamp forests in the region. Logging of adjacent uplands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Good examples with ***northern hardwood - black ash - conifer swamp*** occur at Coleman State Park (Stewartstown), Moore Reservoir vicinity (Littleton), part of Brown Ash Swamp (Thornton), Umbagog State Park (Errol), and South of Cleveland Mtn. (Bethlehem). Good examples with ***northern white cedar - balsam fir swamp*** occur at Hurlbert Swamp (Colebrook).

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MONTANE SLOPING FEN SYSTEM (S1)

Montane sloping fen system on Whitewall Mountain in Bethlehem (photo by Dan Sperduto).

OVERVIEW: Montane sloping fens are found in moderate- to high-elevation (above 2,400 ft.) valley bottoms and adjacent gently sloped mountain side-slopes on definite soligenous (groundwater seepage) slopes, shallow level depressions, and small drainage-ways associated with old beaver dams (abandoned decades ago and have subsequently filled in with organics). Surfaces are nearly level to sloping (up to 10–20 degrees).

This system is small to large patch, oval to irregular or linear in shape, and with irregular zonation. Soils are permanently saturated, shallow, well-decomposed peat, often on glacial lake bed or other silty-gravelly mineral deposits. Water source is soligenous and topogenous (groundwater seepage and surface runoff influenced). Montane sloping fens are weakly to moderately minerotrophic; pH values average 5.3 (4.2 to 6.3).

Calamagrostis pickeringii (Pickering's reed grass) on average contributes about 5% cover, and *Carex wiegandii* (Wiegand's sedge)* is frequent. Numerous other northern poor and medium fen plants are present. Note: Endangered or threatened plant species are noted by an asterisk (*).

VEGETATION PATTERNS: This system consists of ***montane sloping fens*** (key diagnostic community) occurring in a mosaic with ***montane alder - heath shrub thickets*** and ***montane heath woodlands***. The ***montane sloping fen*** is dominated by graminoids or graminoids and shrubs, and is the only known fen in the state or region that is characterized by a grass (*Calamagrostis pickeringii*).

Diagnostic natural communities are ***montane alder - heath shrub thicket*** (S1) and ***montane sloping fen*** (S1). A peripheral or occasional natural community is ***montane heath woodland*** (S2).

These systems are often set in a matrix of spruce - fir forest/swamp systems in high-elevation valley bottoms, which sometimes include ***montane black spruce - red spruce forests***.

DISTRIBUTION IN NEW HAMPSHIRE: Found above 2,400 ft. in the White Mountains.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Acadian-Appalachian Subalpine Woodland and Heath-Krummholz. This ecological system includes sloped montane fens embedded within the surrounding upland matrix.

STRESSORS/THREATS: Threats include fragmentation, habitat displacement and degradation, invasion of non-native species, trampling, alteration of hydrology, and impacts to water quality. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Hydrologic alterations can significantly degrade the ecological integrity of peatlands. Lowering the water table, or conversely increasing surface water inputs, can lead to shifts in species composition and community types. Logging in and near peatlands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation.

GOOD EXAMPLES: Upper East Branch of the Pemigewasset River watershed near Shoal and Ethan Ponds (Lincoln), North Bald Cap Mtn. in the Mahoosuc Range (Success), and Whitewall Mountain (Bethlehem).

PATTERNED FEN SYSTEM (S1)

Patterned fen system at Borderline Fen in Errol (photo by Dan Sperduto).

OVERVIEW: Patterned fen formation requires a poorly drained, gently sloped setting that supports directional sheet flow. Strings and flarks (linear hummocks and hollows, respectively) develop perpendicular to ground- and surface-water flow. Initial establishment of hummocks and hollows creates surface catchments that widen and merge because of recurring flooding and decreased plant growth at pool margins. Patterning in fens is more distinct north of New England where precipitation greatly exceeds evaporation, resulting in substantial groundwater storage and discharge.

This system is small to large patch and oblong to broad oval in shape with repeating parallel zonation of strings and flarks. Soils are permanently saturated, moderately well to well decomposed peat. Water source is soligenous (groundwater seepage) with some topogenous (surface runoff) influence. Of the three sites known in the state, two are acidic (pH values 4–5) and weakly minerotrophic and one is circumneutral to alkaline (pH values 6.3–8.0) and strongly minerotrophic.

While the distinct vegetative differences between acidic and circumneutral examples could support splitting this system into two types, we consider them together as one type for purely pragmatic conservation reasons: there are so few examples, all have high conservation value, and none are likely to be overlooked in conservation efforts.

VEGETATION PATTERNS: Strings and flarks can form a regular to intricate pattern of parallel ridges and hollows. Diagnostic string communities are ***leatherleaf - black spruce bog*** (S3) and ***northern white cedar circumneutral string*** (S1). Diagnostic flark communities are ***circumneutral - calcareous flark*** (S1), ***large cranberry - short sedge moss lawn*** (S3) (*S. cuspidatum* variant), ***liverwort - horned bladderwort fen*** (S3), and ***Sphagnum rubellum - small cranberry moss carpet*** (S3).

Patterned fens are surrounded by black spruce peat swamp and lowland spruce - fir forest/swamp systems (acidic examples) and montane/near-boreal minerotrophic peat swamp system (circumneutral example).

The strings and flarks have dramatically different vegetation. The strings in acidic examples are similar to poor level fen/bog vegetation and primarily composed of dwarf shrub vegetation, dominated by *Chamaedaphne calyculata* (leatherleaf), other dwarf shrubs, and scattered, stunted *Picea mariana* (black spruce) and *Larix laricina* (American larch). Herbs are sparse on these hummock ridges. Hollows are filled with open pools, ***liverwort - horned bladderwort fens***, or *Sphagnum* moss carpets with sparse dwarf shrubs and sundews. *Carex exilis* (meagre sedge)* is a diagnostic herb of flarks in New Hampshire patterned fens. Note: Endangered or threatened plant species are noted by an asterisk (*).

The strings in our one circumneutral example are primarily dominated by stunted (and heavily browsed) *Thuja occidentalis* (northern white cedar), averaging 1 m tall amidst dwarf shrubs, with a taller scattered canopy of northern white cedar, black spruce, eastern larch, and *Acer rubrum* (red maple). Herbs are scattered in low abundance. All of this is over a diverse carpet of peat mosses and "brown" mosses (mostly in Amblystegeacae family). The ***circumneutral - calcareous flarks*** range from a few meters to more than 10 m wide and have a thick mat of brown algae interspersed with low plant cover of herbs and mosses.

DISTRIBUTION IN NEW HAMPSHIRE: Known from only three sites in extreme northern New Hampshire. Patterned peatlands reach their southern extent in New Hampshire where patterning is less well developed than further north; they are more extensive and well-developed in boreal and subpolar areas where precipitation greatly exceeds evaporation.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Boreal-Laurentian-Acadian Acidic Basin Fen.

STRESSORS/THREATS: Threats include fragmentation, habitat displacement and degradation, invasion of non-native species, trampling, alteration of hydrology, and impacts to water quality. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Hydrologic alterations can significantly degrade the ecological integrity of peatlands. Lowering the water table, or conversely increasing surface water inputs, can lead to shifts in species composition and community types. Logging in and near peatlands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation.

GOOD EXAMPLES: South Bay Bog (Pittsburg), East Inlet (Pittsburg), and Umbagog Lake (Borderline Fen in Errol)

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POOR LEVEL FEN/BOG SYSTEM (S3)

Poor level fen/bog system at Red Hill Pond in Sandwich (photo by Dan Sperduto).

OVERVIEW: The poor level fen/bog system occurs in nearly closed basins to broad drainageways with sluggish, meandering streams, and adjacent to lakes but away from the influence of the lake-water; most frequent in areas of glacial outwash or ice-contact deposits. This system is small to large patch (occasionally extensive), circular to irregular in shape, and with more or less concentric zonation (less often irregular zonation). Soils are permanently saturated, deep, poorly decomposed peat. Poor level fen/bogs are oligotrophic to weakly minerotrophic with pH values generally <4.1 (extremely acidic with limited amount of minerotrophic influence from surrounding uplands); pH values often higher in the nearshore zone. Water source is topogenous (surface runoff) with very little or no groundwater or lake and stream influence (limited soligenous and limnogenous influence); often with outlet stream, but without inlet streams.

This system is dominated by species indicative of oligotrophic to, at most, weakly minerotrophic conditions including scattered, stunted *Picea mariana* (black spruce), and extensive areas of mostly dwarfed heath shrubs (<0.5 m; *Chamaedaphne calyculata* (leatherleaf), *Vaccinium oxycoccos* (small cranberry), *Kalmia angustifolia* (sheep laurel), *Kalmia polifolia* (bog laurel)). Floristic differences are evident in northern or higher elevation examples compared to coastal or southern examples, but the overall vegetation patterns are similar.

VEGETATION PATTERNS: A typical community sequence from the upland border towards the peatland's center is a tall shrub fen or ***black spruce swamp*** border, followed by a dense ***leatherleaf - black spruce bog*** zone, then a reddish open moss carpet (*Sphagnum rubellum*) with extremely dwarfed shrubs, and occasionally patches of *Sphagnum* pools or lawns with *Sphagnum cuspidatum* or other aquatic peat mosses. There is sometimes a wet moat separating the peat mat from the surrounding upland. This develops from a combination of elevated nutrient levels in upland runoff and the periodic seasonal draw-down of the water table that increases the decomposition of the peat mat at the peatland margin. If a moat is not present, the outer zone is usually dominated by a peat swamp or a tall shrub fen (most commonly ***highbush blueberry - mountain holly wooded fen***).

Diagnostic natural communities are ***highbush blueberry - mountain holly wooded fen*** (S3S4), ***leatherleaf - black spruce bog*** (S3), ***leatherleaf - sheep laurel shrub bog*** (S2S3), ***montane level fen/bog*** (S2), and ***Sphagnum rubellum - small cranberry moss carpet*** (S3). Peripheral or occasional natural communities are ***large cranberry - short sedge moss lawn*** (S3), ***marshy moat*** (S4), ***mountain holly - black spruce wooded fen*** (S3), and ***water willow - Sphagnum fen*** (S3).

This system can co-occur in large peatland basins with medium level fen and peat swamp systems (e.g., black spruce, coastal conifer, or temperate peat swamps). It is common for poor level fen/bogs to have small marginal areas adjacent to water bodies or uplands that have more minerotrophic communities typical of medium fens. When these areas are limited in extent or constitute a small proportion of the peatland, they are considered inclusions within the poor level fen/bog; when they are more extensive or constitute a substantial proportion of the peatland, the peatland may best be treated as having both poor and medium level fens systems within the same wetland. Conversely, medium level fens can have areas with more limited minerotrophic influence with poor fen communities. These are treated in the same way.

DISTRIBUTION IN NEW HAMPSHIRE: Broadly distributed; largest examples in central and northern New Hampshire.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: North-Central Interior and Appalachian Acidic Peatland; Boreal-Laurentian-Acadian Acidic Basin Fen.

STRESSORS/THREATS: Threats include fragmentation, habitat displacement and degradation, invasion of non-native species, trampling, alteration of hydrology, and impacts to water quality. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Hydrologic alterations, both direct (e.g., connectivity changes, draining, channeling/ditching, diversions, and damming) and indirect (e.g., road construction and vegetation removal on adjacent slopes), can significantly degrade the ecological integrity of peatlands. Lowering the water table, or conversely increasing surface water inputs, can lead to shifts in species composition and community types. Logging in and near peatlands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Increased nutrient inputs (e.g., from nearby roads, agriculture, development, or logging) can cause this system to shift away from its natural range of variability, leading to an increase in fen and marsh species and creating opportunity for invasive plants and "weedy" native species. The related management implication is to increase the size of buffer areas and to limit or control certain activities near these wetland types. Buffers reduce the impact of disturbances outside the system and ensure that other characteristics and processes within the community remain intact. Buffers help protect natural communities from the deleterious effects of increased nutrients, reduced water quality, altered water quantity, invasion by exotic species, windthrow, loss of secondary plant or animal habitat, and future deleterious changes in surrounding land use that may increase threats over the long term. Nutrient-poor systems, such as most types of peatland, may require larger setbacks than other systems because of their high susceptibility to changes in nutrient concentrations.

GOOD EXAMPLES: Heath Pond Bog Natural Area (Ossipee and Effingham) and Red Hill Pond (Sandwich).

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SALT MARSH SYSTEM (S1)

Salt marsh system at Berry's Brook in Rye (photo by NHB staff).

OVERVIEW: Salt marsh systems occur in intertidal coastal embayments, forming narrow to broad linear vegetated bands fringing coastal shorelines (with scattered orbicular patches). Soils are marine peat; organic materials 16 to 50" thick overlying sandy materials (low marsh); organic materials >50" over sand, silt, or bedrock (high marsh); shallow peats (<16") are occasional in areas towards outer limits of salt marsh (seaward and inland). Salt marsh soil water salinity roughly corresponds to polyhaline levels (18–30 parts per thousand [ppt]); salinity levels in pannes found in the ***high salt marsh*** are typically in the range of 40–50(–60) ppt. This system is intermittently flooded and exposed by tidal fluctuation.

Low salt marshes are dominated by *Spartina alterniflora* (smooth cordgrass) and occur between mean sea level and mean high tide in areas protected from high-energy wave action. Other vascular halophytes occur in low abundance. Macroalgae (seaweed) may also be present. ***High salt marshes*** are strongly dominated by *Spartina patens* (saltmeadow cordgrass), with lesser amounts of other graminoids. ***Brackish marshes*** are often indicated by *Bolboschoenus robustus* (sea-coast tuber-bulrush), *Carex paleacea* (chaffy sedge), and *Typha angustifolia* (narrow-leaved cat-tail), among other species. ***Salt pannes and pools*** (pools are deeper) are low wet areas isolated from tidal creeks that occur in both saline and brackish marshes where they support fine-scale natural communities (less than 1m^2 to over 100 m^2). Species composition varies with salinity, hardness of substrate, elevation, soil oxygen, hydroperiod, and other factors.

VEGETATION PATTERNS: The abilities of individual plant species to tolerate the challenging combination of stresses in salt marshes dictate which plant species grow where. There are numerous factors that affect plant distribution: hydroperiod (duration and frequency of tidal flooding), soil salinity, soil oxygen, nutrient availability, elevation of substrate, concentration of growth inhibitors, storms, ice-scouring, land use history, and competitive interactions and biological facilitation between and among species. The transition between high and ***low salt marsh*** occurs approximately at the mean high water mark; from here ***high salt marsh*** stretches landward to the upper reaches of spring tides. Small salt pools and pannes are common, particularly in the high marsh. Brackish marshes occur where fresh water runoff along the upland border reduces salt concentrations to meso-haline levels.

Diagnostic natural communities are ***high salt marsh*** (S3), ***low salt marsh*** (S3), ***marsh elder shrubland*** (S1), and ***salt pannes and pools*** (S3). Peripheral or occasional natural communities are ***brackish marsh*** (S2S3) and ***coastal shoreline strand/swale*** (S2).

Salt marsh systems transition to brackish riverbank marsh upstream and sparsely vegetated intertidal towards the subtidal zone.

DISTRIBUTION IN NEW HAMPSHIRE: Occurs at Great Bay, in the Blackwater River estuary, and in other coastal embayments.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Northern Atlantic Coastal Plain Tidal Salt Marsh; Acadian Coastal Salt Marsh.

STRESSORS/THREATS: From the time of European settlement until recently, salt marshes were routinely drained by farmers to increase the productivity of salt-meadow cordgrass and spike grass for hay, pasture, mulch, and in an effort to reduce *Aedes sollicitans* (salt marsh mosquito) populations. The ecological impacts of ditching include reduced flood duration, lowered water table, and changes in species composition across many groups of organisms in the marsh (insects, mollusks, crustaceans, shorebirds, waterfowl, and plants). Stressors from climate change include loss of marsh from sea level rise, precipitation changes, and warmer temperatures and increased flooding that accelerate peat breakdown. Other human-related stressors include impacts from invasive species, insufficient tidal flow, freshwater runoff, filling, pollution, dredging for docks and marinas, and cultural eutrophication.

GOOD EXAMPLES: Reference condition examples are unknown in New Hampshire. An example with “good to fair” condition is Berry’s Brook (Rye).

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SAND PLAIN BASIN MARSH SYSTEM (S1)

Sand plain basin marsh system in southern New Hampshire (photo by Ben Kimball).

OVERVIEW: This system occurs in sand plain settings in closed shallow basins with no inlets or outlets in outwash, ice-contact deposits, and other glacio-fluvial soils. They are small patch with oval, circular, or irregular shapes and occur as single basins or as clumps of separate basins in close proximity with no or only intermittent surface water connection. Vegetation zonation is concentric.

Soils are poorly to very poorly drained sand or gravelly sand with shallow muck or sandy muck surface horizons. In contrast to peatlands in closed basins, these wetlands have widely fluctuating seasonal and annual water levels, and no or relatively little organic matter accumulation in at least a portion of the basin. Water source is topogenous (surface runoff) and groundwater influenced with a seasonally and semi-permanently flooded to intermittently exposed hydroperiod; nutrient status is oligotrophic.

As with sandy pond shores, these wetlands have infertile mineral soils and support a combination of common wetland marsh plants and uncommon stress-tolerators (including numerous coastal plain species) that are rare or infrequent in other habitats in the state. Examples with the ***meadow beauty sand plain marsh*** contain numerous rare and coastal plain species that are associated with a well-developed sandy drawdown zone.

VEGETATION PATTERNS: Concentric vegetation zonation is typical and wave and ice action is absent. Diagnostic natural communities are ***highbush blueberry - winterberry shrub thicket*** (S4), ***meadow beauty sand***

plain marsh (S1), ***meadowsweet - robust graminoid sand plain marsh*** (S3S4), ***montane sandy basin marsh*** (S1), ***sharp-flowered manna-grass shallow peat marsh*** (S1), ***spikesedge - floating-leaved aquatic mudflat marsh*** (S1), and ***three-way sedge - manna-grass mudflat marsh*** (S2S3). Peripheral or occasional natural communities are ***buttonbush shrubland*** (S4), ***pitch pine - heath swamp*** (S1S2), ***red maple - Sphagnum basin swamp*** (S4), and ***swamp white oak basin swamp*** (S1).

These systems are typically set in upland forest mosaics and thus isolated from other wetlands. Occasionally they are adjacent to temperate or coastal conifer peat swamp systems with shallow organic horizons (see peripheral or occasional natural communities).

DISTRIBUTION IN NEW HAMPSHIRE: Mostly east-central and southern New Hampshire although a few examples that lack coastal plain species can be found in the White Mountain region.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Northern Atlantic Coastal Plain Pond.

STRESSORS/THREATS: Threats include fragmentation, habitat displacement and degradation, invasion of non-native species, all-terrain vehicles, alteration of hydrology, and impacts to water quality. Hydrologic alterations, both direct (e.g., connectivity changes, draining, channeling/ditching, diversions, and damming) and indirect (e.g., road construction and vegetation removal on adjacent slopes), can significantly degrade ecological integrity. Lowering the water table, or conversely increasing surface water inputs, can lead to shifts in species composition and community types. Logging in and near these wetlands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Because they are naturally acidic and low in nutrients, they are particularly susceptible to alteration by elevated nutrient inputs. Increased nutrient inputs (e.g., from nearby roads, agriculture, development, or logging) can cause this system to shift away from its natural range of variability, creating opportunity for invasive plants and "weedy" native species. The related management implication is to increase the size of buffer areas and to limit or control certain activities near these wetland types. Buffers reduce the impact of disturbances outside the system and ensure that other characteristics and processes within the community remain intact. Buffers help protect natural communities from the deleterious effects of increased nutrients, reduced water quality, altered water quantity, invasion by exotic species, windthrow, loss of secondary plant or animal habitat, and future deleterious changes in surrounding land use that may increase threats over the long term. Nutrient-poor systems may require larger setbacks than other systems because of their high susceptibility to changes in nutrient concentrations.

GOOD EXAMPLES: Reference condition examples are unknown in New Hampshire. Examples with "fair" condition are Grassy Pond and Rocky Hill Pond (Litchfield). Good examples of ***montane sandy basin marsh*** occur at Bragdon Ledge and Sugarloaf Basins (Albany).

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SANDY POND SHORE SYSTEM (S1)

Sandy pond shore system on Ossipee Lake in Ossipee (photo by Dan Sperduto).

OVERVIEW: The sandy pond shore system occurs in association with sand plain regions and occasionally along lakes in till settings where there is a local accumulation of sand along the shore. They form narrow-linear patches with narrow zonation parallel to shoreline. Soils are sand and gravel, sometimes peaty sands and poorly to very poorly drained. This system is oligotrophic and ranges from seasonally and semi-permanently flooded to permanently flooded.

While these wetlands do contain many common wetland species, a high proportion of the plants present are stress-tolerators, and many have coastal plain affinities and are restricted to pond shores or basin marshes in New Hampshire. Sand and gravel shores of lakes in ponds in the White Mountains and North Country have some floristic and geomorphic similarities, but lack coastal plain and southern species. Further sampling and evaluation of these examples is needed to determine if they warrant consideration as separate systems.

VEGETATION PATTERNS: These shores are a stressful environment for plants to grow due to the infertile mineral soil, widely fluctuating water levels, and regular wave action and ice scouring. Narrow vegetation zones are strung parallel to the shoreline and relate to elevation above the lake and degree of wave and ice disturbance (ranging from shrub border to ***aquatic beds***). The primary natural community types of this system are the ***bulblet umbrella-sedge open sandy pond shore*** and ***water lobelia aquatic sandy pond shore***. Examples with peaty sand development occur on only a few lakes (including Ossipee Lake) and are characterized by the ***twig-rush sandy***

turf pond shore community with a high diversity of rare coastal plain species. A few examples on Ossipee Lake have the rare ***hudsonia inland beach strand*** community, characterized by sand plain species on a dry beach ridge.

Diagnostic natural communities are ***bayonet rush emergent marsh*** (S2), ***bulblet umbrella-sedge open sandy pond shore*** (S2), ***hudsonia inland beach strand*** (S1), ***montane sandy pond shore*** (S1), ***sweet gale - alder shrub thicket*** (S3), ***twig-rush sandy turf pond shore*** (S1), and ***water lobelia aquatic sandy pond shore*** (S2).

Sandy pond shores are always associated with ponds, lakes and adjacent, upland forest. It is sometimes associated with poor to medium level fen and drainage marsh - shrub swamp systems that typically occur behind a sandy berm or on lower-energy sections of shoreline.

DISTRIBUTION IN NEW HAMPSHIRE: Mostly east-central and southern New Hampshire, occasional further north.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Lakeshore Beach.

STRESSORS/THREATS: Threats include fragmentation, habitat displacement and degradation, invasion of non-native species, aquatic plant control, recreation (e.g., boating, beachgoers, and all-terrain vehicles), managed water levels, and impacts to water quality. Because they are naturally acidic and low in nutrients, they are particularly susceptible to alteration by elevated nutrient inputs from nearby roads, agriculture, development, logging, etc.

GOOD EXAMPLES: Reference condition examples are unknown in New Hampshire. Examples with “fair” condition include Ossipee Lake (Ossipee) and Massabesic Lake (Manchester and Auburn). Good examples of ***montane sandy pond shores*** occur at Gentian Pond (Success), Greeley Ponds (Livermore), Umbagog Lake (Errol), and Lily Pond (Livermore).

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SPARSELY VEGETATED INTERTIDAL SYSTEM (S1S2)

Sparsely vegetated intertidal system at Great Bay National Wildlife Refuge (photo by Ben Kimball).

OVERVIEW: The sparsely vegetated intertidal system corresponds to intertidal areas with sparse vascular vegetation that occur between salt marsh, brackish marsh or upland systems landward and subtidal systems seaward. It is found in partially protected, intertidal coastal embayments, where it can form large patches with narrow-linear to extensive fringes and uniform or narrow zonation parallel to shore.

Soils are fine to coarse mineral and rocky substrates: ***coastal shoreline strand/swales*** on coarse to fine mineral sediments; ***intertidal rocky shores*** on rocky or cobbly materials; and ***intertidal flats*** on broad to narrow, nearly flat extents of sand, mud, and silt. This moderately to strongly minerotrophic system is intermittently flooded and exposed by tidal salt water that is diluted by fresh water flowing in from the watershed above. Vascular plant cover is sparse to generally no more than 25%.

VEGETATION PATTERNS: Diagnostic natural communities are ***coastal shoreline strand/swale*** (S2), ***intertidal rocky shore*** (S3), and ***intertidal flat*** (S3). ***Coastal shoreline strand/swales*** are flooded less than daily and are often characterized by plant stems and other detritus washed in on the higher tides and covering much of the substrate surface. These upper intertidal areas form either large patches or narrow strands along protected low-energy shorelines and are important habitat for various arthropods, shore birds, and other animals. ***Intertidal rocky shores*** are on open stretches of estuarine rivers and streams or quiet, partially enclosed shores. They are flooded daily by tides. Macroalgae are often common on bedrock and rubble including *Ascophyllum* *nodosum* (knotted wrack) on larger outcrops and *Fucus vesiculosus* (bladder wrack) on less stable strata. Rocky shores may form large patches or narrow strands below the upper intertidal shoreline and are important habitat for various arthropods, predatory fish, wading birds, mud snails, and other animals. ***Intertidal flats*** are gently sloping, sparsely vegetated areas between salt or brackish marshes landward and subtidal communities seaward (including tidal creek channels). They form in depositional environments protected from high-energy wave action along the coast behind rocky spits, barrier beaches, and sand bars or along bays and rivers.

This system occurs between the salt marsh system, brackish riverbank marsh system, or upland communities landward, and the subtidal system seaward.

DISTRIBUTION IN NEW HAMPSHIRE: Restricted to the Great Bay estuarine complex, tidal coastal rivers, and other tidal embayments.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: North Atlantic Intertidal Mudflat; North Atlantic Tidal Sand Flat.

STRESSORS/THREATS: Human-related stressors include impacts from invasive species, altered hydrology, sea level rise, freshwater runoff, filling, pollution, increased sediments, cultural eutrophication, dredging, unsustainable shellfishing, shoreline manipulation like retaining walls, and docks and marinas.

GOOD EXAMPLES: Reference condition examples are unknown in New Hampshire. An example with "good to fair" condition occurs at Great Bay.

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SUBTIDAL SYSTEM (S2)

Subtidal system at the southern edge of Great Bay (photo by Ben Kimball).

OVERVIEW: This system corresponds to continuously-submerged areas in association with the lowest portions of coastal embayments, where it can form extensive subtidal patches. Mineral sediments and mud are permanently flooded by salt water diluted by fresh water flowing in from the watershed above.

In New Hampshire, subtidal systems include the ***eelgrass bed*** community and other (currently unclassified) aquatic communities on the bottoms of estuarine creeks, channels, and bays. The system performs important ecological functions including supporting oyster, eelgrass, and flounder populations, providing refuge for fish and invertebrates that retreat from exposed eelgrass beds, intertidal flats, and estuarine marshes at low tide, and serving as spawning and nursery areas for numerous species of aquatic animals (Short 1992).

VEGETATION PATTERNS: Vascular plants are typically absent or sparse in this system. Seaweeds are an important component of channel/bay bottoms and their surrounding environments. A total of 169 seaweed species have been documented as occurring in the Great Bay Estuary. ***Eelgrass beds*** dominated by *Zostera marina* (eel-grass) occur in estuarine waters, on mud rich in organic matter, or on sand bottoms. This rooted aquatic vascular plant covers nearly half of the bottom of Great Bay (2,585 acres). ***Eelgrass beds*** trap sediments, dissolved nutrients, and larval organisms flowing through the community and are an important contributor to ecosystem health and productivity. They serve as breeding, nursery, and feeding areas for many species of fish and invertebrates. ***Eelgrass beds*** also provide foraging grounds for waterfowl and wading birds that feed on the eelgrass or the fish and invertebrates the beds harbor.

New Hampshire's subtidal systems are bordered landward by the sparsely-vegetated intertidal system and seaward (beyond channel mouths) by marine environments.

DISTRIBUTION IN NEW HAMPSHIRE: Restricted to the Great Bay estuarine complex, tidal coastal rivers, and other tidal embayments.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Northern Atlantic Coastal Plain Seagrass Bed.

STRESSORS/THREATS: Human-related stressors include impacts from sea level rise, marinas, dredging, freshwater runoff, filling, pollution, increased sediments, and cultural eutrophication.

GOOD EXAMPLES: Reference condition examples are unknown in New Hampshire. An example with "good to fair" condition occurs at Great Bay.

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TEMPERATE MINEROTROPHIC SWAMP SYSTEM (S3S4)

Temperate minerotrophic swamp system at Paul Brook Swamp in Newington (photo by Ben Kimball).

OVERVIEW: The temperate minerotrophic swamp system occurs in depressional headwater basins, drainage ways, sloping mineral soils around open wetlands, and adjacent to pond and lake basins. It forms small to large patches that are circular-oval or irregular in shape. Vegetation patterns are uniform, sometimes with shrubby openings or surrounding open wetlands.

Soils range from examples with shallow organic layers over silty or sandy mineral soils and apparent seepage influence to sometimes relatively shallow, well decomposed peat. The system is moderately to strongly minerotrophic with pH values in the 5s and 6s. The group of communities associated with this system contains very poorly to poorly drained saturated, seasonally saturated, and seasonally flooded swamps, including seepage and mixed-hydrology swamps. Mixed-hydrology swamps have some combination of water inputs from groundwater, upland runoff, precipitation, and overbank flow, but are not dominated by any single one of those sources.

Native plant species composition is dominated by *Acer rubrum* (red maple), with lesser quantities of other hardwoods [*Fraxinus nigra* (black ash), *Betula alleghaniensis* (yellow birch)] and occasional conifers, particularly *Tsuga canadensis* (hemlock). Many of the species found in temperate peat swamps can also be found in this system, including southern and coastal species, but species indicative of moderately to strongly minerotrophic conditions are diagnostic. Northern conifers, shrubs, and herbs of montane/near-boreal swamps are absent or sparse. The shrub layer is typically well developed, as are the herb and bryophyte layers, which are also quite diverse. *Sphagnum* mosses are usually in relatively low abundance compared to temperate peat swamp systems, but can be abundant in particularly seepy locations. These swamps support a substantial non-*Sphagnum* bryophyte layer. Strongly sloping examples on seepy silty soils often can have a great deal of black ash, *Carex lacustris* (lake sedge), or *Symplocarpus foetidus* (skunk-cabbage).

VEGETATION PATTERNS: The ***red maple - sensitive fern swamp*** community is the most common swamp type in this system. The temperate minerotrophic swamp system also includes other more common minerotrophic swamp types as well as seepage swamps. Shrubby openings are common in these swamps. This system is often bordered by ***hemlock - cinnamon fern*** or ***red maple - red oak - cinnamon fern forests*** that are intermediate between swamp and upland forest. Examples that transition to emergent marshes (drainage marsh - shrub swamp) may contain ***seasonally flooded red maple swamp*** and those that transition to peatlands may contain ***red maple - Sphagnum basin swamp*** (temperate peat swamp system).

Diagnostic natural communities are ***highbush blueberry - winterberry shrub thicket*** (S4), ***red maple - black ash swamp*** (S3), ***red maple - lake sedge swamp*** (S3), ***red maple - sensitive fern swamp*** (S3S4), and ***red maple - skunk cabbage swamp*** (S2). Peripheral or occasional natural communities are ***alder seepage thicket*** (S3), ***hemlock - cinnamon fern forest*** (S4), ***red maple - elm - lady fern silt forest*** (S1S2), ***red maple - red oak - cinnamon fern forest*** (S3S4), ***red maple - Sphagnum basin swamp*** (S4), and ***seasonally flooded red maple swamp*** (S4S5).

DISTRIBUTION IN NEW HAMPSHIRE: Widespread south of the White Mountains.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: North-Central Interior and Appalachian Rich Swamp.

STRESSORS/THREATS: Development threats include fragmentation, habitat displacement and degradation, invasion of non-native species, alterations of flood regimes, and impacts to water quantity and quality (including pollution, eutrophication, and reduction through withdrawal). Impervious surfaces and other alterations to surrounding landcover can affect hydrology and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Logging of forested wetlands may impact hydrologic patterns and alter habitat for forest-restricted species. Regionally, there has been a tendency towards younger, second-growth swamp forests in the region. Logging of adjacent uplands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Paul Brook Swamp (Newington).

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TEMPERATE MINOR RIVER FLOODPLAIN SYSTEM (S3)

Temperate minor river floodplain system along the Lamprey River (photo by Ben Kimball).

OVERVIEW: The temperate minor river floodplain system occurs on floodplains (above bankful) along moderate-gradient and low-gradient sections of minor rivers and large streams. They can form extensive broad-linear patches parallel to riverbanks or corresponding to floodplain terracing and oxbow, slough, or over-flow channel formations. The temporarily flooded soils are sandy to silty alluvium (loamy sand, sandy loam, silt loams). Compared to their major river counterparts, minor river floodplains appear to have reduced flood intensity, duration, and earlier peak floods due to absence or reduced importance of mountain snow-pack meltwater.

Low, medium, and high floodplain variants are marked by shifts in abundance of species preferential to wetter or drier conditions. Invasive plants are problematic in many examples of this system, particularly *Celastrus orbiculatus* (Asian bittersweet) and *Berberis thunbergii* (Japanese barberry).

VEGETATION PATTERNS: This system is indicated by the dominance of ***red maple floodplain forest*** and occasionally other types (e.g., sycamore, swamp white oak, and balsam fir), often in a mosaic with oxbow marshes, vernal pools, and floodplain meadows and thickets. Canopies of these forests are strongly dominated by *Acer rubrum* (red maple), and the understory ranges from open to viny and somewhat shrubbier than silver maple floodplains, with an abundance of ferns. Silver maple floodplain forests may form narrow borders or small patches, but do not dominate extensive areas as they do along the main-stems of major rivers. This system includes ***swamp white oak floodplain forests*** restricted to silty alluvial and marine sediments in the coastal region. Low, medium, and high floodplain variants are distinguishable in many occurrences, which correspond to slightly different elevations and thus flood return intervals.

Diagnostic natural communities are ***red maple floodplain forest*** (S2S3), ***silver maple - false nettle - sensitive fern floodplain forest*** (S2), ***swamp white oak floodplain forest*** (S1), ***sycamore floodplain forest*** (S1), ***alder alluvial shrubland*** (S3), ***alder - dogwood - arrowwood alluvial thicket*** (S4), ***meadowsweet alluvial thicket*** (S3S4), ***herbaceous riverbank/floodplain*** (S4), ***bluejoint - goldenrod - virgin's bower riverbank/floodplain*** (S3S4), and ***emergent marsh*** (S5) – in oxbows. Peripheral or occasional natural communities are ***balsam fir floodplain/silt plain*** (S2) and ***buttonbush shrubland*** (S4) – in oxbows.

This system frequently occurs in association with low-gradient silty-sandy riverbank systems and less commonly with moderate-gradient sandy-cobbly riverbanks.

DISTRIBUTION IN NEW HAMPSHIRE: Found along major streams and minor rivers throughout central and southern New Hampshire, including the tributaries of the Merrimack and Connecticut Rivers and smaller rivers in the Piscataqua and Ossipee River watersheds.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: Laurentian-Acadian Floodplain Forest; Central Appalachian Stream and Riparian.

STRESSORS/THREATS: Floodplain systems have been fragmented and impacted by agriculture, timber harvesting, development, river channelization, dam construction, and invasives. Impervious surfaces and other alterations to surrounding landcover can affect flow and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Pine River (Ossipee and Effingham).

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TEMPERATE PEAT SWAMP SYSTEM (S3S4)

Temperate peat swamp system at Fox State Forest in Hillsborough (photo by Ben Kimball).

OVERVIEW: The temperate peat swamp system occurs in closed or stagnant, open headwater basins with limited drainage, often in depressions in glacial outwash or ice-contact deposits or lake or pond basins away from the influence of lake water. They form small to large patches, circular to irregular in shape, with uniform vegetation patterns or forming exterior zone around open peatlands (sometimes in mosaics with more open peatlands). The permanently saturated to seasonally flooded soils are deep, moderately well decomposed peat. ***Red maple - Sphagnum basin swamp***, the typical community found in this system, is usually a peatland (>40 cm organic matter) but sometimes occurs on mineral soils with a histic epipedon (shallow organic layer <40 cm) where there may be more seasonal water fluctuations than in deep peat settings. Mineral histic examples may occupy the entire swamp basin, or more commonly just the swamp areas marginal to uplands where organic accumulation is less. This system is oligotrophic to weakly minerotrophic with pH values generally less than 5.3 (as low as 3.7), although pH and trophic levels can be higher around the system margins where there is a shift in natural community type.

Native plant species composition is dominated by *Acer rubrum* (red maple) with variable amounts of conifers and other hardwoods. *Picea rubens* (red spruce) is a common but minor associate, but otherwise northern conifers are absent or sparse, particularly in southern New Hampshire. The tall shrub layer is well developed and dominated by *Vaccinium corymbosum* (highbush blueberry) and *Ilex verticillata* (common winterberry). An abundance of peat mosses (*Sphagnum* spp.), *Osmundastrum cinnamomeum* (cinnamon fern), and other herbs are characteristic. It is characterized by oligotrophic to weakly minerotrophic conditions, and therefore lacks minerotrophic indicators (although sometimes found around the margins) indicative of temperate minerotrophic swamps, such as *Onoclea sensibilis* (sensitive fern), *Toxicodendron radicans* (poison-ivy), *Lindera benzoin* (northern spicebush), and *Fraxinus nigra* (black ash). More southern or low elevation examples are more likely to contain species restricted to coastal or southern parts of the state.

VEGETATION PATTERNS: ***Red maple - Sphagnum basin swamp*** is the typical community found in this system. Patches of tall shrub fens (<25% tree cover) are common as part of the swamp mosaic; where these tall shrub fens become extensive, they may be considered part of an adjacent open peatland system. The transition to upland forests in this swamp system is often marked by a border of ***hemlock - cinnamon fern forest*** or ***red maple - red oak - cinnamon fern forest***. Diagnostic natural communities are ***black gum - red maple basin swamp*** (S3), ***highbush blueberry - mountain holly wooded fen*** (S3S4), ***highbush blueberry - winterberry shrub thicket*** (S4), ***red maple - Sphagnum basin swamp*** (S4), ***swamp white oak basin swamp*** (S1), and ***winterberry - cinnamon fern wooded fen*** (S4). Peripheral or occasional natural communities are ***hemlock - cinnamon fern forest*** (S4), ***red maple - pitch pine - cinnamon fern forest*** (S1S2), ***red maple - red oak - cinnamon fern forest*** (S3S4), ***red maple - sensitive fern swamp*** (S3S4), ***red spruce swamp*** (S3), and ***seasonally flooded red maple swamp*** (S4S5).

This swamp system may be found around some poor level fen/bog and kettle hole bog systems, and in association with coastal conifer peat or temperate minerotrophic swamp systems, particularly in larger swamp systems that encompass a broad range of wetland conditions.

DISTRIBUTION IN NEW HAMPSHIRE: Found in central and southern New Hampshire.

NATURESERVE ECOLOGICAL SYSTEM CROSSWALK: North-Central Appalachian Acidic Swamp.

STRESSORS/THREATS: Development threats include fragmentation, habitat displacement and degradation, invasion of non-native species, alterations of flood regimes, and impacts to water quantity and quality (including pollution, eutrophication, and reduction through withdrawal). Impervious surfaces and other alterations to surrounding landcover can affect hydrology and degrade water quality through siltation and pollutants such as fertilizers, pesticides, and road residue. Trampling can impact hummock/hollow microtopography, create permanent trails, and kill plants. Logging of forested wetlands may impact hydrologic patterns and alter habitat for forest-restricted species. Regionally, there has been a tendency towards younger, second-growth swamp forests in the region. Logging of adjacent uplands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation. Naturally acidic, low-nutrient wetland types are particularly susceptible to alteration by elevated nutrient inputs. Residential and industrial pollution, including road, sewage, and agricultural runoff, are sources of nutrients and pollutants that may result in eutrophication. The management implication is to increase the size of buffer areas and limit or control certain activities near these wetland types. The importance of beaver flowages for supporting a variety of habitats for wetland-dependent flora and fauna is well established. However, impacts to natural community types previously unimpacted by beavers may be on the rise. Wetland loss from human encroachment increases the likelihood that the remaining wetland basins will be converted to beaver flowages. Larger beaver populations may further intensify the problem. The recent loss of many Atlantic white cedar and black gum swamps in the southeastern portion of the state where human encroachment is greatest may be examples of this possible trend. Combinations of different types of stressors together with their scope and severity determine the degree to which a system's ecological integrity shifts from a natural condition toward more degraded conditions.

GOOD EXAMPLES: Pawtuckaway State Park (Nottingham) and Fox State Forest (Hillsboro).

Appendix 1. Explanation Of Global And State Conservation Status Rank Codes

These rank codes describe the degree of vulnerability of an element of biodiversity (species, natural community, or natural community system) to extirpation, either throughout its range (global or "G" rank) or within a subnational unit such as a state (subnational or "S" rank). For species, the vulnerability of a subspecies or variety is indicated with a taxon ("T") rank. For example, a G5T1 rank for a subspecies indicates that the subspecies is critically imperiled (T1) while the species is secure (G5).

Code	Examples		Description
1	G1	S1	Critically imperiled because of extreme rarity (e.g., one to five occurrences), very restricted range, very steep recent declines, or other factors making it extremely vulnerable to extirpation.
2	G2	S2	Imperiled due to very few occurrences (e.g., six to 20), restricted range, steep recent declines, or other factors making it very vulnerable to extirpation.
3	G3	S3	Vulnerable due to relatively few occurrences (e.g., 21 to 80), relatively restricted range, recent declines, or other factors making it vulnerable to extirpation.
4	G4	S4	Apparently secure due to having more than a few occurrences (e.g., >80) and/or an extensive range, but possible cause for long-term concern due to local recent declines or other factors.
5	G5	S5	Secure; widespread and abundant.
U	GU	SU	Status uncertain. More information needed.
H	GH	SH	Known only from historical records (e.g., a species not reported as present within the last 20 years or a community or system that has not been reported within 40 years).
X	GX	SX	Believed to be extinct. May be rediscovered, but habitat alteration or other factors indicate rediscovery is unlikely.

Modifiers are used as follows:

Code	Examples		Description
Q	G5Q	GHQ	Questions or problems may exist with the element's taxonomy or classification, so more information is needed.
?	G3?	3?	The rank is uncertain due to insufficient information at the global level, so more inventories are needed. When no rank has been proposed the global rank may be "G?" or "G5T?".

When ranks are somewhat uncertain or the element's status appears to fall between two ranks, the ranks may be combined. For example:

G4G5	The element rank is either 4 or 5, or its rank is near the border between the two.
G5T2T3	For a plant or animal, the species is globally secure (G5), but the subspecies is vulnerable or imperiled (T2T3).
G5?Q	The element seems to be secure globally (G5), but more information is needed to confirm this (?). Further, there are questions or problems with the element's taxonomy or classification (Q).
G3G4Q S1S2	The element is globally vulnerable or apparently secure (G3G4), and there are questions about its taxonomy or classification (Q). In the subnation, the element is imperiled or critically imperiled (S1S2).

APPENDIX 2. EXPLANATION OF STATE LISTING CODES

In 1987, the New Hampshire state legislature passed the Native Plant Protection Act (RSA 217-A) and formally recognized that "for human needs and enjoyment, the interests of science, and the economy of the state, native plants throughout this state should be protected and conserved; and . . . their numbers should be maintained and enhanced to insure their perpetuation as viable components of their ecosystems for the benefit of the people of New Hampshire." To compile a list of the species requiring protection, the NH Natural Heritage Bureau collaborated with knowledgeable botanists and identified the most imperiled taxa as "endangered" and those likely to become endangered as "threatened." The most recent revision to the list was completed in 2010.

In addition to endangered and threatened, state watch and indeterminate categories exist for taxa appearing vulnerable to extirpation where current information does not justify designating them endangered or threatened.

Endangered (E): Native plant taxa vulnerable to extirpation based on having five or fewer natural occurrences in the state observed within the last 20 years, or taxa with more than five occurrences that are, in the judgment of experts, vulnerable to extirpation due to other important rarity and endangerment factors (population size and trends, area of occupancy, overall viability, geographic distribution, habitat rarity and integrity, and/or degree of protection). A rare native plant taxon that has not been observed in over 20 years is considered endangered unless there is credible evidence that all previously known occurrences of the taxon in the state have been extirpated.

Threatened (T): Native plant taxa vulnerable to becoming endangered based on having 6–20 natural occurrences in the state observed within the last 20 years, or taxa that are, in the judgment of experts, vulnerable to becoming endangered due to other important rarity and endangerment factors (population size and trends, area of occupancy, overall viability, geographic distribution, habitat rarity and integrity, and/or degree of protection).

Watch (W): Native plant taxa vulnerable to becoming threatened based on having 21–80 natural occurrences in the state observed within the last 20 years, or taxa that are, in the judgment of experts, vulnerable to becoming threatened due to other important rarity and endangerment factors (population size and trends, area of occupancy, overall viability, geographic distribution, habitat rarity and integrity, and/or degree of protection).

Indeterminate (Ind): Plant taxa under review for listing as endangered, threatened, or watch, but their rarity, nativity, taxonomy, and/or nomenclature are not clearly understood.

Rare (endangered and threatened) species listed in this document are noted by an asterisk (*).

APPENDIX 3. KEY TO WETLAND SYSTEMS IN NEW HAMPSHIRE

1a. Tidal systems
  2a. Vascular plant cover moderate to high
    3a. Supratidal; isolated brackish basin marshes (regularly receive fresh water plus salt water during severe storms from overwash or berm infiltration)…………………………………….. ....**Coastal salt pond marsh system**
    3b. Intertidal; marshes with regular tidal flooding
      4a. Marshes with moderate to high salinities (18-50 ppt) ………………...………...…………………....**Salt marsh system**
      4b. Marshes with lower salinities (0.5-18 ppt)…………………..**Brackish riverbank marsh system**
  2b. Sparsely vegetated to unvegetated
    5a. Intertidal…………..……………….. .... **Sparsely vegetated intertidal system**
    5b. Subtidal………………..……………..…….. **Subtidal system**
1b. Non-tidal systems
  6a. Forested floodplains and open riverbanks and shores
    7a. Open systems below bankfull
      8a. Low gradient riverbanks; substrate silty to sandy..……………………...……**Low-gradient silty-sandy riverbank system**
      8b. Moderate- to high-gradient riverbanks; substrate sandy to rocky
        9a. Moderate gradient riverbanks; substrate sand, gravel, and cobble.**Moderate-gradient sandy-cobbly riverbank sys.**
        9b. High-gradient riverbanks; substrate boulders and bedrock……. …………..**High-gradient rocky riverbank system**
    7b. Forested systems above bankfull
      10a. Floodplains of montane and n. NH rivers; sugar maple or balsam fir are diagnostic; when silver maple present, not dominant
      and may be limited to river edges…………………………………………....................**Montane/near-boreal floodplain system**
      10b. Floodplains of c. and s. NH rivers
        11a. Forests of major rivers; silver maple dominant………………………..**Major river silver maple floodplain system**
        11b. Forests of minor rivers; red maple dominant (occasionally sycamore or swamp white oak) ....…... **Temperate minor river floodplain system**
  6b. Wetlands not directly associated with rivers or large streams (third order or higher)
    12a. Peatlands; organic soils (muck or fibrous peat >16" deep); hummocks and hollows often well developed; *Sphagnum* mosses almost always present, often abundant; sedges or heath shrubs usually more abundant than grasses and forbs
      13a. Peat swamps (tree cover >25%)
        14a. Nutrient-rich peat swamps in n. NH with northern white cedar .... ………………………………....................................... **Montane/near-boreal minerotrophic peat swamp system**
        14b. Nutrient-poor peat swamps, generally without northern white cedar or black ash
          15a. Peat swamps dominated by hardwoods .... **Temperate peat swamp system**
          15b. Peat swamps dominated by conifers
            16a. Peat swamps in c. and s. NH; dominated by Atlantic white cedar or occasionally pitch pine ……………………….. ....**Coastal conifer peat swamp system**
            16b. Peat swamps in c. and n. NH; dominated by black spruce (eastern larch and red spruce occasional to locally abundant)……… ....**Black spruce peat swamp system**
      13b. Open peatlands (trees cover <25%)
        17a. Peatlands usually above 2,500'
          18a. Nutrient-poor peatlands in subalpine and alpine areas…...................................**Alpine/subalpine bog system**
          18b. Weakly enriched sloping fens in montane settings …. ....**Montane sloping fen system**
        17b. Peatlands usually below 2,500'
          19a. Peatlands patterned; only in extreme n. NH…………………….. ....**Patterned fen system**
          19b. Peatlands not patterned
            20a. Nutrient-rich peatlands
              21a. Weakly to moderately enriched peatlands ...…………………………….…..…..**Medium level fen system**
              21b. Strongly enriched peatlands; only in n. NH…………………………...**Calcareous sloping fen system**
            20b. Nutrient-poor peatlands
              22a. Peatlands in kettle holes, usually lack significant inlet or outlet stream; *Cladopodiella fluitans* mud
              bottoms usually present ……………… ....**Kettle hole bog system**
              22b. Peatlands usually with inlet or outlet stream; mud bottoms usually not present .... ……………………………………………………………………….**Poor level fen/bog system**
    12b. Wetlands on mineral or muck soils (fibrous peat absent or <16" deep); hummocks and hollows usually poorly developed; *Sphagnum* mosses if present, generally not abundant; sedges and heath shrubs usually less abundant than grasses and forbs

23a. Open nutrient-poor wetlands in sand plain settings along lake/pond shores or closed basins with widely fluctuating water levels

24a. Wetlands on sandy shores………… .... **Sandy pond shore system**

24b. Wetlands in shallow, closed basins with widely fluctuating water levels…………..**Sand plain basin marsh system**

23b. Nutrient-rich wetlands (forest, shrubland, or herbaceous)

25a. Open wetlands……………………. .... **Drainage marsh - shrub swamp system**

25b. Forested swamps

26a. Small (<5 ac) forested wetlands at slope bases or along drainages; characterized by seepage ……………………………………. ....**Forest seep/seepage forest system**

26b. Larger forested wetlands, not characterized by seepage

27a. Mosaic of wetland and upland softwood forest; mostly n. of White Mts ………………………………………………………………….**Lowland spruce - fir forest/swamp system**

27b. Primarily hardwood swamps……………………………..…**Temperate minerotrophic swamp system**