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Vegetation Map for the Seboeis Unit of Katahdin Woods and Waters National Monument

Scientific Investigations Report 2022–5078

U.S. Department of the Interior
U.S. Geological Survey

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By Andrew C. Strassman, Kevin D. Hop, Stephanie R. Sattler, Justin Schlawin, and Don Cameron

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Ecological site data are not currently available from the Maine Natural Areas Program (MNAP). These data are cited as MNAP (unpub. data, 2018) within the body of this report. Contact the MNAP for further information.

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All digital photographs in this report are by authors of or contributors to this report unless otherwise specified.

Contents

Figures

Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square hectometer (hm^2)	2.471	acre
square kilometer (km^2)	247.1	acre

Multiply	By	To obtain
square centimeter (cm^2)	0.001076	square foot (ft^2)
square meter (m^2)	10.76	square foot (ft^2)
square centimeter (cm^2)	0.1550	square inch (ft^2)
square hectometer (hm^2)	0.003861	section (640 acres or 1 square mile)
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the Universal Transverse Mercator (UTM), Zone 19 North, by using the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations

3D	three-dimensional
AA	accuracy assessment
CBRN	Barren Land map class
CDVA	Developed Area map class
FBST	Black Spruce - Tamarack Bog map class
FFHG	High-gradient Hardwood Floodplain Forest map class
FFTH	Terrace Hardwood Floodplain Forest map class
FHRS	Red Spruce - Northern Hardwood Forest map class
FHSH	Hemlock - Spruce - Hardwood Forest map class
FHWP	Northern Hardwood - White Pine Forest map class
FLSF	Low-Elevation Spruce - Fir Forest map class
FNHW	Northern Hardwood Forest map class
FPHS	White Pine - Hemlock - Red Spruce Forest map class
FRWP	White Pine - Red Pine Forest map class
FSFS	Northern Appalachian Spruce - Fir Swamp Forest map class
FSHC	Hardwood - Conifer Seepage Forest map class
FSRM	Red Maple Swamp and Fen map class
FSWC	Northern White-cedar Swamp map class
FXAB	Ruderal Aspen - Birch Woodland map class
FXNH	Ruderal Sugar Maple - Northern Hardwood Forest map class
FXSH	Successional Mixed Spruce - Fir - Hardwood Forest map class
GIS	geographic information system
GPS	Global Positioning System
HAWL	Water-lily Aquatic Wetland map class
HMBF	Herbaceous Mixed Graminoid and Shrub Bog and Fen map class
HMGS	Herbaceous Graminoid Sedge Marsh map class
HNCS	Northeastern Temperate Cobble Scour Rivershore map class
HOWM	Open Water Marsh with Mixed Submergent/Emergent Vegetation map class
KAWW	Katahdin Woods and Waters National Monument
MMU	minimum mapping unit
MNAP	Maine Natural Areas Program
NAD 83	North American Datum of 1983
NOSR	Open Water Stream & River map class
NOWL	Open Water Lake map class

NOWP	Open Water Pond map class
NPS	National Park Service
NRPP	Natural Resource Preservation Program
NVCS	National Vegetation Classification Standard
SMML	Oligotrophic Peatland Moss Lawn map class
SMSL	Sweetgale - Leatherleaf Shrub Marsh map class
SSAL	Alder Shrub Swamp map class
SXNE	Ruderal Mesic Old-field and Shrubland map class
SXSM	Ruderal Steeplebush / Reed Canarygrass Wet Shrubland map class
UMESC	Upper Midwest Environmental Sciences Center
USGS	U.S. Geological Survey
USNVC	U.S. National Vegetation Classification
UTM	Universal Transverse Mercator
VMI	Vegetation Mapping Inventory
WCRS	Mixed Conifer Ridge and Slope Woodland map class

Vegetation Map for the Seboeis Unit of Katahdin Woods and Waters National Monument

By Andrew C. Strassman,[1] Kevin D. Hop,[1] Stephanie R. Sattler,[1] Justin Schlawin,[2] and Don Cameron[2]

Abstract

The Katahdin Woods and Waters National Monument, located in the forests of central Maine, is a newly (2016) established unit for the National Park Service. To better understand the condition of lands within the monument and inform management planning, Katahdin Woods and Waters National Monument resource managers wanted better information of the vegetation present within the monument. To meet this need, scientists at the U.S. Geological Survey Upper Midwest Environmental Sciences Center worked with ecologists at the Maine Natural Areas Program to catalog and map the vegetation of the Seboeis Unit of the monument. This report details this process, provides results of the survey and mapping efforts, presents results in the form of a vegetation map for the Seboeis Unit, and provides vegetation descriptions and a dichotomous key for the entire Katahdin Woods and Waters National Monument.

Introduction

The Katahdin Woods and Waters National Monument (KAWW) in central Maine (fig. 1) was officially established as a National Monument on August 24, 2016, to "protect approximately 87,500 acres, including the stunning East Branch of the Penobscot River and a portion of the Maine Woods that is rich in biodiversity and known for its outstanding opportunities to hike, canoe, hunt, fish, snowmobile, snowshoe and cross-country ski" (White House, 2016). The KAWW is composed of 11 units including the Seboeis Unit, which is in the northeast part of the KAWW. This unit covers about 4,851 hectares (ha) and has vegetation representative of the rest of the KAWW.

To better understand the condition of lands within the KAWW and inform management planning, KAWW resource managers desired better information of the vegetation present within the KAWW. To meet this need, scientists at the U.S. Geological Survey (USGS) Upper Midwest Environmental Sciences Center (UMESC) worked with ecologists at the Maine Natural Areas Program (MNAP) to catalog and map the vegetation of the Seboeis Unit of the KAWW as part of a vegetation mapping project.

Katahdin Woods and Waters National Monument Seboeis Unit Vegetation Mapping Project

The KAWW Seboeis Unit vegetation mapping project was started in the fall of 2019 through funds allocated from the USGS Natural Resource Preservation Program (NRPP) to classify and map vegetation types of the Seboeis Unit, thereby providing resource managers and biological researchers with useful baseline vegetation information. A previous vegetation mapping project for the Appalachian National Scenic Trail, which terminates on Mount Katahdin less than 8 kilometers (km) from the Monument boundary, provided a starting point for vegetation classification within the KAWW along with a working template for the field key to vegetation (Hop and others, 2017a).

The project boundary extent for the KAWW Seboeis Unit vegetation mapping project is shown in figure 1. The project boundary includes just the Seboeis Unit covering about 4,855 ha of the Monument's about 36,170 ha.

A detailed study plan for the KAWW Seboeis Unit vegetation mapping project was approved by the NRPP and National Park Service (NPS) in 2018. The study plan draws on aspects of the "12-Step Guidance for NPS Vegetation Inventories" (National Park Service, 2013) to create a plan for mapping vegetation at the KAWW to NPS standards while modifying the process to fit within the 3-year limit of an NRPP proposal.

Classification of Vegetation

The vegetation classification for the KAWW Seboeis Unit vegetation mapping project was developed in 2019 by MNAP staff with contributions from UMESC and NatureServe staff but derived from the existing classification created for the northern part of the Appalachian National Scenic Trail vegetation mapping project (Hop and others, 2017a). The KAWW

[1]U.S. Geological Survey.

[2]Maine Natural Areas Program.

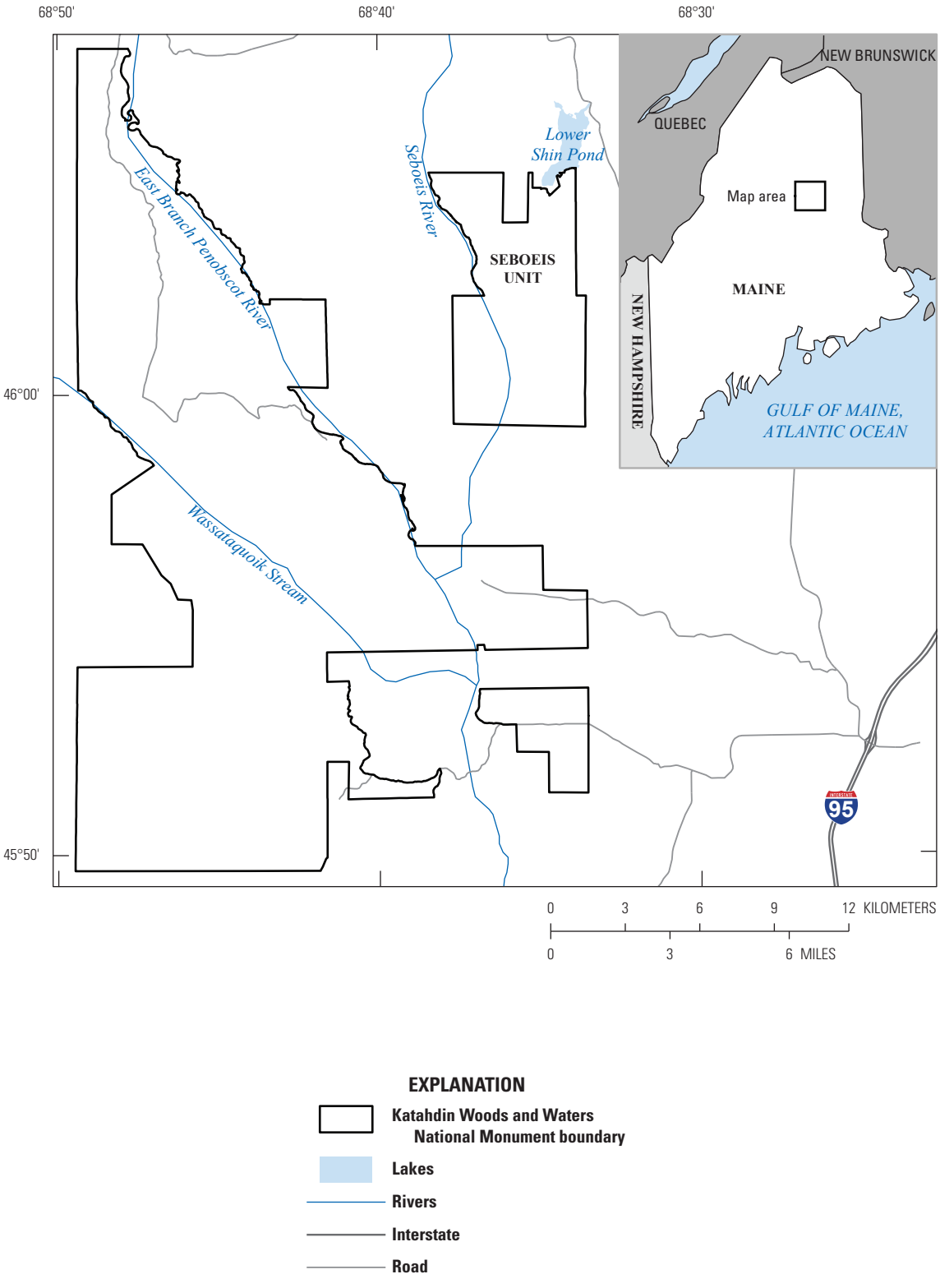

Figure 1. The Seboeis Unit within the Katahdin Woods and Waters National Monument in Maine.

vegetation classification was developed to represent the entire KAWW and contains vegetation types not found within the Seboeis Unit but expected in other parts of the KAWW (apps. 1 and 2). This was done at the request of KAWW staff to provide a more useful and broadly applicable product to assist in future management decisions.

Creation of the vegetation classification relied upon new vegetation plot data collected within the Seboeis Unit supplemented by existing ancillary vegetation data from other projects. Existing projects data used to supplement the classification included the following sources: 223 monumented vegetation plots from DeWolf (2014); 189 sampling points and 96 "quick plots" from Olmstead (2013); and 5 Maine Natural Areas Program Forest Quality Assessment vegetation plots, 11 verification sites, 49 vegetation plots, and 216 accuracy assessment sites from Hop and others (2017a). A total of 94 new vegetation plots were collected within the Seboeis Unit by the MNAP in 2019.

The vegetation classification and field keys were then continually refined and updated throughout the KAWW Seboeis Unit vegetation mapping project with additional data from field reconnaissance and accuracy assessment (AA). Additional vegetation types were identified during the field reconnaissance effort. These vegetation types were documented for the KAWW by qualified ecologists and then added to the KAWW vegetation classification.

The 94 new vegetation plots were entered into the PLOTS database version 4.0 (National Park Service, 2018) for this KAWW Seboeis Unit vegetation mapping project. The project identified 42 U.S. National Vegetation Classification (USNVC) vegetation associations from the PLOTS data, and the field key to vegetation reported a potential for 62 USNVC vegetation associations within the KAWW.

Throughout this project report and the final products, vegetation types are current to the USNVC (2019) database, which follows the methods and organizational hierarchy of the National Vegetation Classification Standard (NVCS), version 2 (Federal Geographic Data Committee, 2008). The NVCS makes a distinction between natural (including ruderal) and cultural vegetation. Areas with at least 1 percent vegetation cover are classified and described with the USNVC with one exception—aquatic areas are only included when at least 10 percent vegetation cover (emergent or submergent) is present. Aquatic areas with less than 10 percent vegetation cover are categorized as open water; these areas are not described in the USNVC.

The term "vegetation type" is used throughout this report to reference vegetation classification units in general, at any level of the classification hierarchy. For example, the *Acer saccharum - Betula alleghaniensis - Fagus grandifolia / Viburnum lantanoides* Forest Association and the *Pinus strobus* Ruderal Forest Association are each treated as a vegetation type.

Project Orientation Meeting

An orientation meeting was held August 12, 2019, at KAWW to discuss the mapping, AA, and end products for the KAWW Seboeis Unit vegetation mapping project. Collaborators from UMESC and NPS met to discuss access logistics to remote areas of the Seboeis Unit, specific information KAWW staff were interested in collecting, and other safety and access protocols within the KAWW.

Program Procedures and Standards

This mapping effort is modeled after similar efforts completed by the NPS Vegetation Mapping Inventory (VMI) Program, part of the NPS Inventory & Monitoring Program. Program scientists developed procedures for classifying and mapping vegetation and for completing a mapping AA to test the reliability of the mapping (Nature Conservancy and Esri, 1994a, b; Nature Conservancy and others, 1994; NatureServe, 2004; Lea and Curtis, 2010). An ecology team from the MNAP collaborated with the mapping team from the UMESC to share knowledge and data and to resolve issues regarding classification and mapping procedures, collect field data, and produce a final report.

Products meet Federal Geographic Data Committee standards for vegetation classification and metadata and meet national standards for spatial accuracy and data transfer. These standards include the following:

- NVCS (Federal Geographic Data Committee, 2008),
- Content Standard for Digital Geospatial Metadata (Federal Geographic Data Committee, 1998a), and
- U.S. National Map Accuracy Standards (U.S. Geological Survey, 1999).

The VMI Program mapping standards include a minimum mapping unit (MMU) of 0.5 ha and a classification accuracy meeting or exceeding 80 percent (with a 90-percent confidence level) for map classes representing natural (including ruderal) vegetation types in the USNVC. Geospatial products are projected in the Universal Transverse Mercator (UTM) and use the North American Datum of 1983 (NAD 83). Mapping products include aerial imagery, spatial map layers of vegetation, metadata, a map-classification description or key, and an AA of the vegetation map. Vegetation products include vegetation classification, field key to vegetation types, formal descriptions of vegetation types, and field data in database format. Products in this project are based on standards established by the NPS VMI Program for vegetation inventories (National Park Service, 2013).

Classification Standard

The NVCS (Federal Geographic Data Committee, 2008) is a methodology for classifying existing vegetation and is a framework for organizing a vegetation classification within a hierarchical structure. The USNVC is a vegetation classification that follows the NVCS to define and organize existing vegetation in the United States. The NVCS is static in its methods and structure, whereas the USNVC is flexible with its vegetation classification concepts and assignments yet remains within the static structural hierarchy of the NVCS. This project uses the USNVC to classify and describe the vegetation of KAWW to provide a uniform approach in vegetation classification consistent with other NPS vegetation mapping products. The use of a national standard aids effective resource stewardship by augmenting compatibility and widespread use of the information throughout the NPS and other Federal and State agencies.

The NVCS separates vegetation into the following two overriding vegetation categories, natural (including ruderal) and cultural, with a hierarchical subdivision within each category. For a detailed review of the USNVC classification and hierarchical structure, consult Jennings and others (2006).

Mapping of Vegetation

The review of the initial vegetation classification before the project orientation meeting prepared the mappers for field reconnaissance, the purpose of which was to visit the vegetation types in the field, discern their appearances in the aerial images, and establish mapping protocols. The mappers completed a 5-day field effort from August 12–16, 2019, assisted intermittently by MNAP vegetation ecologists for classification guidance. During this field reconnaissance effort, UMESC mapping staff worked with MNAP staff to collect vegetation plot data, update the field key to vegetation, explore imagery signatures, refine the mapping classification, and collect data tying vegetation signatures to the mapping classification.

The mapping began in 2019 following the conclusion of the field reconnaissance effort. Mappers interpreted vegetation and land-cover types by viewing the digital aerial imagery collected for this project. The mappers viewed the aerial imagery stereoscopically by using computer workstations equipped with three-dimensional (3D) polarized monitors and geographic information system (GIS) software. Map conventions based on fieldwork and the vegetation classification helped maintain consistency in mapping. Draft versions of the vegetation map (a spatial database layer) were completed in winter 2020. These draft map layers were prepared for AA. Following AA, a final map of the Seboeis Unit was produced.

A total of 33 map classes represents the Seboeis Unit of KAWW. Of these 33 map classes, 28 represent natural (including ruderal) vegetation types consisting of 50 USNVC association types, 2 represent USNVC cultural types for developed areas, and 3 represent non-USNVC types for non-vegetated open water. The vegetation map layer provides 1,261 polygons of detailed attribute data covering 4,854.8 ha. Methods and results of vegetation mapping are provided in greater detail in the “Vegetation Mapping” section of this report.

Minimum Mapping Units

A standard MMU of 0.5 ha was applied to the mapping of forest and cultural map classes. For woodland, shrubland, and herbaceous vegetation and open-water map classes, an MMU of 0.25 ha was applied. More details on MMU conventions are provided in the “Vegetation Mapping” section of this report.

Accuracy Assessment Study

An AA was completed on a draft version of the vegetation map layer. The AA was limited to the Seboeis Unit and was a prorated effort. The prorating was done based upon the expectation of a full AA of the entire National Monument. This was accomplished by first estimating AA sites for each map class for the entire Monument. Next, the actual coverage of each map class in the Seboeis Unit was used to estimate proportional representation of AA sites in the Seboeis Unit.

During the 2020 field season, field crews collected data from 107 stratified-random sites to evaluate the accuracy of the vegetation map layer for those map classes representing natural (including ruderal) vegetation types. The AA field data were compared to the vegetation map data, the initial results were reviewed by the AA and mapping teams, and the map data were reconciled as necessary with agreement by NPS staff from the KAWW. Results from the AA study indicate an overall accuracy of 87.6 percent (kappa index of 87.0 percent, which accounts for chance agreements) based on an analysis of data from 105 of the 107 AA sites. The results were tabulated into a contingency matrix. Methods and results of the AA are provided in greater detail in the “Accuracy Assessment” section of this report.

Product Development and Delivery

The suite of end products developed and compiled for the KAWW Seboeis Unit vegetation mapping project includes a project geodatabase; orthorectified aerial imagery collected for the project; metadata documentation for geospatial datasets; a vegetation database with the formal field data collected during this project (vegetation plots and AA sites); a field key to vegetation types; and this report summarizing the project and results. The set of products is available in Strassman and others (2022).

The ancillary project geodatabase contains the following four feature classes: (1) polygon features showing the locations of vegetation types and general land-cover features; (2) point features showing the locations of vegetation plots and AA sites; (3) point features showing the locations of the

digital aerial imagery set obtained for the vegetation mapping project; and (4) polygon features showing the project boundary extent. Geospatial products were projected in the UTM, Zone 19 North, by using the NAD 83.

Digital Aerial Imagery

Digital aerial imagery provides baseline data for mapping vegetation types and other land-cover features. Vertical imagery (images taken with the aerial camera pointed straight down at the ground) collected with proper overlap for each flight line allows an interpreter to study the images three dimensionally with a stereoscope (Avery, 1978) or, as with this project, to view stereo models of digital aerial images in 3D using specialized computers and specialized GIS software. Because ecological settings are considered when mapping vegetation types, viewing the aerial images in 3D helps the interpreter to recognize those ecological settings.

To maximize the usability of the aerial imagery for vegetation mapping purposes, digital aerial imagery was acquired for the project at peak leaf-phenology change of deciduous trees. Staff from the KAWW and the MNAP within the Maine Department of Agriculture, Conservation and Forestry provided input on the time to best capture peak-phenology change of deciduous trees within the KAWW. The goal was to collect aerial imagery of the entire KAWW with a minimum of a 100-meter buffer beyond the KAWW boundary.

Imagery acquisition parameters included a sun angle greater than 30 degrees off horizon and under conditions free from clouds and cloud shadows, smoke, haze, light streaks, snow, flooding, and excessive soil moisture. These environmental conditions and peak leaf-phenology stages were monitored to regulate the windows of opportunity to capture aerial imagery. The imagery set was collected to achieve a ground sampling distance of 15-centimeter pixel resolution, and with a 60-percent forward lap for stereo viewing and a 40-percent side lap for adequate coverage with minimal parallax distortion along imagery margins.

The aerial imagery used for this project was collected on October 5, 2019, and was reviewed to ensure that requirements for mapping purposes were met. Upon acceptance, exposures were adjusted for viewing and interpreting purposes. The aerial imagery was then processed for field and mapping purposes. Processing resulted in the creation of the following two products: (1) orthorectified four-band imagery including both individual aerial images (orthoimages) and a mosaic for background display in a GIS and (2) stereo models to view and map images in 3D using a GIS and specialized 3D computer hardware and software.

Orthorectified Mosaic

For the aerial imagery set, individual image tiles were converted to Tagged Image File Format and referenced to the Earth using the camera-generated Global Positioning System (GPS) and Inertial Measurement Unit records. Because the Inertial Measurement Unit records the rotation values from the camera sensor in three directions (roll, pitch, and yaw), and the GPS records the horizontal and vertical values from the sensor at the moment of exposure, specific software programs can reference each digital aerial image precisely to its ground position. To further increase the fit of the images to the Earth, software programs drape each aerial image over the landscape using digital elevation models.

Once referenced, or orthorectified, the orthoimages were color balanced and "stitched" together to form an orthoimage mosaic by flight line. Each orthoimage mosaic was compressed into the Joint Photographic Experts Group 2000 file format to accommodate computer hardware systems and GIS software with manageable file sizes. The orthoimage mosaics were projected in the UTM, Zone 19 North, by using the NAD 83. The aerial imagery mosaics could then be viewed on computers in true color and color-infrared to aid mappers during fieldwork and mapping.

Stereo Models

Digital aerial images were collected with a 60-percent forward lap of each frame along a flight line. This overlapping coverage of the ground on the images is what allows for the creation of a 3D onscreen view in specialized computer systems. Before the aerial imagery can be viewed in 3D, several processing steps occur. For this project, stereo models were produced using IMAGINE Photogrammetry (Hexagon Geospatial, 2018). A stereo model is a flight line of imagery, along with a separate georeferencing file called a block file. The block file establishes the relation of each aerial image to the adjacent image in order to precisely align the image pair (also known as a stereo pair), so that the image pair is viewable in 3D and is displayed in the correct geospatial position. When the stereo model is imported into the software program called "Stereo Analyst for ArcGIS" (Hexagon Geospatial, 2020), the imagery can be viewed in 3D and the map can be interpreted. Because the block file associated with each stereo model contains georeferencing information, the delineations made on-screen by the interpreter are also georeferenced as they are drawn, creating the vegetation map. More information on the use of stereo models with specialized stereo viewing equipment for mapping is provided in the "Vegetation Mapping" section of this report.

In addition to mosaic orthoimages and stereo models, a feature-class layer was produced of the aerial imagery to show in the GIS the center locations of individual aerial images. This feature class is incorporated into the final products for the KAWW Seboeis Unit vegetation mapping project. Aerial orthoimage mosaics are included as products in Ruhser and Finley (2022).

Vegetation Classification

A vegetation classification is a document that details how and where different types of vegetation occur across a landscape. This document is a necessary component of the vegetation mapping process as it allows the mappers to link the vegetation signatures that they see in the imagery to the vegetation communities that the ecologists recognize across the landscape.

Vegetation Classification Development

A vegetation classification of the KAWW was developed by MNAP ecologists using existing data from other projects, new vegetation plot data collected specifically for this project, and expert opinion and experience. Existing data was drawn primarily from DeWolf (2014) and Olmstead (2013); and MNAP internal datasets (MNAP, unpub. data, 2018) with vegetation classification were drawn from Gawler and Cutko (2010). As the project proceeded with field reconnaissance, mapping, and AA, additional vegetation types were recognized in the KAWW. Vegetation quick plots were collected to verify and characterize many of these additional vegetation types. Furthermore, at the close of the vegetation mapping project, classification concepts, names, and codes were updated to the current version of the USNVC database (USNVC, 2019; NatureServe, 2020). This report section discusses methods and results of vegetation classification for the project, including the methods to develop the vegetation classification before the mapping and AA efforts.

Existing Classification

As a first step, the vegetation classification and field key to vegetation for the Northern Appalachian section of the Appalachian National Scenic Trail (Hop and others, 2017a) were used as templates for the KAWW. The Appalachian National Scenic Trail ends about 8 km from the KAWW boundary. Although the habitat on top of Mount Katahdin is vastly different from that found in the KAWW, the Appalachian National Scenic Trail corridor passes through vast tracts of Maine's north woods identical in habitat and land use history to the KAWW. This provided the vegetation classifiers a ready-made foundation from which to build. These resources were updated to remove vegetation types not found in the KAWW and add vegetation types known or expected within the KAWW, per the existing vegetation data.

Existing data come from the works of Olmstead (2013), DeWolf (2014), and MNAP (MNAP, unpub. data, 2018). The most comprehensive data source was "East of Katahdin: Ecological Survey of the East Branch Properties of Elliotsville Plantation, Inc., Penobscot County, Maine" (DeWolf, 2014). As part of this work, 223 monumented vegetation plots were sampled across a systematic 1- by 1-km grid from 2005 through 2008. These plots cover most of the land that is now the KAWW, excluding the Seboeis Unit. Plot data and GPS locations, as well as shape files of the resulting vegetation map, formed a good foundation for understanding the vegetation types possible within the KAWW. These data formed the backbone of the vegetation classification for the KAWW, but because relation between the Maine Natural Communities Classification used by DeWolf (2014) and the USNVC was not 1 to 1, some plots did not have the needed resolution for classification (Gawler and Cutko, 2010; USNVC, 2019). Additionally, because a 1- by 1-km grid was used, some of the rarer vegetation types are potentially excluded from the original effort.

The vegetation mapping project conducted by Nancy Olmstead as part of a University of Vermont master's project in 2013 (Olmstead, 2013) also informed the project vegetation classification. This project, coordinated and managed by Don Cameron at MNAP, resulted in a vegetation map of the 9,700-ha township T5 R9 WELS, which is next to the northwest part of the KAWW. The vegetation map was generated using 189 detailed sampling points and 96 "quick points." The project's final report includes descriptions of the vegetation types on the property and provided supplemental data used to develop the vegetation key for the KAWW.

Beyond the two reports cited above, MNAP maintains datasets (MNAP, unpub. data, 2018) that were used to supplement the vegetation classification including site-level data for five Forest Quality Assessment vegetation plots within the KAWW boundary. Additionally, more than 40 long-term vegetation monitoring plots from the adjacent Baxter State Park and Maine's Wassataquoik Ecological Reserve, all less than 20 km away and from habitat similar to the KAWW, were used to inform the KAWW's vegetation classification.

This updated field key to vegetation and vegetation classification were presented to the mappers by MNAP. An initial list of 42 USNVC vegetation types potentially located within the Seboeis Unit was generated by MNAP. This initial classification was subsequently tested in the field and refined based on the 2019 field reconnaissance and vegetation plot data collection and the 2020 accuracy assessment.

Field Data Collection 2019

Vegetation plots were collected in 2019. These focused on rare types not found in the existing classification and ruderal types found within the formerly heavily managed areas of the Seboeis Unit. The field sampling method was adapted from field-method standards of the NPS VMI Program (NatureServe, 2004). Details are provided therein, and a general summary is provided in this section. Data were collected both opportunistically during the field season and at the direction of mappers after a review of aerial imagery. A total of 94 vegetation plots were collected. For each plot, the locational, environmental, and vegetation data were collected. Locational data, along with coordinate accuracy, were recorded using a Wide Area Augmentation System enabled handheld GPS unit. Environmental data collected at each plot

included slope, aspect, soil texture, and evidence of disturbance. Within each plot, the vegetation was first visually separated into strata (canopy, subcanopy, tall shrub, short shrub, and herbaceous). Visual estimates were collected for average height and total cover of each stratum and for total cover of the dominant and characteristic species in the entire plot and each stratum. Percent cover estimates for each dominant and characteristic species were assigned using cover-scale classes (tables 1 and 2). Data from plots were taken from an estimated rectangular area of 20 by 20 meters (400 square meters).

Digital photographs were also taken for the plot to provide additional information and assist in the vegetation classification. Digital photographs were taken in each cardinal direction from plot center, and at least one additional image was taken to best capture the character of the vegetation.

These vegetation plots were identified in the field, or shortly thereafter, to a vegetation type. When a vegetation type was determined at a plot, the existing field key to vegetation types of KAWW was used. Furthermore, as fieldwork progressed and vegetation types were identified that were not part of the initial classification, the field key was revised by MNAP ecologists in consultation with the mappers, and new versions of the field key were used on subsequent visits.

Data Entry and Quality Control

Vegetation data from the field forms were checked and then entered into the PLOTS database version 4.0 (National Park Service, 2018) for the project. In cases where writing was unclear, fields were highlighted and checked again. Species and cover data entered into the database were subjected to several quality control processes to ensure accuracy in the vegetation dataset. The vegetation plot data were provided to the mappers, but the data were not analyzed with multivariate analysis because the number of plots sampled was so few and the vegetation classification was already well-developed.

Table 1. Cover-scale classes and codes used during vegetation plot sampling to develop the initial vegetation classification of the Katahdin Woods and Waters National Monument, Maine.

Cover-scale classes, in percent	Cover-scale codes
>Trace	1
>0.5–1	2
>1–2	3
>2–5	4
>5–10	5
>10–25	6
>25–50	7
>50–75	8
>75–95	9
>95	10

Table 2. Vegetation strata codes and vegetation strata names used during vegetation plot sampling to develop the initial vegetation classification of the Katahdin Woods and Waters National Monument, Maine.

Vegetation strata code	Vegetation strata names
T1	Emergent Canopy
T2	Tree Canopy
T3	Subcanopy
S1	Tall Shrub (>1–5 meters)
S2	Short Shrub (<1 meter)
H	Herbaceous
N	Nonvascular
V	Vines (lianas)
E	Epiphytes

Results

The final vegetation classification for the project is discussed in this section. Vegetation classification and a field key to vegetation types are each included as appendixes; however, brief explanations of each of these products are provided in this section.

Vegetation Classification Results and Descriptions

A total of 50 vegetation types are recognized for the KAWW Seboeis Unit. All natural (including ruderal) and cultural (at the subtype level) vegetation types identified with this project are documented with vegetation descriptions. Further descriptions for the natural types are found in the USNVC (2019) database.

The global information in a vegetation description applies to the entire range of the vegetation type. This information has been gathered from scientific literature and other field data and is stored in the central database (USNVC, 2019) from which the descriptions are pulled. For the descriptive text fields, global information presents as an average of a relatively natural stand throughout the range of the vegetation type.

Vegetation Field Key

The field key to vegetation types of the KAWW (app. 1) consists of dichotomous options that lead to natural (including ruderal) vegetation types. This field key is meant to apply to the entire KAWW and not be restricted to the Seboeis Unit. The vegetation descriptions (app. 2) are recommended to complement the field key to vegetation to determine a correct assessment of vegetation classification. Additionally, the field key to vegetation types, designed to cover the entire KAWW, includes 12 USNVC association types not found within the Seboeis Unit but that are expected to be present in the KAWW.

Vegetation Mapping

The vegetation mapping process begins long before any mapping occurs. Fully integrated into the vegetation classification process, vegetation mapping aims to leverage the knowledge gained in creating a vegetation classification to produce both the best map possible and best vegetation classification possible.

Methods

Mapping vegetation of the KAWW Seboeis Unit involved the following five primary steps: (1) preliminary map classification with a vegetation primer, (2) field reconnaissance, (3) map classification, (4) aerial image interpretation and mapping, and (5) database development of the map layer. Although these steps proceeded sequentially, they overlap to some degree.

Preliminary Map Classification

Before field reconnaissance, mappers at UMESC had become familiar with the vegetation types expected to exist in the KAWW through their work along the Appalachian National Scenic Trail. Using this information, the mappers began developing a working map classification to test, update, and refine during field reconnaissance.

Field Reconnaissance

Field reconnaissance efforts were started to prepare for mapping vegetation types. Mappers visited many locations within the Seboeis Unit and were often joined by MNAP staff to assist in field classification of vegetation. With the aid of weatherized field computers, the mappers compared the ground conditions to vegetation signatures (appearances) on the digital aerial imagery sets that were obtained for this project in 2019. Vegetation types were determined by a vegetation field key and the classifier. This process was necessary, as Riemann Hershey and Befort (1995) explained, because photography (or imagery) is not consistent among image sets to allow a species to be depicted precisely. Sun angle, light intensity, shadow, exposure, and difference in digital post-capture processing can affect image appearance. Differences in site history, hydrologic regime, intraspecific variation, and seasonality can change the appearance of a single species across a single image. Hence, ground exploration of the landscape represented in the imagery is a critical endeavor. The field reconnaissance effort at the KAWW helped correlate the aerial imagery signatures of the vegetation with the vegetation classification on the ground.

Field reconnaissance also allowed mappers to become familiar with the local ecology of vegetation types, which is important when applying ecological concepts to mapping. Where mappers discovered limitations to interpreting vegetation types using digital aerial imagery, environmental models were tested to determine if vegetation types could be consistently separated by environmental elements. For this mapping effort, no environmental models were found to be explanatory.

The mappers and classifier proceeded with field reconnaissance at the KAWW in 2019. The field efforts for mapping were completed over one 7-day trip. The trip occurred August 11–17, 2019. During the field reconnaissance effort, mappers worked with MNAP staff in the Seboeis Unit to learn vegetation signatures, determine if any vegetation types were missing from the classification, and test the field key to vegetation. The mappers and classifier worked as a team, rather than as individuals, to ensure correct assessment of vegetation types and, subsequently, to promote agreement on

classification during mapping and accuracy assessment. The team became familiar with the vegetation and local ecology as they discussed the structural, floristic, and habitat characteristics of the vegetation present in the field and compared the vegetation types to the appearance of the vegetation in the imagery. Through this process, the team built an understanding of how to map the vegetation types, how to establish a working map classification with mapping protocols, and how to help the classifier to refine the vegetation classification and the field key to vegetation types.

During the field reconnaissance, the mappers studied a representative sample of the landscape of the Seboeis Unit and determined much variability within vegetation types. In some cases, the classifier determined that some vegetation types existed that had not been represented by the vegetation plots or that were not fully addressed in existing descriptions in the vegetation classification. These vegetation types were added accordingly to the vegetation and map classifications. During the field reconnaissance effort, the number of vegetation types recognized within the KAWW increased by four, and vegetation classification was substantially refined.

The project orthoimagery mosaic was not available at the time of field reconnaissance as the imagery capture occurred after the field reconnaissance efforts. For the field reconnaissance effort, U.S. Department of Agriculture National Agriculture Imagery Program imagery from 2018 (U.S. Department of Agriculture, 2018) and State of Maine imagery (State of Maine, 2016) were used to guide the 2019 field efforts. The National Agriculture Imagery Program imagery was collected in 4-band (true color and color-infrared) at peak biomass, not in stereo, and at 1-m resolution. The State of Maine imagery was collected in 4-band at leaf-off, not in stereo, and at 0.6-m resolution. Although neither imagery set was suitable for mapping, together they provided enough information to direct the field reconnaissance effort. This imagery was accessed using ArcMap in ArcGIS (Esri, 2019), which also allowed the mapping team to digitally collect notes on vegetation and imagery signatures in the field, such as recording the map-class assignment, if known. Notes to promote proper perspective of species composition, such as comments regarding significant species, also were recorded. An example of species composition is a heterogeneous, mature northern hardwood forest stand versus a monotypic, ruderal northern hardwood forest stand.

Map Classification

A map class represents a definable feature (such as a vegetation type, a non-vegetated feature, or an anthropogenic area) that can be consistently distinguished on aerial imagery, by use of an environmental model, or by some combination of both. The set of map classes that represents all the mapped features defines the map classification. The map classification and protocols that define the mappable features are based on existing classification systems. For this project, all map classes, except those representing open water, were linked to the vegetation types in the USNVC. For natural (including ruderal) vegetation, map classes were linked to natural types in the USNVC at the finest (lowest) level possible. For cultural vegetation, a map class was linked to a cultural type in the USNVC at the lowest applicable level.

After a draft of the map classification was developed, a "mapping tree" was created to facilitate the mapping process (fig. 2). A mapping tree is a diagram that divides the map classes into logical groups (for example, Upland Coniferous Forest, Wetland Shrubland, and Sparse Vegetation) and then, if needed, further divides the groups into subgroups (for example, Deciduous Swamp, and Deciduous Floodplain), with a final selection of choices between the similar map classes in each subgroup. The choices in a mapping tree are meant to present the mappers with a small and consistent set of options and to remind the mappers of possible alternative map classes.

To develop map-class names, for those map classes representing a single vegetation type in the USNVC, the type's common name was used; for example, the Red Spruce - Fraser Fir Forest (Deciduous Shrub Type). For those map classes representing more than one vegetation type, a comparable name that encompassed all the vegetation types was derived; for example, the Low-Elevation Spruce - Fir Forest map class was used for the collective USNVC associations of Lowland Red Spruce - Fir Forest and Northern Spruce - Fir Flats. For map classes representing cultural vegetation, a generic name, such as Developed Lands, was derived. For the map classes representing non-USNVC features, a generic name, such as Flowing and Ponded Water, was derived.

Throughout the project, the map classification remained fluid. Each field endeavor, including the accuracy assessment (AA) effort, revealed new information that prompted modifications to the map classes and their definitions. Revisions also were made to the map classification as the vegetation classification matured; as aerial images were interpreted, new problems forced redefinition, expansion, conjunction, or minor adjustment to map-class definitions. As individual map classes changed, these changes were consistently reapplied to areas that previously had been mapped to ensure consistent mapping across the Seboeis Unit.

A map-class code was derived for each map class for ease of assigning information to map polygons. Each map-class code was made using four alpha characters, and the code was to represent an independent map class; each code was to begin with one of the following first alpha characters to represent the major physiognomic characteristic:

- F—Forest (typically greater than [>] 60 percent tree cover),
- W—Woodland (>25 percent tree cover),
- S—Shrubland (>25 percent shrub cover and less than [<] 25 percent tree cover),
- H—Herbaceous vegetation (>10 percent herbaceous cover and <25 percent tree or shrub cover),

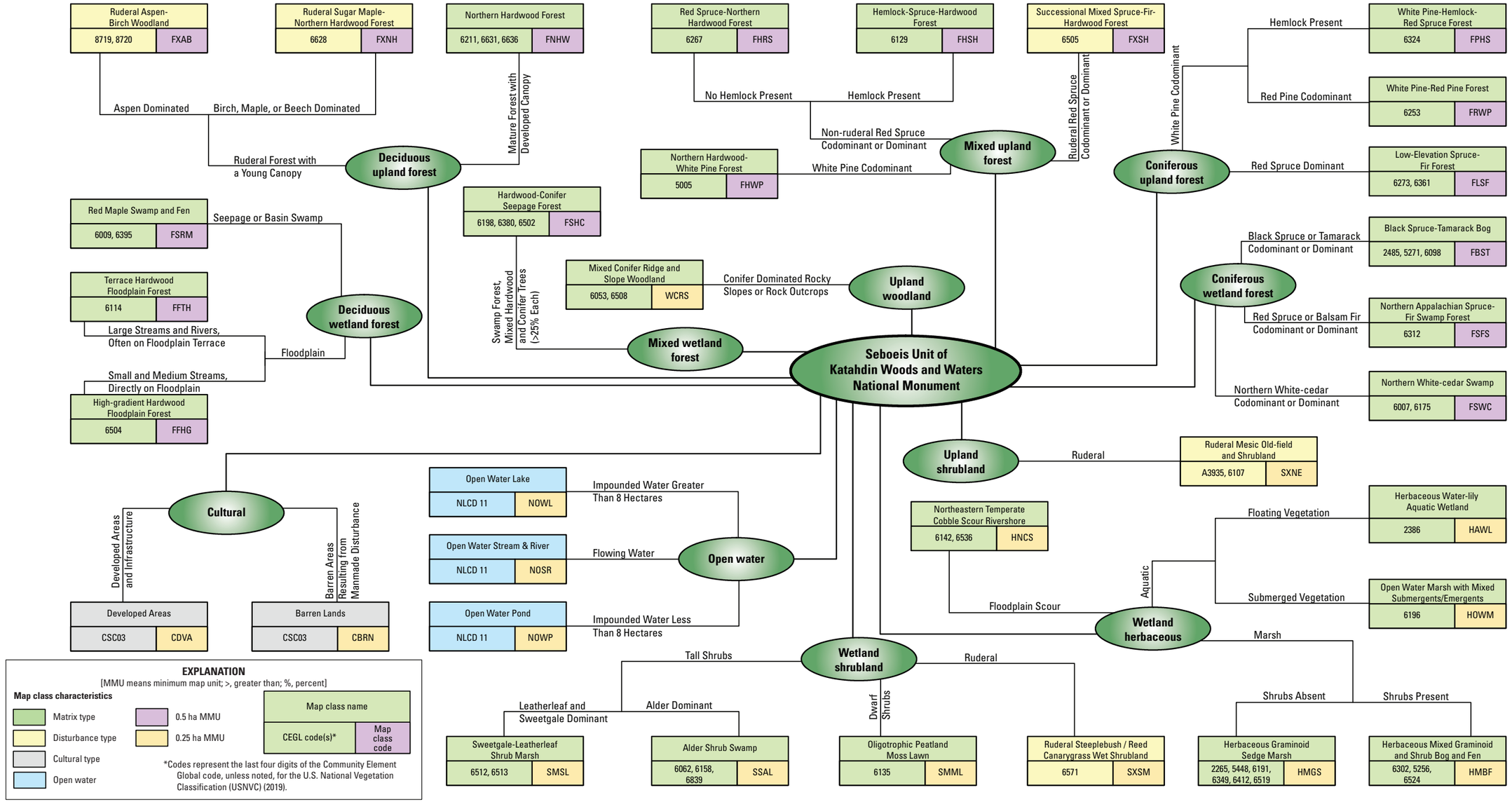

Figure 2. Vegetation mapping decision tree for the Katahdin Woods and Waters National Monument Seboeis Unit vegetation mapping project.

- C—Cultural (developed landscapes), and
- N—Non-USNVC (open water with <10 percent vegetation cover).

The second character represents one of the following two possible scenarios: (1) to denote a ruderal map class with an "X" or (2) to denote the first significant term in the map-class name. The third and fourth characters were to loosely represent latter significant terms in the map-class name (for example, FXNH for Ruderal Sugar Maple - Northern Hardwood Forest, HAWL for Water-lily Aquatic Wetland, CDVA for Developed Area, and NOSR for Open Water Stream & River).

Aerial Image Interpretation and Mapping

The vegetation of the Seboeis Unit was mapped by a mapping team at the UMESC using digital-onscreen three-dimensional (3D) mapping systems running geographic information system (GIS) software. The mapping team performed onscreen interpretation of digital imagery that was spatially referenced in GIS. The mapping tree was used to further assist the mapping process and enforce consistent application of the map classification. A draft version of the vegetation map—a spatial-database layer—was then prepared for AA. The vegetation map was then adjusted according to the results from the analysis of the AA to meet accuracy criteria set by the National Park Service (NPS) Vegetation Mapping Inventory (VMI) Program.

The digital aerial imagery used for the onscreen mapping was collected on October 5, 2019, using a plane-mounted digital camera. The mappers used systems that incorporated passive stereo technology that uses polarized glasses to produce a 3D image on a liquid-crystal-display monitor for a computer. The stereo models were imported into the software program "Stereo Analyst for ArcGIS" (Hexagon Geospatial, 2020) for 3D viewing and editing.

Mapping proceeded during the fall 2019 to spring 2020. The mapper mapped the entire Seboeis Unit and then gave this draft work to a second mapper for quality assurance/quality control. The second mapper assessed the draft work for errors in mapping and returned the draft to the initial mapper for review and modification. Areas of high complexity could be revised more than once. This review process ensured that all parts of the Seboeis Unit were examined at least twice and by different individuals.

ArcGIS software was used as the GIS platform for the onscreen digital mapping. Because the 3D images were viewed directly in the GIS environment, vegetation could be mapped directly in ArcGIS. The polygon vector data were stored using an ArcGIS file geodatabase, which was projected in the Universal Transverse Mercator (UTM), Zone 19 North, by using the North American Datum of 1983 (NAD 83).

Standard image signature characteristics were applied—including texture, color, pattern, and position in the landscape—to guide placement of polygons during mapping. In addition to image signature characteristics, mappers needed to understand the environmental distribution of the vegetation types across the landscape to help identify those vegetation types and to properly place polygon boundaries. For each polygon, the appropriate map-class code was applied.

Supplemental imagery and datasets were also used by the mappers to visualize and understand the landscape. These layers increased the mappers' ability to understand historical landscape change and use, determine wet and dry areas, and better visualize evergreen vegetation. Supplemental data included digital aerial imagery, field reconnaissance data, and vegetation plot data.

The NPS VMI Program's standard MMU of 0.5 hectare (ha) was applied to forest map classes. For woodland, shrubland, herbaceous vegetation, cultural areas, and non-vegetated map classes, an MMU of 0.25 ha was applied. The smaller MMU was applied because of the consistent small patch presentation of vegetation types represented by the map classes.

For polygons that represent vegetation crossing outside the boundary of the Seboeis Unit, mappers allowed the polygons to be mapped less than the MMU if the vegetation that continued over the project boundary was contiguous and covered at least the standard MMU for that map class. In these instances, map classes with a 0.5-ha MMU were mapped down to 0.1 ha, and map classes with a 0.25-ha MMU were mapped down to 0.05 ha. For example, a 0.18-ha polygon of the Northern Hardwood Forest map class would be mapped inside the boundary if at least 0.32 ha of contiguous connected Northern Hardwood Forest was outside the boundary.

Database Development

Following the AA reconciliation, the map layer would have only map-attribute codes assigned to each polygon. To assign information to each polygon (for example, map-class names and other data), a feature-class table and other supportive tables were produced, and ArcGIS was used to relate the tables of polygon information within a geodatabase. A geodatabase provides access to a variety of interrelated datasets, is expandable, and equips resource managers and researchers with a powerful GIS tool. The geodatabase developed for the KAWW Seboeis Unit vegetation mapping project includes many feature-class layers produced from this project, including the map layer, vegetation plots, AA sites, aerial image locations, and project boundary extent. This geodatabase is provided as an ancillary product in addition to the machine-readable standard geospatial products, which lack the capacity to support interrelated tables.

Results

The final map classification for the project is presented in this section, along with a summary report of map-class distribution across the vegetation map.

Map Classes

After reconciling map classes from the AA analysis, 33 map classes represent the KAWW Seboeis Unit; 28 of the 33 map classes represent natural (including ruderal) vegetation types recognized in the USNVC. At the time of mapping, 35 map classes existed to map the KAWW, of which 30 map classes represented natural vegetation types.

The AA study determined that confusion in mapping existed among some map classes; these map classes were listed with accuracy levels <80 percent (in the 90-percent confidence interval), as set by the NPS VMI Program. Map classes with low accuracy were examined for consistent sources of error, and then NPS staff from the KAWW were consulted to determine if map classes should be merged to reduce error rates. The map classes with low accuracies were merged with the map classes that they were most often confused with during mapping unless the lower accuracy was accepted by NPS staff. Various reasons are recognized for where confusion in mapping existed among the map classes, including a breakdown of the mapping tree or ecological mapping conventions, inconsistent signatures on the aerial imagery across and among map classes, and disagreement in classification between field reconnaissance and AA. Further details regarding the mapping confusion are provided in the "Accuracy Assessment" section of this report and in individual map-class descriptions in appendix 3. The descriptions in appendix 3 also explain the link among map classes and the vegetation types they represent. Digital photographs taken by field personnel showing representations of the map classes are provided where possible.

Of the 33 map classes that represent the Seboeis Unit, 28 represent natural (including ruderal) vegetation types, consisting of 50 USNVC association types. For the remaining 5 of the overall 33 map classes, 2 represent USNVC cultural types for barren areas and developed areas and 3 represent non-USNVC types for non-vegetated open water. Of the 28 map classes representing natural (including ruderal) vegetation types, 15 represent a single vegetation type (when it exists above an MMU), 7 represent 2 vegetation types mapped together, 5 represent 3 vegetation types mapped together, and 1 represents 6 vegetation types mapped together. The map classification for the KAWW Seboeis Unit vegetation mapping project is listed in appendix 3.

Summary Report of the Map Layer

The vegetation map layer provides 1,261 polygons of detailed attribute data covering 4,854.8 ha. The spatial-data layer (vegetation map) is summarized for each individual map class at the map-class attribution level. The frequency of polygons, area, average polygon size, and percent map coverages for each map class are summarized in table 3.

Brief Analysis and Discussion

Collectively, the spatial-database layer (vegetation map) produced for the Seboeis Unit vegetation mapping project consists of 1,261 polygons and covers 4,854.8 ha, with an average polygon size of 3.8 ha (fig. 3; table 3). The 28 map classes representing natural (including ruderal) vegetation types apply to 97.6 percent of polygons (1,231 polygons; average size of 3.9 ha) and cover 98.6 percent of the Seboeis Unit (4,787.5 ha). Further broken down, map classes representing natural vegetation types indicate that the Seboeis Unit is 93.2 percent forest and woodland (4,526.6 ha), 4.0 percent shrubland (195.3 ha), and 1.3 percent herbaceous cover (65.6 ha). Map classes representing cultural vegetation types in the USNVC apply to 1.0 percent of polygons (12 polygons; average size of 2.5 ha) and cover 0.6 percent of the Seboeis Unit (29.7 ha). Map classes representing non-vegetation open and flowing water (non-USNVC) apply to 1.4 percent of polygons (18 polygons; average size of 2.1 ha) and cover 0.8 percent of the Seboeis Unit (37.4 ha).

Forest and Woodland

Map classes representing ruderal forest vegetation types account for 34.1 percent (430 polygons) of the mapped polygons and 77.9 percent (3,782.3 ha) of the Seboeis Unit, whereas map classes representing non-ruderal forest and woodland vegetation types account for 39.0 percent (492 polygons) of the polygons but only 15.3 percent (744.3 ha) of the Seboeis Unit. This difference indicates that ruderal forest and woodland types are generally in larger, more homogenous and contiguous blocks, and the average area of a ruderal forest block is 8.8 ha compared to 1.5 ha for non-ruderal forest and woodland map classes. These ruderal forest coverage statistics also discount the value of large blocks of contiguous forest that consist of many different ruderal map classes.

The ruderal forest types, and forests in general, of the Seboeis Unit are dominated by two different map classes. The Successional Mixed Spruce - Fir - Hardwood Forest (FXSH) and the Ruderal Sugar Maple - Northern Hardwood Forest (FXNH) map classes each cover large areas of the Seboeis Unit following extensive forestry. Together these two map classes cover 77.1 percent (3,744.8 ha) of the Seboeis Unit and dominate not only the forest map classes, but the Seboeis Unit in general. The FXSH map class generally represents a ruderal mixed hardwood - conifer to conifer-dominated forest with codominant or dominant red spruce (*Picea rubens*) in the canopy. The FXNH map class generally represents a ruderal mixed hardwood forest with codominant or dominant sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis*) in the canopy.

The major part of the non-ruderal forest and woodland map classes in the Seboeis Unit are the Red Spruce - Northern Hardwood Forest (FHRS), Low-Elevation Spruce - Fir Forest (FLSF), and Northern Hardwood Forest (FNHW).

Table 3. Frequencies of polygons and areas for map classes represented in the vegetation map layer for the Katahdin Woods and Waters National Monument Seboeis Unit vegetation mapping project.

[--, not applicable; ~, about]

Map-class category	Map class code	Map class name	Polygon frequency	Map class area, in hectares[1]	Average polygon size, in hectares[1]	Map class coverage, in percent[2]
Northern Hardwood Forest	FNHW	Northern Hardwood Forest	78	136.2	1.7	2.8
Mixed Conifer-Hardwood Forest	FHRS	Red Spruce - Northern Hardwood Forest	85	204.8	2.4	4.2
Mixed Conifer-Hardwood Forest	FHWP	Northern Hardwood - White Pine Forest	9	24.9	2.8	0.5
Mixed Conifer-Hardwood Forest	WCRS	Mixed Conifer Ridge and Slope Woodland	5	10.3	2.1	0.2
Conifer Forest	FHSH	Hemlock - Spruce - Hardwood Forest	5	8.1	1.6	0.2
Conifer Forest	FLSF	Low-Elevation Spruce - Fir Forest	71	136.5	1.9	2.8
Conifer Forest	FPHS	White Pine - Hemlock - Red Spruce Forest	21	33.6	1.6	0.7
Conifer Forest	FRWP	White Pine - Red Pine Forest	2	2.2	1.1	0.04
Ruderal Hardwood Forest	FXAB	Ruderal Aspen - Birch Woodland	32	37.6	1.2	0.8
Ruderal Hardwood Forest	FXNH	Ruderal Sugar Maple - Northern Hardwood Forest	207	1,680.1	8.1	34.6
Ruderal Mixed Conifer-Hardwood Forest	FXSH	Successional Mixed Spruce - Fir - Hardwood Forest	191	2,064.7	10.8	42.5
Floodplain Forest	FFHG	High-gradient Hardwood Floodplain Forest	14	14.9	1.1	0.3
Floodplain Forest	FFTH	Terrace Hardwood Floodplain Forest	14	29.7	2.1	0.6
Bog, Fen, and Swamp Forest	FSRM	Red Maple Swamp and Fen	68	59.5	0.9	1.2
Bog, Fen, and Swamp Forest	FSHC	Hardwood - Conifer Seepage Forest	78	54.0	0.7	1.1
Bog, Fen, and Swamp Forest	FSWC	Northern White-cedar Swamp	3	1.2	0.4	0.02
Bog, Fen, and Swamp Forest	FSFS	Northern Appalachian Spruce - Fir Swamp Forest	20	12.6	0.6	0.3
Bog, Fen, and Swamp Forest	FBST	Black Spruce - Tamarack Bog	19	15.9	0.8	0.3
Ruderal Mixed Herbaceous-Shrub Upland	SXNE	Ruderal Mesic Old-field and Shrubland	64	55.4	0.9	1.1
Shrub Wetland	SMSL	Sweetgale - Leatherleaf Shrub Marsh	26	24.5	0.9	0.5
Shrub Wetland	SSAL	Alder Shrub Swamp	107	104.9	1.0	2.2
Ruderal Mixed Herbaceous-Shrub Wetland	SXSM	Ruderal Steeplebush / Reed Canarygrass Wet Shrubland	18	10.2	0.6	0.2
Mixed Herbaceous-Shrub Wetland	HMBF	Herbaceous Mixed Graminoid and Shrub Bog and Fen	13	7.7	0.6	0.2
Mixed Herbaceous-Shrub Wetland	SMML	Oligotrophic Peatland Moss Lawn	2	0.4	0.2	0.007
Herbaceous Wetland	HMGS	Herbaceous Graminoid Sedge Marsh	59	42.1	0.7	0.9
Herbaceous Wetland	HNCS	Northeastern Temperate Cobble Scour Rivershore	3	1.1	0.4	0.02
Herbaceous Aquatic Vegetation	HAWL	Water-lily Aquatic Wetland	2	1.0	0.5	0.02
Herbaceous Aquatic Vegetation	HOWM	Open Water Marsh with Mixed Submergent/Emergent Vegetation	15	13.6	0.9	0.3
Open Water	NOSR	Open Water Stream & River	1	28.2	28.2	0.6

Table 3. Frequencies of polygons and areas for map classes represented in the vegetation map layer for the Katahdin Woods and Waters National Monument Seboeis Unit vegetation mapping project.—Continued

[--, not applicable; ~, about]

Map-class category	Map class code	Map class name	Polygon frequency	Map class area, in hectares[1]	Average polygon size, in hectares[1]	Map class coverage, in percent[2]
Open Water	NOWL	Open Water Lake	1	0.6	0.6	0.01
Open Water	NOWP	Open Water Pond	16	8.6	0.5	0.2
Developed Areas	CBRN	Barren Land	2	0.3	0.2	0.007
Developed Areas	CDVA	Developed Areas	10	29.4	2.9	0.6
Total	--	--	1,261	4,854.8	3.8	~100.0

[1]Values are rounded to nearest tenth-hectare.

[2]Values are rounded to nearest significant decimal.

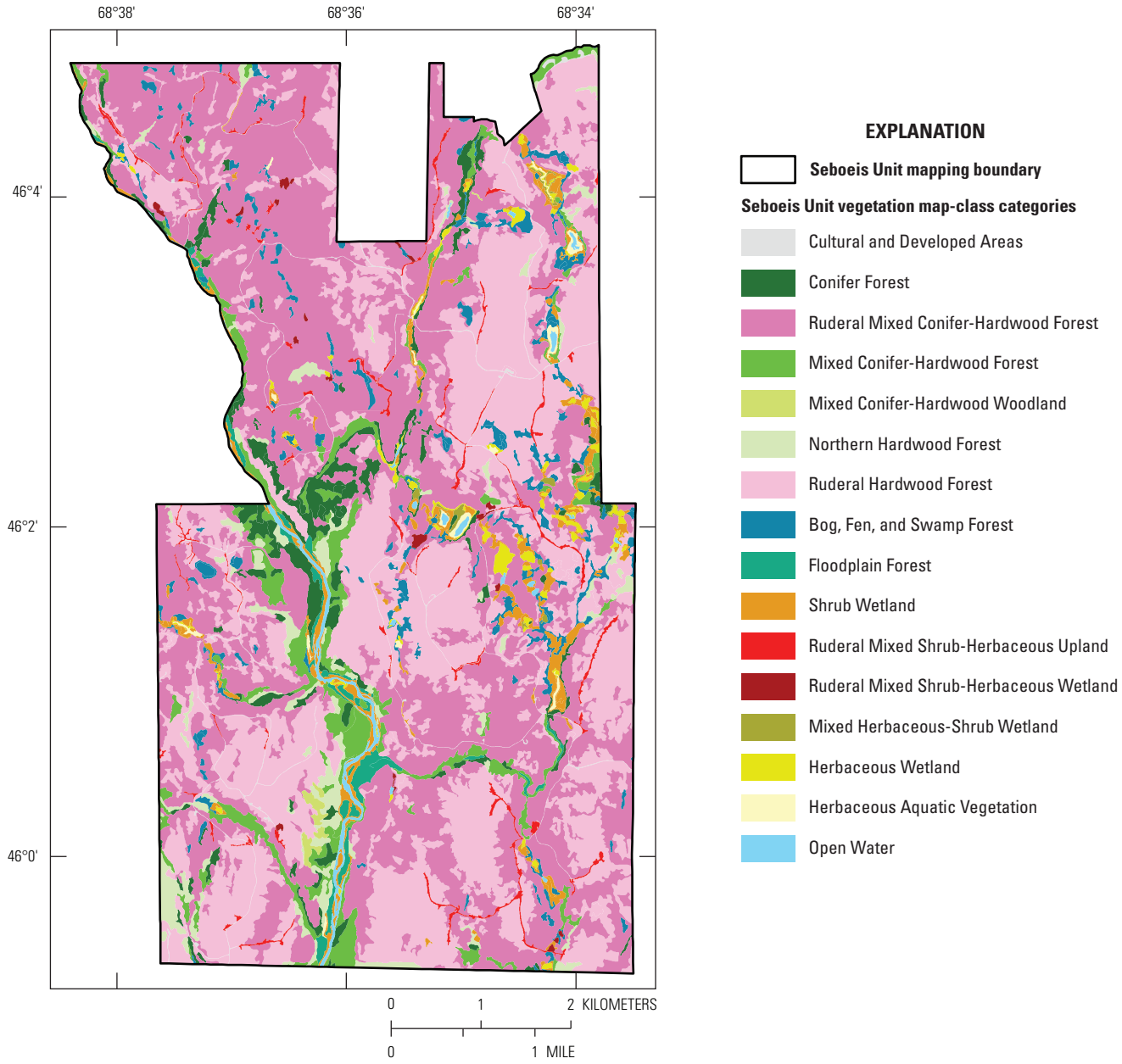

Figure 3. Final map for the Katahdin Woods and Waters Seboeis Unit vegetation mapping project. Map-class categories are detailed in table 3.

These forests are very common throughout the Seboeis Unit. Together, these three map classes cover over 9.8 percent (477.5 ha) of the KAWW.

Shrublands

Map classes representing ruderal shrubland vegetation types account for 6.5 percent (82 polygons) of the mapped polygons and 1.3 percent (65.6 ha) of the Seboeis Unit, whereas map classes representing non-ruderal shrubland vegetation types account for 10.7 percent (135 polygons) of the polygons but 2.7 percent (129.8 ha) of the Seboeis Unit. This difference indicates that non-ruderal shrubland vegetation types are generally in larger, more homogenous and contiguous blocks, with the average area of a ruderal shrubland being 0.8 ha compared to 1.0 ha for non-ruderal shrubland map classes.

The Alder Shrub Swamp (SSAL) and Ruderal Mesic Old-field and Shrubland (SXNE) are the most common shrubland map classes in the Seboeis Unit. These two very different map classes occur in very different locations throughout the Seboeis Unit; SSAL is present in open swamps and wetlands often in association with American beaver (*Castor canadensis*) disturbance, whereas SXNE is present in disturbed, dry uplands often in association with past forestry. The SSAL map class accounts for 8.5 percent (107 polygons) of the mapped

polygons and 2.2 percent (104.9 ha) of the Seboeis Unit area, whereas SXNE accounts for 5.1 percent (64 polygons) of the polygons and 1.1 percent (55.4 ha) of the Seboeis Unit.

Herbaceous Vegetation

Map classes representing herbaceous vegetation types account for 7.3 percent (92 polygons) of the mapped polygons and 1.4 percent (65.6 ha) of the Seboeis Unit; no ruderal herbaceous vegetation was mapped as an independent map class.

The Herbaceous Graminoid Sedge Marsh (HMGS) accounts for almost all herbaceous vegetation found within the Seboeis Unit. This map class occurs in open marshes and wetlands throughout the Seboeis Unit. The HMGS map class accounts for 4.7 percent (59 polygons) of the mapped polygons and 0.9 percent (42.1 ha) of the Seboeis Unit.

Cultural Areas and Open Water

Map classes representing cultural area types account for 1.0 percent (12 polygons) of the mapped polygons and 0.6 percent (29.7 ha) of the Seboeis Unit, whereas map classes representing open water types account for 1.4 percent (18 polygons) of the polygons and 0.8 percent (37.4 ha) of the Seboeis Unit. Cultural areas are primarily roads, whereas open water is primarily the Seboeis River.

Accuracy Assessment

The objective of conducting an accuracy assessment (AA) is to measure the probability that a particular location has been assigned the correct vegetation class in the vegetation map layer. The process of an AA is based on field observations, and the process of mapping is based on aerial image interpretation; each process has different perspectives of scale and observation. An AA estimates thematic accuracy by map class in the map layer, giving users the information needed to determine suitability of the map layer for a particular application. At the same time, map layer producers learn more about the nature of accuracy, including error, in the map layer. Thus, the two attributes of an AA are "users' accuracy," which is the probability that the map actually represents what was classified on the ground, and "producers' accuracy," which is the probability that an AA site has been mapped correctly. An error in mapping from the users' perspective is one of commission where a map class was mapped as a vegetation type that did not exist at the assessment site. An error in mapping from the producers' perspective is one of omission where a map class was not mapped as the vegetation type that existed at the assessment site. Both users' and producers' accuracies can be obtained from the same set of data by using different analyses per Lea and Curtis (2010). Errors exist when map classes are not the same as the classes observed in the field. A major assumption of an AA is that the application of the classification system is identical between mapping and field assessment. When the application of classification is not applied consistently with the field assessment, a "false error" could result. A "false error" requires additional review of field data and classification decisions.

Methods

An AA sampling design was developed for the project. Field data were collected at AA sites that were randomly selected by the sampling design. The field data were then used to analyze the classification accuracy of the vegetation map layer.

Sampling Design

A stratified random sampling approach was used to select the AA sites, and the number of sites selected for the Seboeis Unit was prorated. This prorating was done by estimating the proportion of the entire KAWW that the Seboeis Unit covered and then determining the proportion of AA sites this should represent. The Seboeis Unit comprises about 13.5 percent of the total KAWW area. For map classes requiring 30 AA sites with an equal distribution across the KAWW, this equates to an average of 4 AA sites randomly occurring within the Seboeis Unit. For map classes over-represented in the Seboeis Unit, five sites were used, whereas three or fewer were used for map classes under-represented in the Seboeis Unit. All map classes representing natural (including ruderal) vegetation types in the USNVC were included in the site selection process.

Total estimated cover by each map class in the KAWW was used to determine sample size. The number of samples needed for each map class (theme) was determined by using NPS VMI Program recommendations (Lea and Curtis, 2010) as suggested in the following scenarios.

- Scenario A—The class is abundant, covering more than 50 ha in total area (estimated for the entire KAWW). The map class receives the maximum sample size of 30.
- Scenario B—The class is relatively abundant, covering at least 8.33 ha but no more than 50 ha in total area (estimated for entire Monument). The map class receives a sample size of six-tenths of the observations per hectare of the map class (equal to one observation for every 1.67 ha of map-class area). (This ratio allocates observations at a density rate equal to 30 observations per 50 ha).
- Scenario C—The class is relatively rare, covering less than 8.33 ha in total area (estimated for the entire KAWW). The map class receives five observations, the recommended minimum sample size.

For Scenario C, a map class could receive fewer than five observations if the area was too limited to support five AA sites, noting that map classes in this scenario received one sample site in the Seboeis Unit.

The AA sites were placed so that they were a minimum distance from polygon boundaries. This reduced the chance of the survey area accidentally including vegetation types represented in adjacent polygons. The required buffer distance was calculated with the following formula:

$$\text{Buffer distance} = \sqrt{R^2+F^2+M^2} \quad (1)$$

where

R is the radius distance of the observation area;
F is the expected (for example, 90th percentile) GPS error distance; and
M is the standard requirement (maximum positional error distance in the map) for positional accuracy.

The minimum mapping unit (MMU) areas used to map the Seboeis Unit were 0.5 ha and 0.25 ha, depending on the map class. Depending on MMU size, values for *R*, *F*, *M*, and the polygon buffer distance vary; these values are given in table 4.

Once the number of AA sites was determined and buffers were applied, random sites with associated geographic coordinates were located manually. Each map polygon had a negative buffer applied (it was buffered inward), depending on the MMU for the assigned map class, and those polygons that remained were assigned a random number using a random number generator. Going in ascending order, an AA site was placed in each polygon until the total number of AA sites for that particular map class was met. If the total number of sites needed were not met with the first applied buffer, a negative buffer was applied on the polygons that did not already receive an AA site and site locations were found. For example, for a map class that has a 0.5-hectare MMU, a –44-meter buffer was applied to all polygons. If the total number needed for AA was not met, the buffer was reduced by 4 meters (meaning reduced from 44 meters to 40 meters) and reapplied; this method of buffer reduction continued until the total number of AA sites were located. Any AA site that did not meet the original buffer, 44 meters for 0.5-ha MMU and 34 meters for 0.25 ha, were also given a survey area polygon to ensure the survey area occurred in the correct polygon. The site coordinates were projected in UTM, Zone 19 North, by using NAD 83. The site coordinates along with the MMU for each site and an accompanying survey area boundary (if different than a circle) were provided electronically to upload into GPS receivers for use by field crews.

Field Data Collection

Without knowing the map classifications of AA site locations, field observation data were collected by AA field teams (field crews) composed of different individuals; each field crew consisted of a lead botanist and field assistant. Each field crew navigated to the preselected AA sites using GPS.

Field crews assessed an area approximately the size of the MMU defined for each AA site. The size of the MMU defined for each AA site is either a circle with a 40-meter radius for a MMU of 0.5 ha; a circle with a 28-meter radius for an MMU of 0.25 ha; or if the mapped polygon boundaries could not support a circular MMU, an area specified by polygon boundaries was provided. At each AA site, field crews determined the assessment area size (0.5 ha or 0.25 ha) by reviewing the GPS data or by surveying the provided shape on their GPS.

Within the targeted assessment area, the field crew recorded data that included: the GPS coordinate location, dominant species and any indicator species noted in the field key, environmental data, pertinent comments, and a series of systematic photographs. The indicator species noted in the field key are drawn from the full USNVC association description and are meant to assist users to key to the correct vegetation association. Plant taxonomy and nomenclature were recorded per Haines (2011). A field key to KAWW vegetation types guided field crews to the vegetation type that best classifies the AA site. When the vegetation type was uncertain (for example, a type that expressed a variation not supported by the vegetation field key or an ecotone between two vegetation types), the field crew made a single “best call” but took extra notes on the circumstance. In numerous instances, an “alternate field call” was recorded and, therefore, provided a second vegetation type to classify a specific site. When two vegetation types were recognized, the crew was instructed to note the vegetation type that covered the most area within the radius of an MMU. For additional field collection details and procedures, see “Appendix G: Accuracy Assessment Field Manual” in Hop and others (2017b).

Table 4. Values for calculating buffer distance from map polygon boundaries for the random selection of accuracy assessment sites.

[See equation 1. MMU, minimum mapping unit; *R*, radius; *F*, global positioning system error; *M*, map positional accuracy]

MMU, in hectares	*R*, in meters	*F*, in meters	*M*, in meters	Buffer distance, in meters
0.5	40	15	12	44
0.25	28	15	12	34

Field Data Review

Following the collection of field data, a systemic review and update was conducted on each AA site prior to analysis. The AA team lead reviewed the data for each AA site to ensure completeness of data and that the plant species list for each site contained species that were known to occur in the Monument and appropriate to the location of the AA site. Finally, the field call(s) for each site was reviewed with a final "office" call provided by the AA team lead. This office call, based on all the data and photographs collected for the AA site, became the official vegetation classification for the AA site that was then used in the final analysis.

Data Analyses

Field data for 107 AA sites were collected and then entered into the NPS PLOTS database version 4.0 (National Park Service, 2018) for the project, with subsequent review of data entry. Of the 107 AA collection sites, two sites were excluded from the analysis because of unresolvable issues with the field data. Thus, 105 AA sites were used in the analysis of vegetation map layer accuracy. The analysis included the following steps:

- initial comparative analysis of the field-site and map-polygon data,
- review of all disagreements and correction of false errors as necessary,
- analysis of individual map classes,
- final output of results into a contingency (matrix) table, and
- final output of the analyses and results into a spatial database for use in a GIS.

Initial Comparative Analysis

The AA field-site data and map-polygon data were spatially joined using ArcGIS Pro (Esri, 2020). Each AA field-site classification call (to a vegetation type) was compared to the corresponding map-polygon classification call (to a map class representing one or more vegetation types). Results from this initial comparison were tabulated either as a "match" (agreement) or a "mismatch" (disagreement). Matches were determined when either the primary or the secondary field-site calls, or the office call, were in agreement with the map-polygon call. Mismatches were determined when the criteria for a match was not met. The initial comparison revealed that 56.60 percent of the AA sites matched the corresponding mapped polygons.

Review of Disagreements

Each set of mismatched classification calls were reviewed and specified as either a "false error" or a "true error." A false error is defined as a mismatch that was caused by one of the following: (1) spatial accuracy error in the field-site coordinates or map layer, (2) a missing or misapplied field-site classification call, (3) a field-site assessment of an area smaller than an MMU for the map class being assessed (an inclusion), or (4) a significant change in vegetation with time (such as the time between image acquisition and AA sampling). In contrast, a true error is defined as a mismatch that was caused by the mapping, determined after exploring causes for a false error. This review process involved using ArcGIS to locate and view the AA field site locations and their corresponding polygons on a computer screen by using digital aerial imagery and the software program called "Stereo Analyst for ArcGIS" (Hexagon Geospatial, 2020). The field data sheets were also reviewed to gain a fuller sense of the context of the ground data. A classification determined to be a false error could be reclassified as a match pending a secondary review during an AA reconciliation meeting.

Spatial Accuracy

A spatial error might exist when (1) the GPS device acquired inaccurate field coordinates or (2) a geospatial error existed within the vegetation map layer (called a "map-layer shift"). These spatial errors could displace the newly acquired field coordinate to an adjacent polygon on the map layer. Spatial errors in GPS coordinates were minimized during the random site selection process by selecting AA site coordinates more than 34 meters (for 0.25-ha MMU map classes) or 44 meters (for 0.5-ha MMU map classes) from map polygon edges; however, field-acquired GPS coordinates collected with a poor GPS accuracy could position the coordinates into an adjacent map polygon. Furthermore, during AA site selection, the buffer distance from polygon edges was reduced when the target number of AA sites for a map class could not otherwise be attained; this increased the likelihood that the field-acquired GPS position was not in the correct map polygon, even with acceptable GPS accuracy.

Field-Site Classification Call

A field-site classification call might have been questioned during the analysis. A likely reason for questioning a field-site call was when the perspective from the ground was limited by impenetrable vegetation, wet soils prevented the field crew from accessing the entire AA site, or the site was assessed prior to emergence or following senescence of vegetation. For example, the area of an MMU for the map class could not be assessed so herbaceous indicator species were not recorded on the data sheet. Another reason for questioning a field-site call was if the AA site had diverse or complicated vegetation, and other vegetation types were omitted or not recognized by the field crew. Questionable field-site calls were reviewed by

checking the aerial imagery at the AA site, inspecting the field data sheets for misapplications, and reviewing AA site photographs for additional information. These field sites required further, joint analysis by UMESC and MNAP staff during the AA reconciliation meeting.

Inclusion

An area assessed in the field might have been smaller than the MMU for the map class. When this happened, it was termed an "inclusion." The AA site in question may have contained vegetation that was merely an inclusion to the entire AA site area, but this may have been impossible to determine from the ground. Certain vegetation features were quite distinct from each other when the aerial imagery was viewed three-dimensionally (such as open woodland versus dense forest), which made for easier determination of site inclusion. An inclusion might also exist when the field assessment was indeed of a proper area (size of an MMU for the map class being assessed), but the field-assessed area overlapped into an adjacent map polygon. Determining if the assessed area fell within the intended polygon could sometimes be difficult, particularly in the case of smaller, complex polygons. Along with the questionable field-site classification calls, inclusion errors required further joint analysis by UMESC and MNAP staff during the AA reconciliation meeting.

Vegetation Change with Time

The vegetation map layer represents the ground conditions at the time aerial imagery was collected for the project. Because the vegetation landscape is not static like the imagery, change could occur. When this happened, the assessed area was termed as a "change in vegetation with time." Determinations of vegetation change were easily made by a comparison between the aerial imagery and AA field-site pictures. Examples of potential changes in the vegetation landscape are tree mortality from insect infestation or beaver flooding, maintenance activities by the KAWW staff, and severe weather events such as ice storms, tornados, and high winds. Determinations were confirmed during the AA reconciliation meeting.

Individual Map-Class Analysis

A contingency table was generated to present the results of the initial analysis of the AA data with the vegetation map layer. This contingency table provided important information including users' and producers' accuracies of individual map classes, and agreements and disagreements of map classes. Individual map-class accuracies that fell below the NPS VMI Program standard were reviewed to determine which map classes were in confusion with each other. If repeated confusion was evident, a decision was made whether to merge the map classes to gain higher accuracy or to leave the map classes separate and accept lower accuracy. When a lower accuracy was accepted, the benefits of having that particular class mapped separately outweighed the benefits of a merge with other classes to produce a higher accuracy. These decisions were made with input from UMESC and KAWW staff.

To avoid underestimating the role that the MNAP and UMESC staff played in the reconciliation of AA results, and the effect that these results had on the final map classification for the project, further understanding of the processes and steps that ultimately produced the final AA results and map classification is provided.

Review and Reconciliation of Site-Specific AA Data

Staff from UMESC met in January 2021 to review and reconcile site specific AA field-site data. Site-specific AA field-site data were reviewed for potential changes to classification assignments, for inclusions of vegetation not characterized by the MMU, and for vegetation that changed from the time of imagery capture to the time of AA data collection. Adjustments to the vegetation classification, mapping classification, and field key to vegetation were also addressed. Once the UMESC staff completed the review, a spreadsheet containing notes on each site was sent to the MNAP staff for their input on each field site reviewed. Of the 105 analyzed AA sites, 47 were included in the review and reconciliation of AA field data.

Post-reconciliation AA Contingency Table

The AA contingency table was updated to reflect adjustments from the review and reconciliation meeting. Individual map-classes that fell below the 80 percent accuracy standard of the NPS VMI Program were studied for where confusion was present in the mapping. Detailed proposals to address mapping issues were sent to KAWW staff for their input and decision.

Final AA Contingency Table

The results from the complete analyses, including the reconciliations of AA site data and the consolidation of map classes, were updated into the contingency table. The frequency of agreement and the placement of disagreements are listed in the contingency table. The percentages of users' and producers' accuracies were recalculated for each map class.

Results and Discussion

Of the 105 sites used in the analysis, the initial comparison determined that only 56.60 percent of the AA sites matched the corresponding polygons that represented natural (including ruderal) vegetation types. Through the review process of correcting false errors and of combining some map classes because of low accuracies, the overall accuracy was increased to 87.6 percent. A kappa adjustment for chance agreements resulted in an overall accuracy of 87.0 percent.

The contingency matrix of the AA results for the project is shown in figure 4. The matrix table lists the accuracy of each map class (along with 90-percent confidence intervals); with the users' accuracy reflecting errors of inclusion (commission errors) and the producers' accuracy reflecting errors of exclusion (omission errors). The very large width of each confidence interval was affected by the low sample size used to derive the point estimate with the low sample size being a consequence of the prorated sampling design used on this project.

The overall AA met the accuracy requirement of 80 percent established by the NPS VMI Program. The most important factors affecting accuracy were (1) confusion among forested wetland types and (2) overaggressive mapping of forested wetlands. With the analysis complete, some individual map class accuracies did not meet the 80 percent requirement (taking into account 90-percent confidence intervals). In general, errors of commission (users' accuracy) occurred in fewer map classes than did errors of omission (producers' accuracy). The following are map classes for which the mapping project did not meet the required rates of accuracy in terms of either the actual percentage or the confidence intervals.

Users' Accuracy (Errors of Commission)

For each map class that has a users' accuracy (errors of commission) below NPS VMI Program standards, the individual errors of commission are reviewed and reported. This section reports on individual map classes with users' accuracy below program standards and the associated map classes with which the errors of commission occur. A low users' accuracy indicates that a map class was mapped too aggressively, which refers to an overapplication of the map class within the Seboeis Unit. At the individual AA site level, the low users' accuracy indicates that for the map class being tested, AA determined that the vegetation at the AA site is represented by a different map class. For example, the mappers called the polygon the Northern Appalachian Spruce - Fir Swamp Forest (FSFS) map class, but the AA recognized a vegetation type at the AA site that is represented by the Hardwood - Conifer Seepage Forest (FSHC) map class.

For simplification, the following explanations of map classes with low users' accuracy provide vegetation classification of AA sites using map classes that represent the classified vegetation types. Some map classes represent multiple vegetation types. For the purpose of these explanations, the level of detail by vegetation type is not necessarily needed.

Northern Appalachian Spruce - Fir Swamp Forest (FSFS) Map Class

The users' accuracy for the Northern Appalachian Spruce - Fir Swamp Forest (FSFS) map class was 0 percent, with a 90-percent confidence interval of –17 to 17 percent. Of the three AA sites tested for FSFS, all contained vegetation types other than FSFS. The following are the attributed errors.

- Two Hardwood - Conifer Seepage Forest (FSHC) sites were mapped as FSFS because mappers underestimated the total cover of hardwoods or were unable to see the extent of hardwood tree cover under overtopping conifer trees.
- One Northern White-cedar Swamp (FSWC) site was mapped as FSFS because mappers misinterpreted northern white cedar (*Thuja occidentalis*) as red spruce (*Picea rubens*).

Red Maple Swamp and Fen (FSRM) Map Class

The users' accuracy for the Red Maple Swamp and Fen (FSRM) map class was 25 percent, with a 90-percent confidence interval of –23 to 73 percent. Of the four AA sites tested for FSRM, three sites contained vegetation types other than FSRM. The following are the attributed errors.

- One Ruderal Aspen - Birch Woodland (FXAB) site and one Successional Mixed Spruce - Fir - Hardwood Forest (FXSH) site were mapped as FSRM because mappers overestimated the amount of hydrologic influence in ruderal upland forests (there are no ruderal wetland hardwood forests in the KAWW).
- One Herbaceous Graminoid Sedge Marsh (HMGS) site was mapped as FSRM because mappers overestimated the amount of hardwood tree cover in an otherwise herbaceous marsh.

Producers' Accuracy (Errors of Omission)

No map classes had a producers' accuracy (errors of omission) below programmatic standards.

Summary

Katahdin Woods and Waters National Monument, established on August 24, 2016, is composed of 11 distinct units and covers approximately 35,410 ha in central Maine (fig. 1). The Seboeis Unit, located in the northeast part of the Monument, covers approximately 4,851 ha. This unit was studied by the UMESC and MNAP starting in the fall of 2019 through funding from the USGS NRPP. This project provided Katahdin Woods and Waters National Monument managers with the following products that are available in the associated data release:

- fall, true-color and near-infrared imagery with a 15-centimeter pixel resolution for the entire monument,
- a vegetation classification and field key to vegetation for the entire monument,
- vegetation plots data for the Seboeis Unit,

Accuracy Assessment: Contingency Table

Map codes (table 3)	FBST	FFHG	FFTH	FHRS	FHSH	FHWP	FLSF	FNHW	FPHS	FRWP	FSFS	FSHC	FSRM	FSWC	FXAB	FXNH	FXSH	HAWL	HMBF	HMGS	HNCS	HOWM	SMML	SMSL	SSAL	SXNE	SXSM	WCRS	Commission: Total	Commission: Users' accuracy	Commission: 90-percent confidence intervals –	Commission: 90-percent confidence intervals +
FBST	6													1															7	86%	57%	115%
FFHG		4																											4	100%	88%	113%
FFTH			4																										4	100%	88%	113%
FHRS				6																									6	100%	92%	108%
FHSH					1		1																						2	50%	-33%	133%
FHWP						4																							4	100%	88%	113%
FLSF							4																						4	100%	88%	113%
FNHW								3				1																	4	75%	27%	123%
FPHS							1		3																				4	75%	27%	123%
FRWP										1																			1	100%	50%	150%
FSFS												2		1															3	0%	-17%	17%
FSHC												8																	8	100%	94%	106%
FSRM													1		1		1			1									4	25%	-23%	73%
FSWC														1															1	100%	50%	150%
FXAB															4														4	100%	88%	113%
FXNH				1												5													6	83%	50%	117%
FXSH																	6												6	100%	92%	108%
HAWL																		1											1	100%	50%	150%
HMBF																			2	2									4	50%	-4%	104%
HMGS																				4									4	100%	88%	113%
HNCS																					1								1	100%	50%	150%
HOWM																						4							4	100%	88%	113%
SMML																							1						1	100%	50%	150%
SMSL																								4					4	100%	88%	113%
SSAL																									3				3	100%	83%	117%
SXNE																										4			4	100%	88%	113%
SXSM																											3		3	100%	83%	117%
WCRS																												4	4	100%	88%	113%
TOTAL	6	4	4	7	1	4	6	3	3	1	0	11	1	3	5	5	7	1	2	7	1	4	1	4	3	4	3	4	105	Total Samples		

		FBST	FFHG	FFTH	FHRS	FHSH	FHWP	FLSF	FNHW	FPHS	FRWP	FSFS	FSHC	FSRM	FSWC	FXAB	FXNH	FXSH	HAWL	HMBF	HMGS	HNCS	HOWM	SMML	SMSL	SSAL	SXNE	SXSM	WCRS
Omission	Producers' accuracy	100%	100%	100%	86%	100%	100%	67%	100%	100%	100%	No value	73%	100%	33%	80%	100%	86%	100%	100%	57%	100%	100%	100%	100%	100%	100%	100%	100%
	90-percent confidence interval –	92%	88%	88%	57%	50%	88%	27%	83%	83%	50%	No value	46%	50%	-28%	41%	90%	57%	50%	75%	19%	50%	88%	50%	88%	83%	88%	83%	88%
	90-percent confidence interval +	108%	113%	113%	115%	150%	113%	107%	117%	117%	150%	No value	99%	150%	95%	119%	110%	115%	150%	125%	95%	150%	113%	150%	113%	117%	113%	117%	113%

Total Samples Correct
92

Figure 4. Final accuracy assessment contingency table by map class for the Katahdin Woods and Waters Seboeis Unit vegetation mapping project. Map class codes are presented in table 3.

- a mapping classification and vegetation mapping tree for the Seboeis Unit,
- a geospatial dataset with the vector and attribution data needed to prepare a vegetation map of the Seboeis Unit,
- an accuracy assessment and associated data for the Seboeis Unit map,
- and this final report detailing all aspects of this project.

The final map, covering 4,854.8 ha with 1,261 polygons, included 33 different map classes representing the vegetation of the Seboeis Unit. The map classes in turn represent 50 U.S. National Vegetation Classification (USNVC) association types, 2 USNVC cultural types for developed areas, and 3 non-USNVC types for non-vegetated open water. This final map, tested for accuracy, showed an overall accuracy of 87.04 percent when adjusted for random chance (kappa).

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Glossary

Bryoids Mosses. Also referred to as Bryophyta.

Calciphile Plants that require soils rich in calcium. These soils generally support a greater diversity of plant species.

Hardwood Used to describe any deciduous tree or group of deciduous trees.

Minerotrophic Usually used in reference to a wetland, such as a rich fen or fen, where the water inflow to the system is from mineral-rich, circumneutral groundwater.

Ombrotrophic Usually used in reference to a wetland, such as a poor fen or a bog, where the water inflow to the system is from precipitation and tends to be circumneutral to slightly acidic.

Ruderal vegetation For this report, ruderal vegetation is defined as "vegetation found on human-disturbed sites, with no apparent recent historical natural analogs and whose current composition and structure is not a function of continuous cultivation by humans and includes a broadly distinctive characteristic species combination, whether tree, shrub, or herb dominated. The vegetation is often composed of invasive species, whether exotic or native, that have expanded in extent and abundance due to the human disturbances" (Faber-Langendoen and others, 2014).

Softwood Used to describe any coniferous tree or group of coniferous trees.

Appendix 1. Field Key to Vegetation Types

Appendix 1 is a field key to the vegetation types (plant communities) of Katahdin Woods and Waters National Monument (KAWW). This field key, authored by Don Cameron and Justin Schlawin of the Maine Natural Areas Program, includes vegetation types represented by vegetation plot data (legacy plots and quick plots), field observations for the KAWW vegetation mapping project, and vegetation types otherwise expected to occur within the KAWW. Vegetation types that are not represented in this vegetation field key possibly could be present in the KAWW.

Most of the vegetation types in this field key represent a subset of the U.S. National Vegetation Classification that were recognized from the KAWW vegetation mapping project. For each U.S. National Vegetation Classification association in the field key, the scientific name for the association in the U.S. National Vegetation Classification is given followed by a Community Element Global code (CEGL00####).

Guidance on Using the Vegetation Field Key

The vegetation field key consists of dichotomous options that ultimately lead to a vegetation type. The field key is divided into four subkeys to narrow the focus to similar vegetation types: wooded uplands, wooded wetlands, open uplands, and open wetlands.

For the best results, all assessments of vegetation types in the field should be done on a defined area of homogeneous (uniform) vegetation (meaning a single vegetation type). For vegetation types that are larger scale (greater than 0.5 hectares [ha]), a 0.5-hectare (5,000-square-meter) area is used, which is equivalent to a 40-meter (m) radius around a center point or to a 50- by 100-m rectangle. For vegetation types that are smaller scale (0.25–0.5 ha), a 0.25-hectare area (2,500-square-meter) is used, which is equivalent to a 28-m radius around a center point or to a 50- by 50-m square. Appendix 2 in this report is recommended to complement the appendix 1 vegetation field key to determine a correct assessment of the vegetation classification. Appendix 2 provides descriptions to all vegetation types included in this vegetation field key.

Key to the Keys for the Vegetation Types of Katahdin Woods and Waters National Monument

1a.	Trees over 3.5 m tall form at least 30 percent cover: forests and woodlands	(2)
1b.	Trees over 3.5 m tall form less than 30 percent cover; some small islands of trees may be present: open vegetation	(3)
2a.	UPLANDS: soils are not saturated or seasonally flooded. Exception: sometimes in summit or other ledge types the “soil” of localized peat pockets over bedrock may be saturated; these are treated as inclusions in uplands	Wooded Uplands Key
2b.	WETLANDS: soils are saturated or seasonally flooded; usually basins or streamsides	Wooded Wetlands Key
3a.	UPLANDS: soils are not saturated or seasonally flooded. Exception: sometimes in summit or other ledge types the “soil” of localized peat pockets over bedrock may be saturated; these are treated as inclusions in uplands	Open Uplands Key
3b.	WETLANDS: soils are saturated or seasonally flooded; usually basins or streamsides	Open Wetlands Key

Wooded Uplands Key

1a.	Closed canopy forests, tree cover greater than 65 percent	(2)
1b.	Open canopy forests (woodlands), average tree cover ranging from about 25 to about 65 percent	(16)
2a.	Conifer dominated forests, broad-leaved trees less than 25 percent cover	(3)
2b.	Broad-leaved or mixed hardwood - conifer forests, broad-leaved trees greater than 25 percent cover	(7)
3a.	*Picea* spp. and/or *Abies balsamea* dominant	(4)
3b.	*Pinus* spp. and/or *Tsuga canadensis* dominant	(5)

4a.	*Picea rubens - Abies balsamea* dominated forest of lower elevation settings (244–610 m) with cold air drainage; *Betula alleghaniensis*, if present, with low cover; *Picea* and *Abies* regeneration are common components of the herb and shrub layer; herbs and dwarf shrubs are typically sparse with less than 10 percent cover each, the substrate is primarily needle litter and mosses that are present include a large proportion of broom-mosses (*Dicranum* spp.) and pincushion moss (*Leucobryum glaucum*)	**Lowland Spruce - Fir Forest (CEGL006273)**
4b.	*Picea rubens - Abies balsamea* dominated forest of higher elevation positions (typically above 457 m). *Betula alleghaniensis* often present and may form as much as 25 percent cover, rarely more; *Acer pensylvanicum* is a common shrub; herb layer with moderate to extensive cover of herbaceous species (often in patches), including *Oxalis montana*, *Dryopteris campyloptera*, *Clintonia borealis*, and/or *Streptopus* spp.; bryoid layer greater than 20 percent cover with feather-mosses prominent (including *Hylocomium splendens*, *Thuidium delicatulum*, and *Pleurozium schreberi*)	**Montane Red Spruce - Fir Forest (CEGL006128)**
5a.	*Pinus resinosa* dominant or codominant in canopy with *Pinus strobus* and *Picea rubens*	**White Pine - Red Pine Forest (CEGL006253)**
5b.	*Pinus resinosa* absent or scarce	(6)
6a.	*Tsuga canadensis* dominant or codominant with *Picea rubens*, variable presence of *Betula alleghaniensis*, *Betula papyrifera*, *Fagus grandifolia*, and *Acer saccharum*, on somewhat sheltered mesic well-drained settings	**Hemlock - Spruce - Hardwood Forest (CEGL006129)**
6b.	*Pinus strobus* is dominant with *Picea rubens* common, *Tsuga canadensis* is typical, but with variable cover	**White Pine - Hemlock - Red Spruce Forest (CEGL006324)**
7a.	Mid-successional to late successional upland forest, forest typically greater than 40 years old, any past dense regeneration has thinned out, older trees at subcanopy to canopy height	(8)
7b.	Early successional upland forests recovering from past harvest or other large-scale disturbance. Forest dominated by a mix of young trees of variable density, average tree age is less than 30 years old, canopy height well below the potential for the type	(12)
8a.	Hardwood dominated forests, conifers absent or when present rare to occasional and less than 25 percent cover	(9)
8b.	Mixed northern hardwoods with *Picea rubens* or *Pinus strobus*, conifer component exceeds 25 percent cover	(11)
9a.	Some combination of *Fagus grandifolia*, *Acer saccharum*, *Acer rubrum*, and *Betula alleghaniensis* dominates the canopy, with *Acer saccharum* less than 50 percent cover; *Fraxinus* spp. if present minor; herb layer rarely exceeds 40 percent cover except for tree seedlings; herbs of highly enriched sites absent	**Northern Hardwood Forest (CEGL006631)**
9b.	*Acer saccharum* dominant or codominant with *Fraxinus americana*	(10)
10a.	*Tilia americana* occasional; herbs and ferns include richness indicators such as *Caulophyllum thalictroides*, *Adiantum pedatum*, *Deparia acrostichoides*, *Carex plantaginea*, *Panax quinquefolius*, *Dryopteris goldiana*, and others, these richness indicators are usually widely distributed through the site	**Northern Sugar Maple - Ash Rich Mesic Forest (CEGL006636)**
10b.	*Tilia americana* rare or absent; presence of herbs that are indicators of moderate enrichment such as *Solidago flexicaulis*, *Osmorhiza* spp., *Carex pedunculata*, *Arisaema triphyllum*, *Botrychium virginianum*, these moderate richness indicators may be localized or patchy within the site	**Semi-rich Northern Hardwood Forest (CEGL006211)**
11a.	Canopy dominants are the northern hardwood species *Acer saccharum*, *Betula alleghaniensis*, and *Fagus grandifolia* along with *Pinus strobus*. Minor canopy associates may include *Tsuga canadensis* and/or *Quercus rubra*. *Abies balsamea*, *Picea rubens*, and *Thuja occidentalis* may also occur sparingly. The subcanopy is dominated by *Acer pensylvanicum*	**Northern Hardwood - White Pine Forest (CEGL005005)**

11b.	Dominant trees are *Picea rubens* and a variable mixture of the northern hardwoods *Acer saccharum*, *Betula alleghaniensis*, and *Fagus grandifolia* (at KAWW also commonly with *Acer rubrum*)	**Transitional Northern Hardwood - Red Spruce Forest (CEGL006267)**
12a.	Softwood or mixed hardwood - softwood dominated (softwood cover greater than 25 percent) early successional forest	(13)
12b.	Hardwood dominated early successional forest (softwood cover less than 25 percent)	(14)
13a.	Mixed hardwood - softwood dominated (softwood cover greater than 25 percent) early successional forest	**Successional Mixed Spruce - Fir - Hardwood Forest (CEGL006505)**
13b.	*Pinus strobus* dominated ruderal forest, often monotypic and even-aged, typically in former old fields or cleared flats along streams	**Ruderal Eastern White Pine Forest (CEGL007944)**
14a.	*Quercus rubra* common, early successional forest dominated by a mix of *Quercus rubra*, *Pinus strobus*, *Acer rubrum*, and *Betula papyrifera*	**Northeastern Ruderal Oak - Red Maple Forest (CEGL006506)**
14b.	Quercus rubra absent or rare	(15)
15a.	Early successional forest dominated by a mix of *Populus* spp. and *Betula* spp.	**Ruderal Aspen - Birch Woodland (CEGL006303)**
15b.	Early successional forest dominated by a mix of northern hardwood tree species including *Acer saccharum*, *Fagus grandifolia*, and *Betula alleghaniensis*	**Ruderal Sugar Maple - Northern Hardwood Forest (CEGL006628)**
16a.	*Thuja occidentalis* the dominant tree species, usually twice as abundant as any other tree species	**Northern White-cedar Mesic Rocky Woodland (CEGL006508)**
16b.	Species other than *Thuja occidentalis* dominate the tree layer	(17)
17a.	*Pinus resinosa* dominant in tree layer	**Red Pine Woodland (CEGL006010)**
17b.	Species other than *Pinus resinosa* dominate the tree layer	(18)
18a.	On talus, *Picea rubens* dominant	**Red Spruce Talus Slope Woodland (CEGL006250)**
18b.	On bedrock, *Picea rubens* dominant or codominant with other conifers including *Pinus strobus*	**Northern Appalachian Red Spruce Rocky Ridge (CEGL006053)**

Wooded Wetlands Key

1a.	Floodplains located along streams and rivers of third order or greater	(2)
1b.	Wetland setting various (basins, drainages, forested seepage areas) may be near a river but not directly affected by river overflow	(5)
2a.	*Alnus incana* dominated floodplain thickets	**Alluvial Alder Thicket (CEGL006062)**
2b.	*Acer* spp. dominated floodplain forests	(3)
3a.	*Acer saccharinum* dominant in canopy; spring flooding of high frequency and duration; soils are poorly drained and deep	**Silver Maple Floodplain Bottom Forest (CEGL006176)**
3b.	*Acer saccharum* dominant in canopy; alluvial soils are coarse and less regularly inundated	(4)
4a.	Canopy is dominated by *Acer saccharum*; the herb layer usually features *Matteuccia struthiopteris*, and a mixture of other ferns, forbs, and graminoids; these floodplain forests are found on slightly elevated alluvial terraces and active floodplains of larger rivers; the setting is a raised river terrace; however, this forest may occur very close to the riverbank if the water channel is well-entrenched, and may even be on sloping banks along some river reaches; soils are fine sand or silt, usually with good drainage capacity and relatively high nutrient levels	**Terrace Hardwood Floodplain Forest (CEGL006114)**
4b.	*Acer saccharum* dominates the canopy, with other upland trees including *Quercus rubra* and *Betula alleghaniensis*, *Ostrya virginiana* is a common smaller tree, herb layer with moderate cover, and features *Brachyelytrum aristosum*, *Carex intumescens*, *Solidago flexicaulis*, and *Danthonia spicata*; unlike other floodplain forests, ferns are limited; floods tend to be short-duration and high-disturbance events; soils are alluvial sands or sandy loams over coarser substrates, sometimes interspersed with buried organic layers	**High-gradient Hardwood Floodplain Forest (CEGL006504)**
5a.	*Picea mariana* or *Larix laricina* dominant in deep peat setting (typically greater than 50 centimeters [cm] thick)	(6)

5b.	Other tree species dominant or codominant, *Picea mariana* may be present, soils variable	(8)
6a.	Ombrotrophic; *Picea mariana* dominated open bog of large, raised peatlands, minerotrophic indicators absent, *Alnus incana* absent, *Larix laricina* if present typically infrequent	**Black Spruce Open Bog Woodland (CEGL002485)**
6b.	Weakly minerotrophic; not of large, raised peatlands, *Larix laricina* may be common	(7)
7a.	Shrubs are primarily ericaceous forming a well-developed low shrub layer, common shrubs may include *Chamaedaphne calyculata*, *Ledum groenlandicum*, *Kalmia angustifolia*, *Kalmia polifolia*, and *Rhododendron canadense*	**Black Spruce - Tamarack / Labrador-tea Poor Swamp (CEGL005271)**
7b.	Shrubs such as *Vaccinium corymbosum*, and/or *Ilex mucronata* (*Alnus incana* at KAWW) form a patchy tall shrub layer	**Subboreal Black Spruce Semi-treed Bog (CEGL006098)**
8a.	Conifers compose more than 50 percent of canopy	(9)
8b.	Conifers compose less than 50 percent of canopy	(14)
9a.	Deep peat substrate (typically greater than 50 cm thick), *Thuja occidentalis* dominant in broad, level, lowland sites	**White-cedar Peatland Swamp Forest (CEGL006007)**
9b.	Mineral-substrate or mineral substrate below a layer of peat or muck typically less than 35 cm thick	(10)
10a.	*Picea rubens* codominant with *Acer rubrum*	**Red Spruce - Red Maple Acidic Swamp Forest (CEGL006198)**
10b.	Other conifers dominant, *Acer rubrum* may be present in relatively low cover	(11)
11a.	*Thuja occidentalis* dominant on gently sloping terrain or toe slopes	**Northern White-cedar - Spruce Seepage Forest (CEGL006175)**
11b.	*Picea rubens* and/or *Picea mariana* dominant; *Thuja occidentalis* may be present in lesser amounts	(12)
12a.	Well-drained, tree-cover less than 60 percent	**Northern Spruce / Heath Barrens (CEGL006421)**
12b.	Poorly drained, tree cover greater than 60 percent	(13)
13a.	Canopy dominated by some combination of *Picea rubens*, *Picea mariana*, and *Abies balsamea*. The bryophyte layer is well-developed and includes *Pleurozium schreberi*, *Hylocomium splendens*, *Ptilium crista-castrensis*, *Bazzania trilobata*, and *Sphagnum* spp.; soils are poorly drained but usually not saturated	**Northern Spruce - Fir Flats (CEGL006361)**
13b.	Canopy dominated by *Picea rubens* and *Abies balsamea* with smaller amounts of *Picea mariana*, *Picea glauca*, or *Larix laricina*; the bryophyte layer is dominated by *Sphagnum* spp. but also includes *Bazzania trilobata*, *Pleurozium schreberi*, and *Aulacomnium palustre*; soils are typically saturated	**Northern Appalachian Spruce - Fir Swamp (CEGL006312)**
14a.	Partially open canopy with *Acer rubrum* as dominant hardwood in lowland basins, lake basins, or peatland settings with herbaceous richness indicators generally absent, *Fraxinus nigra* present or absent	(15)
14b.	Moderate to closed canopy dominated by a mix of *Acer rubrum*, *Fraxinus nigra*, and *Betula alleghaniensis* in groundwater seepage areas such as headwater basins, ecotones, or streamsides	(16)
15a.	*Acer rubrum* is dominant in an open to moderate cover canopy, *Picea mariana*, *Abies balsamea*, and *Larix laricina* may be associates; the shrub layer is well developed; the herbaceous layer generally includes *Osmunda regalis*, *Osmundastrum cinnamomeum*, *Coptis trifolia*, *Thelypteris palustris*, and *Onoclea sensibilis* with *Carex trisperma* as the most frequent and abundant sedge	**Red Maple Wooded Fen (CEGL006395)**
15b.	*Acer rubrum* is dominant in the canopy and consists of scattered trees, common associates are *Fraxinus nigra* and *Ulmus americana*; the shrub layer is often patchy, but may be extensive in places; the herbaceous layer is typically dominated by the graminoids *Carex stricta*, *Carex lacustris*, or *Calamagrostis canadensis*; hummock-and-hollow topography may be pronounced	**Red Maple / Upright Sedge Wet Woodland (CEGL006119)**

16a.	Canopy is codominated by a mix of hardwoods such as *Betula alleghaniensis*, *Fraxinus pennsylvanica*, and *Acer rubrum*. *Fraxinus nigra* is often present. Muck soils are not deep nor permanently saturated. Occurs in moist ecotonal areas between uplands and wetlands or localized on weak slopes	**Hardwood - Conifer Seepage Forest (CEGL006380)**
16b.	Canopy is codominated by *Acer rubrum*, *Betula alleghaniensis*, and *Fraxinus nigra*, with *Alnus incana* common in the tall shrub layer. Soils are deep muck and may exceed 1 m, primarily occurs in headwater seepage basins	(17)
17a.	Herbaceous richness indicators limited to species such as *Geum rivale*, *Impatiens capensis*, and *Chrysosplenium americanum* (type includes scattered *Picea glauca* and lacks *Tsuga canadensis* in KAWW region)	**Northern Hardwood - Hemlock Seepage Swamp Forest (CEGL006502)**
17b.	Herbaceous species indicative of calcium-rich seepage present such as *Carex flava*, *Carex lacustris*, *Packera* spp. or *Cypripedium reginae*	**Red Maple - Black Ash Rich Seepage Swamp Forest (CEGL006009)**

Open Uplands Key

1a.	Site with little to no exposed bedrock, often resulting from past human disturbance	(2)
1b.	Site with a predominance of exposed bedrock	(3)
2a.	Grasslands, generally composed of mid-height (0.5–1 m tall) grasses and forbs, with occasional scattered shrubs	**Northeastern Old Field (CEGL006107)**
2b.	Shrub dominated old fields or clearings (for KAWW: *Betula populifolia*, *Prunus pensylvanica*, *Alnus incana*, *Spiraea alba*, *Sambucus racemosa*, *Acer rubrum*, *Fraxinus americana*, *Populus tremuloides*, *Populus grandidentata*, and *Alnus viridis* and *Populus balsamifera* on drier sites)	**Northeastern Ruderal Shrubland (CEGL006451)**
3a.	Patches of low stature vegetation interspersed with bare rock in open areas on ridgelines, hill tops, or low mountains, typically below tree line; *Vaccinium angustifolium*, *Vaccinium uliginosum*, and *Empetrum nigrum* typically common; scattered trees and taller shrubs often present	**Blueberry Granite Barrens (CEGL005094)**
3b.	Nearly vertical cliff faces with sparse vegetation and without circumneutral indicator species; granitic or other acidic bedrock	**Northern Appalachian Acidic Cliff (CEGL006528)**

Open Wetlands Key

1a.	Type dominated by submerged or floating-leaved aquatic vegetation; emergent plants, if present, are mostly those that die back below the water in autumn	(2)
1b.	Not as above; lakeshores, river shores, bogs, fens, marshes that are not permanently underwater or, if so, are vegetated with emergent vegetation that remains through the winter	(5)
2a.	Dominated by submerged and floating-leaved aquatic vegetation	(3)
2b.	Dominated by emergent-leaved aquatic vegetation	(4)
3a.	Dominated by *Nuphar variegata* or *Nymphaea odorata* with mix of floating-leaved and submerged species	**Water-lily Aquatic Wetland (CEGL002386)**
3b.	Dominated by submergent or emergent plants with only minor floating-leaved components	**Open Water Marsh with Mixed Submergents/ Emergents (CEGL006196)**
4a.	*Pontederia cordata* dominant among the emergent species	**Northeastern Leafy Forb Marsh (CEGL006191)**
4b.	Graminoids dominant among emergent species	**Eastern Cattail Marsh (CEGL006153)**
5a.	Vegetation of river shores or lakeshores, with the substrate primarily mineral rather than organic; mostly in linear bands following the shoreline; may be flooded seasonally, but out of the water for most of growing season	(6)
5b.	Wetlands in basins or along broad drainages, with organic soils or with an organic layer over mineral substrate; vegetation often covering a large part of the substrate; saturated through all or most of the year	(9)
6a.	Shrubs, mostly greater than 1 m tall, predominate	**Alluvial Alder Thicket (CEGL006062)**
6b.	Shrubs less than 1 m tall, or mixture of shrubs and herbaceous plants, predominate	(7)

7a.	Mixed shrub–herb vegetation on sloping eroding river shores where substrate is constantly saturated by groundwater seepage; calciphile fen species present, examples include *Parnassia glauca*, *Lobelia kalmii*, and *Triantha glutinosa*; bryophyte layer at least locally well developed, with species other than *Sphagnum* dominant	**Northern Appalachian Calcareous Riverside Seep (CEGL006142)**
7b.	Vegetation of almost flat river shores or lakeshore sand/cobble beaches, substrate gravelly to sandy and not constantly saturated to the surface by seepage; bryophytes sparse or absent	(8)
8a.	Tall graminoids and forbs dominant, forming a dense meadow; shrubs, if present, are rarely taller than the herbs; *Calamagrostis canadensis*, *Eutrochium maculatum*, and *Doellingeria umbellata* characteristic	**Laurentian & Northeast Bluejoint Wet Meadow (CEGL005448)**
8b.	Vegetation of cobble river scours, often including *Carex torta*	**Northeastern Temperate Cobble Scour Rivershore (CEGL006536)**
9a.	Bogs and fens: substrate of accumulated peat (undecayed to partially decayed), usually greater than 0.5 m deep and with extensive *Sphagnum* moss on the surface, sometimes floating on water; saturated	(10)
9b.	Marshes or shrublands: substrate is mineral soil, often with a surface layer of well-decomposed organic matter (peat, typically sedge-derived, may be greater than 0.5 m thick but is generally less); *Sphagnum* may be present but typically does not form an extensive deposit; some sites remain saturated, but many dry out for at least part of the growing season	(18)
10a.	Open *Sphagnum* lawns with varying degrees of low growing sedges and dwarf shrubs	(11)
10b.	Shrub and/or herb cover more extensive	(12)
11a.	*Sphagnum*-dominated, often in raised peatlands; substrate flat, highly saturated, and unstable; vascular plants usually less than 25 percent cover and limited to low-growing species such as *Vaccinium oxycoccos*, *Utricularia cornuta*, and *Rhynchospora alba*; severely dwarfed *Chamaedaphne calyculata* or other ericaceous shrubs may be present	**Oligotrophic Peatland Moss Lawn (CEGL006135)**
11b.	*Sphagnum*-dominated with or without high cover of the low sedges, *Carex oligosperma* and *Carex pauciflora*, as well as *Eriophorum vaginatum* and *Eriophorum virginicum*; scattered low shrubs may occur, such as *Andromeda polifolia*, *Chamaedaphne calyculata*, *Kalmia angustifolia*, *Ledum groenlandicum*, and *Vaccinium oxycoccos*; substrate hummocky to flat	**Open Graminoid / Sphagnum Bog (CEGL005256)**
12a.	Graminoid cover equals or exceeds shrub cover, including dwarf shrubs	(13)
12b.	Shrub cover (including dwarf shrubs) exceeds graminoid cover	(15)
13a.	Dominated by *Carex oligosperma* or other low growing sedges often mixed with *Eriophorum vaginatum* and *Eriophorum virginicum*; low stature *Chamaedaphne calyculata* and/or *Andromeda polifolia* are present but with lower cover then sedges	**Few-seeded Sedge - Leatherleaf Fen (CEGL006524)**
13b.	Dominated by robust sedges mixed with taller stature ericaceous shrubs	(14)
14a.	Dominated by *Carex lasiocarpa* with *Chamaedaphne calyculata* up to 25 percent cover	**Northern Sedge Poor Fen (CEGL002265)**
14b.	Vegetation dominated by tall sedges: typically dominated by *Carex utriculata* or *Carex lasiocarpa*; *Myrica gale*, *Andromeda polifolia*, and *Chamaedaphne calyculata* grow among the tall sedges	**Medium Fen (CEGL006302)**
15a.	Vegetation dominated by tall shrubs (mostly greater than 1.5 m); *Ilex mucronata*, *Alnus incana*, and *Calla palustris* characteristic; standing water usually present among hummocks of *Sphagnum* mosses; in peatlands often at the upland/peatland interface	**Northern Peatland Shrub Swamp (CEGL006158)**
15b.	Vegetation dominated by herbs or shrubs mostly under 1 m tall, typically including abundant ericaceous shrubs; *Ilex mucronata* and *Alnus incana* may be present, but are not dominant	(16)
16a.	Shrubs less than 1.5 m tall with *Myrica gale*, *Spiraea tomentosa*, and/or *Spiraea alba* prominent; *Chamaedaphne calyculata* often present, but other ericaceous shrubs not abundant; typically, in standing shallow water without a continuous *Sphagnum* carpet	**Sweetgale Mixed Shrub Fen (CEGL006512)**

16b.	Vegetation dominated by ericaceous shrubs (although *Myrica gale* often present), usually well under 1 m tall; bogs and fens on well-developed *Sphagnum* carpets	(17)
17a.	Weakly minerotrophic fen conditions (vegetation mostly in contact with the water table), with *Chamaedaphne calyculata* (or a combination of *Chamaedaphne* with *Andromeda polifolia* and/or *Myrica gale*) the dominant shrub; other shrubs and sedges mixed in; graminoid cover variable	**Leatherleaf Boggy Fen (CEGL006513)**
17b.	Ombrotrophic bog conditions (vegetation mostly raised above the water table), with *Kalmia angustifolia*, *Ledum groenlandicum*, and/or *Rhododendron canadense* together more abundant than *Chamaedaphne calyculata* and *Myrica gale*; graminoid cover rarely exceeds 15 percent	**Raised Dwarf-shrub Bog (CEGL006225)**
18a.	Ruderal vegetation, usually in human or beaver impacted areas. Shrub species usually include *Spiraea alba*, *Cornus amomum*, *Rubus allegheniensis*, *Salix* spp., and others. Associated herbaceous species are variable in composition. Invasive exotics sometimes present	**Ruderal Steeplebush / Reed Canary Grass Wet Shrubland (CEGL006571)**
18b.	Not ruderal vegetation	(19)
19a.	Shrub cover exceeds herb cover	(20)
19b.	Herb cover exceeds shrub cover	(21)
20a.	*Alnus incana* strongly dominant, greater than 30 percent cover; ericaceous shrubs absent or virtually so	**Alder Shrub Swamp (CEGL006839)**
20b.	*Myrica gale* and/or heath shrubs dominant, *Alnus incana* occasional or absent	**Sweetgale Mixed Shrub Fen (CEGL006512)**
21a.	*Carex stricta* is the dominant herbaceous species (greater than 30 percent cover, and usually greater than 50 percent); shrub cover usually less than 30 percent; standing water between hummocks for much of season	**Eastern Upright Sedge Wet Meadow (CEGL006412)**
21b.	Herb component dominated by species other than *Carex stricta*	(22)
22a.	*Scirpus* spp. dominant in variable mixed herbaceous cover in seasonally flooded or beaver impacted marsh settings, little to no shrub cover present	**Northeastern Woolgrass Wet Meadow (CEGL006349)**
22b.	*Calamagrostis canadensis* shares dominance with other robust graminoids such as *Scirpus* spp., *Dulichium arundinaceum*; shrub cover is less than herb cover (may include beaver impacted areas)	**Mixed Graminoid Wet Meadow (CEGL006519)**

Acknowledgments

This dichotomous key to the vegetation of the Seboeis Unit of Katahdin Woods and Waters National Monument was drafted by Don Cameron and Justin Schlawin of the Maine Natural Areas Program. It was continually tested and refined over the course of the project with thanks to Jamie Attanasio, Tiffany Reese, David Rubin, and Jennifer Tibbetts for directly testing the key during field work.

Appendix 2. Descriptions of Vegetation Types

Appendix 2 provides descriptions of each U.S. National Vegetation Classification (USNVC) vegetation association found in appendix 1. These descriptions, authored by Don Cameron and Justin Schlawin of the Maine Natural Areas Program, are based on data drawn from both the national description for each vegetation type found in the USNVC (USNVC, 2019) and the local data found in vegetation plots, collected in 2019, and in accuracy assessment sites, collected in 2020. The full USNVC descriptions have been edited in limited ways to increase their relevance to the northern Maine region where the Katahdin Woods and Waters National Monument (KAWW) is located.

These descriptions are not intended to capture all the potential variation found in each vegetation type, but to provide both a general overview and present distinguishing characteristics of each vegetation type.

Descriptions are ordered according to, first, their sub-key (Wooded Upland, Wooded Wetland, Open Upland, Open Wetland), and second, their CEGL00#### code. Descriptions are presented in this format:

- USNVC CEGL00#### code—USNVC common name
- [USNVC scientific name]
- Local description of vegetation as it presents in the Seboeis Unit of the KAWW.

Wooded Uplands

CEGL005005—Northern Hardwood - White Pine Forest

[*Acer saccharum* - *Pinus strobus* / *Acer pensylvanicum* Forest]

This dry white pine - northern hardwood forest occurs widely throughout the upper midwestern and northeastern United States and eastern Canada. The typical environmental setting is well-drained, acidic, sandy or gravelly soil over glacial till, in general a less mesic setting than northern hardwoods lacking white pine. Stands are characterized by a closed canopy, sometimes with supercanopy pine, patchy (but overall, fairly sparse) shrubs, and relatively sparse herb and bryoid strata. Canopy dominants are the northern hardwood species *Acer saccharum*, *Betula alleghaniensis*, and in the Northeast *Fagus grandifolia*, with *Pinus strobus*, the pine often occurring as a supercanopy. Minor canopy associates may include *Tsuga canadensis* and *Quercus rubra*. In the Northeast at the northern edge of the range, *Abies balsamea*, *Picea rubens*, and *Thuja occidentalis* may also occur sparingly. The subcanopy is dominated by *Acer pensylvanicum*. The herbaceous layer is characterized by *Trientalis borealis*, *Maianthemum canadense*, *Pteridium aquilinum*, and *Oryzopsis asperifolia*, intermixed with the dwarf-shrubs *Gaultheria procumbens*, *Vaccinium angustifolium*, and *Gaylussacia baccata*. Bryophytes include *Polytrichum commune*, *Pleurozium schreberi*, *Bazzania trilobata*, or *Hypnum imponens*.

CEGL006053—Northern Appalachian Red Spruce Rocky Ridge

[*Picea rubens* / *Vaccinium angustifolium* / *Sibbaldiopsis tridentata* Woodland]

This red spruce woodland of the Northern Appalachians occurs primarily on acidic bedrock outcrops or summits. Soil development is restricted to crevices or sheltered areas interspersed with substantial amounts of exposed bedrock. What soils are present are shallow, well-drained to excessively drained, acidic, coarse sands. Elevations of known examples range from near sea level at the coast to 305–760 meters (m) inland. The canopy is patchy and open, with areas of moderate canopy cover interspersed with areas of sparse vegetation and much open rock. Taken over a large area, woodland structure (25–60 percent canopy cover) is evident. Tall shrubs and herbs are sparse. The dwarf-shrub layer is of variable cover, and may be locally extensive, as may bryoids. Canopy trees are primarily *Picea rubens* and *Abies balsamea*, with *Pinus strobus* occasionally codominant. Associated tree species include *Betula papyrifera* var. *papyrifera*, *Betula papyrifera* var. *cordifolia*, *Pinus rigida*, *Thuja occidentalis*, and *Picea mariana*. Typical tall shrubs are *Sorbus americana*, *Sorbus decora*, *Viburnum nudum* var. *cassinoides*, *Ilex mucronata*, *Aronia melanocarpa*, and *Amelanchier* spp. The low heath layer is made up of *Vaccinium angustifolium*, *Vaccinium myrtilloides*, *Gaylussacia baccata*, and *Kalmia angustifolia*. Forbs and graminoids include *Deschampsia flexuosa*, *Danthonia spicata*, *Piptatheropsis pungens*, *Sibbaldiopsis tridentata*, *Solidago simplex* var. *randii*, and *Maianthemum canadense*. Bryoids include *Cladonia* spp., *Pleurozium schreberi*, *Dicranum polysetum*, *Polytrichum juniperinum*, *Polytrichum piliferum*, and *Polytrichum commune*. Ground cover is sparse needle litter and exposed bedrock. This association occurs on bedrock ridges and outcrops, compared to the floristically similar *Picea rubens* / *Ribes glandulosum* Woodland (CEGL006250), which occurs on talus.

CEGL006010—Red Pine Woodland

[*Pinus resinosa* / *Gaylussacia baccata* - *Vaccinium angustifolium* Woodland]

This red pine - heath woodland is scattered across the glaciated regions of the northeastern United States. Usually found on bedrock outcrops or mid-elevation ridges and summits, it can also occur on steep, excessively drained glacial deposits such as eskers and deltas. Elevations of known examples range from 152–823 m; most are at 305–732 m. The soils are dry, acidic, and nutrient-poor; on outcrops, soil development is restricted to crevices or sheltered areas interspersed with substantial amounts of exposed bedrock. Most if not all sites have a history of fire. Scattered conifers form a partial canopy over a patchy, but locally extensive, heath-forb understory. The bryoid layer may be extensive, with lichens generally more abundant than bryophytes. *Pinus resinosa* dominates the canopy. Associates at lower elevations include *Quercus rubra*, *Pinus strobus*, and *Acer rubrum*; as elevation increases above about 610 m, the common associates become *Picea rubens*, *Betula papyrifera* var. *papyrifera*, *Betula papyrifera* var. *cordifolia*, and *Abies balsamea*. Scattered shrubs include

Sorbus americana, *Viburnum nudum* var. *cassinoides*, *Acer pensylvanicum*, *Ilex mucronata*, *Aronia melanocarpa*, or *Amelanchier* spp. The low heath layer is characteristically well-developed, and typical species include *Vaccinium angustifolium*, *Vaccinium myrtilloides*, *Vaccinium pallidum*, *Gaylussacia baccata*, *Kalmia angustifolia*, and, at higher elevations, *Diervilla lonicera*. Herbs, less abundant than the dwarf-shrubs, include graminoids such as *Deschampsia flexuosa*, *Danthonia spicata*, and *Carex lucorum*; forbs include species such as *Sibbaldiopsis tridentata*, *Solidago simplex* var. *randii*, *Corydalis sempervirens*, *Epigaea repens*, *Maianthemum canadense*, *Aralia nudicaulis*, and *Gaultheria procumbens*; *Pteridium aquilinum* as a typical fern. Rock outcrops have abundant mosses (*Grimmia* spp. and others) and lichens (*Cladonia* spp.). The ground cover is sparse needle litter and exposed bedrock. Red pine is fire-resistant, and fire appears be important in maintaining its dominance at some sites. In the absence of fire, the associated spruces, white pines, and hardwoods tend to become more abundant. The open *Pinus resinosa* canopy and well-developed dwarf-shrub layer dominated by heaths are diagnostic features of this association.

CEGL006128—Montane Red Spruce - Fir Forest

[*Picea rubens* - *Abies balsamea* / *Sorbus americana* Forest]

These are red spruce - balsam fir forests in moist upland environments of the northern Appalachian Mountains, northern Maine, and adjacent Canada, forming the matrix forest of elevations between 670 and 1,070 m; this forest becomes patchy at lower and higher elevations. They occur on well-drained, strongly podzolized, nutrient-poor, usually shallow soils in areas where high-elevation clouds and fog or other microsite conditions provide a continuously moist environment. Through much of its range in the Northeast, this forest is strictly montane; however, north of the 45th parallel [KAWW] it occurs in cool lower-elevation settings as well. It occurs on gentle to steep slopes, north-, east-, or west-facing. These forests have mostly closed canopies, but gaps from windthrow are common and are rapidly colonized by regenerating tree species. The shrub and herb layers are variable in cover, generally sparse under closed canopies and better developed in gaps. The bryoid layer is well-developed: one of the characteristic features of these forests is the lush carpet of mosses and liverworts. The moderate to low light levels, persistent snowpack, and high moisture availability create favorable conditions for mosses and ferns. The canopy is dominated by *Picea rubens* and *Abies balsamea* with associates including *Betula papyrifera* var. *cordifolia*, *Betula alleghaniensis*, and *Picea mariana*. Scattered shrubs include *Sorbus americana*, *Sorbus decora*, *Amelanchier bartramiana*, *Ilex mucronata*, and *Vaccinium myrtilloides*. Particularly characteristic herbs are boreal/montane species such as *Oxalis montana*, *Clintonia borealis*, *Linnaea borealis*, *Coptis trifolia*, *Huperzia lucidula*, *Dryopteris campyloptera*, and *Gaultheria hispidula*. More widespread associated herbs include *Trientalis borealis*, *Maianthemum canadense*, *Cornus canadensis*, and the ferns *Dryopteris intermedia* and *Phegopteris connectilis*. Bryophytes include *Pleurozium schreberi*, *Hylocomium splendens*, *Bazzania trilobata*, *Dicranum scoparium*, *Hypnum curvifolium*, and *Ptilium crista-castrensis*. These spruce-fir forests are distinguished from similar types by their montane or higher-latitude upland setting, prevalence of *Picea rubens* and *Abies balsamea* in the canopy, and boreal herbs scattered in the lush bryoid layer.

CEGL006129—Hemlock - Spruce - Hardwood Forest

[*Tsuga canadensis* - (*Betula alleghaniensis*) - *Picea rubens* / *Cornus canadensis* Forest]

This mesic coniferous to mixed hemlock forest of northern and central New England and New York occurs on somewhat sheltered slopes at moderate elevations (30–610 m). Hillslopes, stream valleys, ravines, and river or kame terraces are typical settings. The soils are mesic, well-drained sands or loams, often derived from till, acidic and typically shallow (<50 cm to obstruction). Canopy cover is typically dense, resulting in low-light levels near the forest floor and correspondingly sparse lower layers of vegetation. The canopy is dominated by *Tsuga canadensis* and may be either almost entirely coniferous or a mixture of conifers and deciduous trees. Northern hardwoods are characteristic associates, including *Betula alleghaniensis*, *Betula papyrifera*, *Fagus grandifolia*, and *Acer saccharum*. *Picea rubens* is a common conifer associate and may approach codominance with hemlock at some sites. The scattered subcanopy and shrub layers may feature *Acer pensylvanicum* and *Viburnum lantanoides*. Herb richness and cover are very low; typical species include *Aralia nudicaulis*, *Cornus canadensis*, *Dryopteris intermedia*, *Gaultheria procumbens*, *Maianthemum canadense*, *Medeola virginiana*, *Mitchella repens*, *Thelypteris noveboracensis*, and *Trientalis borealis*. In northern settings (for example, where red spruce is common), the herb layer may contain more boreal species such as *Dryopteris campyloptera*, *Huperzia lucidula*, *Oxalis montana*, and *Trillium undulatum*. This association differs from other upland hemlock forest associations in the presence of *Picea rubens* and/or *Betula alleghaniensis* and the more generally boreal species affinities.

CEGL006211—Semi-rich Northern Hardwood Forest

[*Acer saccharum* - (*Fraxinus americana*) / *Arisaema triphyllum* Forest]

These are northern hardwood forests of slightly enriched soils in the northern Appalachian Mountains and adjacent northeastern United States and Canada. They occur at

moderate elevations of 245 to 610 m on slightly enriched soils, often silt loams derived from pelite or other subacidic bedrock. Ridgetops and slight concavities on hillslopes are both typical settings. They may occur as inclusions within typical northern hardwood forests or may occur over larger areas and be the locally dominant northern hardwood forest. The closed-canopy forest has sparse to moderate shrub cover, moderate herb cover, and may have local carpets of *Acer saccharum* seedlings in the ground vegetation. Bryoids are a minor component of the forest floor. The canopy is dominated by *Acer saccharum*, frequently with *Fraxinus americana* as an associate or even canopy codominant. Other associated hardwood species include *Betula alleghaniensis*. *Fagus grandifolia* is often present but less abundant than in matrix northern hardwood forests. Conifers are usually sparse. Shrubs can include *Cornus alternifolia*, *Sambucus racemosa*, *Acer pensylvanicum*, and *Ostrya virginiana*. Typical herbs of this semi-rich type, which are scarce or absent from standard beech-birch-maple forests, include *Arisaema triphyllum*, *Viola rotundifolia*, *Tiarella cordifolia*, *Actaea pachypoda*, *Osmunda claytoniana*, *Osmunda cinnamomea*, *Carex laxiculmis*, *Carex platyphylla*, *Carex pedunculata*, *Eurybia divaricata*, *Botrychium* spp., and *Solidago flexicaulis*. These forests are intermediate in nutrient regime and composition being less rich than the *Acer saccharum - Fraxinus americana* / *Acer spicatum* / *Caulophyllum thalictroides* Forest (CEGL006636) and *Acer saccharum - Tilia americana* / *Acer pensylvanicum* / *Caulophyllum thalictroides* Forest (CEGL006637), but more rich than the *Acer saccharum - Betula alleghaniensis - Fagus grandifolia* / *Viburnum lantanoides* Forest (CEGL006631) and *Acer saccharum - Fagus grandifolia - Fraxinus americana* / *Arisaema triphyllum* Forest (CEGL006632). They are more depauperate than other communities of this alliance, for example lacking rich-soil indicators such as *Adiantum pedatum*, *Caulophyllum thalictroides*, and *Tilia americana* that are typical of CEGL006636 and/or CEGL006637.

CEGL006250—Red Spruce Talus Slope Woodland

[*Picea rubens* / *Ribes glandulosum* Woodland]

This association is a red spruce woodland of acidic talus slopes in the Northern Appalachians. The community occurs generally within the spruce-fir forest zone at moderate to high elevations. The substrate varies, even within a site, from cobble to large boulder-sized talus. There is variable soil development depending on the periodicity and intensity of rockslides, but generally soils are thin and extremely patchy. The tree distribution is likewise patchy: in some areas there may be a partial to almost closed canopy; at most sites these areas are interspersed with patches of nearly open talus. Shrub and herb vegetation is very scattered and sparse. The bryoid layer ranges from sparse to well-developed; bryophytes are mostly desiccation-tolerant species, and crustose lichens may be extensive. The canopy is dominated by *Picea rubens*, in association with *Abies balsamea*, *Betula papyrifera* var. *papyrifera*, *Betula papyrifera* var. *cordifolia*, and *Betula alleghaniensis*. The tall-shrub cover is composed of *Acer spicatum*, *Acer pensylvanicum*, *Sorbus americana*, and *Sorbus decora*. *Ribes glandulosum* is a typical and diagnostic smaller shrub. Low heaths include *Kalmia angustifolia*, *Vaccinium angustifolium*, *Vaccinium myrtilloides*, and occasionally *Gaylussacia baccata*. The herbaceous layer is made up of vines and forbs confined to crevices and may include *Parthenocissus quinquefolia*, *Dryopteris marginalis*, *Polypodium appalachianum*, *Polygonum cilinode*, *Solidago simplex* var. *randii*, *Deschampsia flexuosa*, and occasionally *Juncus trifidus*. The bryoid layer is made up of *Umbilicaria* spp., *Cladonia* spp., *Grimmia* spp., *Ptilidium ciliare*, *Dicranum polysetum*, and other *Dicranum* spp. Ground cover is talus with variable litter accumulation. This association is differentiated from most other red spruce woodlands, such as the *Picea rubens* / *Vaccinium angustifolium* / *Sibbaldiopsis tridentata* Woodland (CEGL006053), in its occurrence on talus on steep slopes, and in general has a lower cover of heath shrubs. At some sites, near the base of the talus slope it may grade into *Picea mariana* / *Ledum groenlandicum - Empetrum nigrum* / *Cladonia* spp. Dwarf-shrubland (CEGL006268); this cold-air talus community has a much more extensive dwarf-shrub layer dominated by *Ledum groenlandicum*.

CEGL006253—White Pine - Red Pine Forest

[*Pinus strobus - Pinus resinosa* / *Cornus canadensis* Forest]

This dry pine forest is scattered across northern New England on very well-drained, coarse-textured, acidic soils. Substrates include sand and gravel deposits on flats, such as outwash sands, delta sands, eskers, kames, kame terraces, and dry lake sands. They also occur on upper hillslopes and low ridges, with shallow-to-bedrock soils. The canopy closure is usually 70–90 percent; shrubs are sparse, and the herb and bryoid layers are patchy, with overall cover generally well under 20 percent and often virtually absent. Needle accumulation and dry conditions are factors in the limited understory growth. The canopy is dominated by *Pinus strobus* and *Pinus resinosa*, with scattered minor associates including *Quercus rubra*, *Betula alleghaniensis*, *Abies balsamea*, *Picea rubens*, *Thuja occidentalis*, and *Acer rubrum*. Shrubs include *Kalmia angustifolia*, *Viburnum nudum* var. *cassinoides*, *Vaccinium angustifolium*, *Vaccinium myrtilloides*, *Gaylussacia baccata*, *Amelanchier canadensis*, and *Acer pensylvanicum*. Characteristic herbs include *Pteridium aquilinum*, *Oryzopsis asperifolia*, *Mitchella repens*, *Maianthemum canadense*, *Gaultheria procumbens*, *Cornus canadensis*, *Trientalis borealis*, and *Clintonia borealis*. Where mosses occur, typical species include *Dicranum polysetum*, *Dicranum undulatum*, *Polytrichum juniperinum*, *Pleurozium schreberi*, and *Brachythecium* spp. This community probably requires periodic fires for maintenance.

CEGL006267—Transitional Northern Hardwood - Red Spruce Forest

[*Betula alleghaniensis - Picea rubens* / *Dryopteris campyloptera* Forest]

This transitional hardwood - spruce forest occurs in montane regions of northern New England, the Northern Appalachians, and in adjacent Canada. This forest is most extensive at middle elevations, between 305 and 760 m, occurring on slopes with rocky, nutrient-poor, and often shallow till soils that are well-drained to excessively well-drained. This association forms a relatively broad transitional zone between the lower northern hardwood forests and the higher montane spruce-fir forests. The canopy varies from nearly closed to partly open. Shrubs, herbs, and tree regeneration forms a dense cover in gaps; under closed canopies, understory layers can be sparse. The dominant trees are *Picea rubens* and a variable mixture of the northern hardwoods *Acer saccharum*, *Betula alleghaniensis*, and *Fagus grandifolia*. Other canopy associates include *Acer rubrum*, *Abies balsamea*, *Thuja occidentalis*, and *Betula papyrifera*. *Abies balsamea* may be the major conifer, in either the canopy or subcanopy, in stands that have been selectively logged. Shrub and herbaceous layers contain species common to both northern hardwood and spruce-fir forests. Characteristic shrubs include *Sorbus americana*, *Sorbus decora*, *Acer pensylvanicum*, *Acer spicatum*, and *Viburnum lantanoides*. Characteristic herbs include *Dryopteris intermedia*, *Dryopteris campyloptera*, *Clintonia borealis*, *Oxalis montana*, *Linnaea borealis*, *Maianthemum canadense*, *Streptopus lanceolatus* var. *roseus*, and *Aralia nudicaulis*. The bryophyte layer is of variable cover and may include *Bazzania trilobata*, *Dicranum scoparium*, *Hypnum imponens*, *Hylocomium splendens*, *Leucobryum glaucum*, and *Polytrichum commune*. On the ground, this community can grade into both northern hardwood forest and spruce-fir forest types; this type is distinguished by the codominance of conifers and hardwoods.

CEGL006273—Lowland Spruce - Fir Forest

[*Picea rubens - Abies balsamea - Betula papyrifera* Forest]

These red spruce - balsam fir forests are widespread on lower-elevation slopes across boreal regions of the northeastern United States and adjacent Canada. They occur in cool and generally moist upland settings, on well-drained tills, and occasionally on kame deposits or eskers. Some areas of poorly drained soils may be present. Most are at elevations of 245–610 m; occasionally, cold-air drainage allows them to occur in lowlands at elevations below northern hardwood forests. These low-diversity forests have a closed canopy and very sparse shrub and herbaceous layers, except in gaps where regeneration can be dense. The canopy is dominated by *Picea rubens*, with a minor to moderate amount of *Abies balsamea*. Associate canopy species may include *Picea glauca*, *Picea mariana*, *Betula alleghaniensis*, *Betula papyrifera*, and minor amounts of *Acer rubrum*, *Populus tremuloides*, or *Larix laricina*. *Tsuga canadensis* and *Pinus strobus* may be present but are rarely abundant. The shrub layer is patchy and typically includes *Acer pensylvanicum* and *Viburnum lantanoides*. Occasional shrubs include *Viburnum nudum* var. *cassinoides*, *Ilex mucronata*, and *Sorbus americana* or *Sorbus decora*. The herb layer includes *Oxalis montana*, *Cornus canadensis*, *Gaultheria hispidula*, *Clintonia borealis*, *Huperzia lucidula*, *Aralia nudicaulis*, *Tiarella cordifolia*, and *Trillium erectum*. The bryoid layer varies from sparse to locally well-developed and is typified by *Dicranum* spp. and *Bazzania trilobata*. Feathermosses, including *Hylocomium splendens*, *Pleurozium schreberi*, *Ptilium crista-castrensis*, and *Thuidium delicatulum*, are often present but less abundant than in other spruce-fir forest types. The influence of local cold-air drainage creates a micro-climate that favors this coniferous forest at elevations below the norm for montane spruce-fir. Certain high-elevation species such as *Dryopteris campyloptera* and *Sorbus decora* are less abundant here while other lower-elevation species such as *Aralia nudicaulis*, *Tiarella cordifolia*, and *Trillium erectum* may be more abundant. This association is distinguished from other spruce-fir forest types by the combination of upland soils, low- to mid-elevation setting, absence or low importance of *Picea mariana*, and not maritime-influenced.

CEGL006303—Ruderal Aspen - Birch Woodland

[*Populus* (*tremuloides*, *grandidentata*) - *Betula* (*populifolia*, *papyrifera*) Ruderal Woodland]

This is a common successional deciduous woodland/forest of the northern Appalachian Mountains. It occurs in various settings, often over thin glacial till. Elevation and aspect vary. The community is broadly defined and includes vegetation developing after severe disturbance such as logging, fires, or severe hurricanes. This community can occur as closed-canopy forest or open woodland; in a few very exposed areas, it has been seen to grade to shrubland. Understory shrub cover varies from sparse to well-developed depending primarily on canopy closure. Herbs are typically sparse but may be locally dense. Bryoids are typically minor. The tree canopy is a heterogeneous mixture of light-requiring, wind-dispersed trees usually composed of several codominant species, including *Populus tremuloides*, *Populus grandidentata*, *Betula papyrifera*, *Betula populifolia*, *Populus balsamifera*, *Acer rubrum*, *Prunus serotina*, and/or *Prunus pensylvanica*. More minor components can include *Pinus strobus*, *Picea rubens*, *Abies balsamea*, *Acer saccharum*, *Quercus rubra*, *Fraxinus americana*, *Fraxinus pennsylvanica*, or *Ulmus americana*. The shrub layer can include *Sorbus americana*, *Acer pensylvanicum*, *Viburnum nudum* var. *cassinoides*, or *Hamamelis virginiana*. *Vaccinium angustifolium*, *Kalmia angustifolia*, *Gaylussacia baccata*, and *Comptonia peregrina* may form a dwarf-shrub layer. Associated herbs typically include *Pteridium aquilinum*, *Deschampsia flexuosa*, *Festuca*

ovina, *Cornus canadensis*, *Doellingeria umbellata*, *Eurybia macrophylla*, *Danthonia spicata*, *Carex lucorum* and related species, and *Maianthemum canadense*. Typical bryoids include *Polytrichum commune*, *Polytrichum juniperinum*, *Dicranum* spp., and *Cladonia* spp. In the absence of major disturbance, these forests mostly succeed to northern hardwood, spruce-fir, or mixed northern hardwood-spruce-fir.

CEGL006324—White Pine - Hemlock - Red Spruce Forest

[*Pinus strobus* - *Tsuga canadensis* - *Picea rubens* Forest]

This dry-mesic pine - hemlock forest occurs on lower-elevation slopes and flats in northern New England. The typical setting is sheltered slopes with sandy or stony, acidic, moderately well-drained soils overlying bedrock, talus, or till. The closed coniferous canopy admits little light, and lower layers are patchy and sparse. Dense needle accumulation and dry conditions appear to further limit the growth of herbs and bryoids. The canopy is composed of substantial *Pinus strobus*, with variable components of *Picea rubens* and *Tsuga canadensis*. *Picea rubens* is characteristic, although it may not be abundant, and its presence indicates a cool climatic regime. Occasionally *Abies balsamea* or *Thuja occidentalis* will be present in the canopy or subcanopy. Minor deciduous associates may include *Quercus rubra*, *Acer rubrum*, *Betula alleghaniensis*, *Betula papyrifera*, or *Betula populifolia*. In the shrub layer, characteristic species include *Gaylussacia baccata*, *Kalmia angustifolia*, *Viburnum nudum* var. *cassinoides*, *Vaccinium angustifolium*, *Vaccinium myrtilloides*, or, less commonly, *Comptonia peregrina*, *Diervilla lonicera*, *Ilex mucronata*, or *Rubus hispidus*. Characteristic herb species include *Pteridium aquilinum*, *Polypodium virginianum*, *Aralia nudicaulis*, *Maianthemum canadense*, *Gaultheria procumbens*, *Oclemena acuminata*, *Eurybia macrophylla*, *Cornus canadensis*, *Trientalis borealis*, and *Clintonia borealis*. The bryophyte layer often includes *Dicranum undulatum* and *Leucobryum glaucum* and may include species of *Cladonia*.

CEGL006421—Northern Spruce / Heath Barrens

[*Picea mariana* - *Picea rubens* / *Rhododendron canadense* / *Cladonia* spp. Swamp Woodland]

These undulating barrens are found on cold lowland flats of glacially derived materials at near-boreal latitudes. The soils are highly acidic and nutrient poor. The sandy to clay soils over till can vary with the microtopography from well-drained to very poorly drained, often within the same site. The wetter pockets may have a shallow peat layer (around 25 centimeters [cm] or less) over the mineral soil. The canopy is usually open (25–60 percent closure), occasionally with areas of more closed canopy. The shrub-sapling layer is usually at least 25 percent and may be locally dense. Dwarf-shrubs, herbs, and tree regeneration cover the ground layer. The bryoid layer is usually well-developed and often essentially continuous. Dominant trees are *Picea mariana*, *Picea rubens*, and often hybrids of the two. Less common, but frequent, are *Acer rubrum*, *Abies balsamea*, *Pinus strobus*, and *Populus grandidentata*. Shrub cover is usually dominated by small spruce and fir, sometimes with *Betula populifolia*, *Pinus strobus*, and *Sorbus decora* or *Sorbus americana*. *Ilex mucronata* is a typical shrub. Ericaceous dwarf-shrubs are almost always present, with *Rhododendron canadense*, *Kalmia angustifolia*, and *Vaccinium angustifolium* (and possibly *Vaccinium myrtilloides*) the most abundant. Herbs are rarely abundant; frequent species include *Pteridium aquilinum*, *Cornus canadensis*, *Maianthemum canadense*, *Coptis trifolia*, and *Aralia nudicaulis*. Local moisture appears to influence the distribution of bryoids, with *Dicranum* and *Polytrichum* mosses in the moister portions and *Cladonia* spp. lichens in the drier areas. These barrens appear to be fire-maintained.

CEGL006505—Successional Mixed Spruce - Fir - Hardwood Forest

[*Picea rubens* - *Abies balsamea* - *Betula* spp. - *Acer rubrum* Forest]

This association is a mixed forest of northern New England in which the typical spruce and fir are mixed with earlier successional species. This forest occurs at various landscape positions and aspects but in general is more common on gentle to moderate slopes and low flats. Soils are loamy to sandy till and, in general, are deeper than those of pure spruce-fir forests. The canopy is more or less closed, and the cover of the lower layers is variable, but rarely extensive. The boreal conifers *Picea rubens* and *Abies balsamea* form a mixed canopy with *Acer rubrum* and other trees such as *Populus tremuloides*, *Populus grandidentata*, *Betula papyrifera*, *Thuja occidentalis*, or *Pinus strobus*. Less common associates include *Quercus rubra*, *Acer saccharum*, *Betula alleghaniensis*, *Picea glauca*, or *Prunus serotina*. The subcanopy and shrub layers are composed of *Picea rubens*, *Abies balsamea*, and *Acer pensylvanicum*. Dwarf-shrubs are usually absent or sparse; *Vaccinium angustifolium* or *Vaccinium myrtilloides* are typical species. The herbaceous layer is dominated by tree seedlings with herbs including *Pteridium aquilinum*, *Trientalis borealis*, *Cornus canadensis*, and *Maianthemum canadense*. In wetter spots, *Osmunda cinnamomea* may also be present. The bryophyte layer includes *Bazzania trilobata*, *Dicranum polysetum*, *Leucobryum glaucum*, *Hypnum imponens*, *Pleurozium schreberi*, and *Sphagnum girgensohnii*. This association has a mixed canopy, in contrast to the ecologically similar *Picea rubens* - *Abies balsamea* - *Betula papyrifera* Forest (CEGL006273). It can have relatively deeper soils than *Betula alleghaniensis* - *Picea rubens* / *Dryopteris campyloptera* Forest (CEGL006267), and usually lacks any appreciable amount of *Betula alleghaniensis*.

CEGL006506—Northeastern Ruderal Oak - Red Maple Forest

[*Quercus rubra* - *Acer rubrum* - *Betula* spp. - *Pinus strobus* Ruderal Forest]

This deciduous to mixed forest of northern New England is a broadly defined community, usually developing after severe disturbance, including clearing, pasturing, logging, fires, or severe hurricanes. Although in some cases it is a successional type, it may persist in some settings, particularly where soils are limited, for example along ridgelines. The canopy trees are mostly 40–100 years old. The canopy ranges from somewhat open to closed; the shrub, herb, and bryoid layers are patchy and rarely extensive. Composition is variable depending on site history. The canopy is usually mostly deciduous, dominated by a heterogeneous mixture of *Quercus rubra*, *Acer rubrum*, *Pinus strobus*, and *Fagus grandifolia*. Typically, these occur in association with light-requiring, wind-dispersed trees such as *Populus tremuloides*, *Populus grandidentata*, *Betula papyrifera*, *Betula populifolia*, *Fraxinus americana*, and *Prunus serotina*. Minor associates include *Picea rubens* and *Acer saccharum*. Understory species tend to reflect pre-disturbance conditions and include *Acer pensylvanicum*, *Corylus cornuta*, *Viburnum acerifolium*, or *Hamamelis virginiana* in the shrub layer. *Vaccinium angustifolium* is a typical low shrub, although it does not form a coherent layer. *Pteridium aquilinum* is characteristic and may be abundant in the herbaceous layer; other common herbs include *Trientalis borealis*, *Maianthemum canadense*, *Deschampsia flexuosa*, and *Aralia nudicaulis*. The bryophyte layer is of variable cover and may include *Polytrichum commune* and *Dicranum polysetum*. This association is differentiated from similar forests and woodlands by its thin canopy that usually includes early successional species, particularly *Acer rubrum*, low abundance of tolerant hardwoods other than red oak, and the lack of a well-developed heath shrub layer (as is typical in oak-pine woodlands).

CEGL006508—Northern White-cedar Mesic Rocky Woodland

[*Thuja occidentalis* - *Fraxinus pennsylvanica* / *Acer pensylvanicum* Woodland]

This association is a northern white-cedar open-canopy woodland known only from scattered locations in northern New England. It occurs on gentle to moderately steep slopes over talus, glacial till, or bedrock, in settings that are not xeric and that may have areas where seepage emerges. Where the underlying bedrock is granitic, a near-coastal location may ameliorate the effects of the acidic substrate to some degree; substrates in other locations appear to have a circumneutral tendency. Canopy closure is variable from closed to quite open. The lower layers are typically sparse, although the herb layer may be locally extensive. The canopy is strongly dominated by *Thuja occidentalis*. Associated canopy trees include *Betula papyrifera*, *Betula alleghaniensis*, *Fraxinus pennsylvanica*, *Picea rubens*, *Pinus strobus*, *Tsuga canadensis*, *Abies balsamea*, or *Acer saccharum*. The shrub layer may include *Abies balsamea*, *Acer pensylvanicum*, *Diervilla lonicera*, or *Amelanchier* spp. The herbaceous layer includes *Eurybia macrophylla*, *Oclemena acuminata*, *Dryopteris marginalis*, *Maianthemum canadense*, *Trientalis borealis*, *Danthonia spicata*, *Carex pedunculata*, *Carex gracillima*, and *Carex laxiflora*. Typical bryophytes include *Dicranum* spp., *Leucobryum glaucum*, *Pleurozium schreberi*, and *Hylocomium splendens*.

CEGL006628—Ruderal Sugar Maple - Northern Hardwood Forest

[*Acer saccharum* - *Betula* spp. - *Fagus grandifolia* Ruderal Forest]

This is an early-successional variant of the widespread typic northern hardwood forest (CEGL006631) dominated by a monotypic canopy of *Acer saccharum* or some combination of young, small-diameter *Acer saccharum*, *Fraxinus americana*, *Prunus serotina*, *Betula alleghaniensis*, *Fagus grandifolia*, and *Betula papyrifera*. A disturbed shrub layer may be present with exotics or, more commonly, there is no shrub layer. The herbaceous layer is patchy and most often consists of a mix of ferns, clubmosses (Lycopodiaceae), and other herbs. This community arises from cutting or extended grazing. It occurs on acidic soils in central New England and at lower elevations in northern New England and upstate New York.

CEGL006631—Northern Hardwood Forest

[*Acer saccharum* - *Betula alleghaniensis* - *Fagus grandifolia* / *Viburnum lantanoides* Forest]

This association, known commonly as “northern hardwood forest,” is a widespread matrix forest. This forest occurs most commonly on acidic (pH 5–6), moderate to well-drained tills at elevations generally below 762 m. In northern New England, this forest covers extensive mid-elevation ridges; elsewhere, slope settings are common. The closed-canopy forest has sparse to moderate shrub and herb cover and may have local carpets of tree seedlings in the ground vegetation. Bryoids are a minor component of the forest floor. On some rocky, higher-elevation sites, dense ferns and other herbs may form a lush understory (the “fern-glade variant”). The canopy is dominated by *Acer saccharum* mixed with variable amounts of *Fagus grandifolia* and *Betula alleghaniensis*. Associated hardwood species include *Acer rubrum*, *Betula papyrifera*, and *Fraxinus americana*. Conifers are usually present in low abundance. Characteristic species include *Pinus strobus*, *Tsuga canadensis*, and *Picea rubens*. Oaks are generally not present, although *Quercus rubra* is sometimes present in low numbers. The shrub layer is often dominated by saplings of canopy tree species. Characteristic understory

shrubs or small trees include *Acer pensylvanicum*, *Ostrya virginiana*, *Viburnum lantanoides*, and *Acer spicatum*. The patchy herbaceous layer is a mix of ferns, rhizomatous herbs, and clubmosses. Characteristic species include *Dryopteris intermedia*, *Dryopteris carthusiana*, *Polystichum acrostichoides*, *Huperzia lucidula*, *Maianthemum canadense*, *Clintonia borealis*, *Trientalis borealis*, *Oclemena acuminata*, and *Uvularia sessilifolia*. Occasional species include *Aralia nudicaulis*, *Trillium erectum*, *Trillium undulatum*, *Dryopteris campyloptera*, *Streptopus lanceolatus*, *Cinna latifolia*, *Thelypteris noveboracensis*, *Mitchella repens*, *Solidago macrophylla*, and *Medeola virginiana*. The bryophyte layer may include *Dicranum* spp. and *Leucobryum glaucum*. Structure and composition of the forest are maintained primarily by single small tree-fall gaps. *Betula alleghaniensis* is maintained in the system by mineral soils on "tip-up mounds."

CEGL006636—Northern Sugar Maple - Ash Rich Mesic Forest

[*Acer saccharum* - *Fraxinus americana* / *Acer spicatum* / *Caulophyllum thalictroides* Forest]

This rich *Acer saccharum* - *Fraxinus americana* forest is found in the northern regions of the northeastern United States. Stands occur on nutrient-rich, mesic, or wet-mesic settings on sloped to rolling terrain. Slope bottoms, where colluvium collects, are a common landscape position. The surface soils are deep sand, loamy sand, or loam and may be underlain by sandy clay loam to clay loam. The sites are somewhat poorly drained to well-drained and can have a water table 0.4–2 m below the surface. Small (<1 hectare [ha]) seep areas that may occur within these forests have soils that are usually saturated. This forest community has a well-developed tree canopy composed of deciduous species. Shrubs are scattered, but the herbaceous stratum is generally extensive. Bryoids are only a minor component of the ground layer, which is predominantly nitrogen-rich *Acer saccharum* leaves. *Acer saccharum* and *Fraxinus americana* are the dominant trees; *Tilia americana* is frequent but not necessarily abundant. *Ostrya virginiana* is very common as a small tree. *Acer rubrum*, *Betula alleghaniensis*, *Fagus grandifolia*, and *Prunus serotina* are typical associates, in small amounts. Shrubs that may be found in this community include *Cornus alternifolia*, *Viburnum lantanoides*, *Hamamelis virginiana*, *Dirca palustris*, and *Lonicera canadensis*. The ground flora, including many spring ephemerals, is diverse and consists primarily of nutrient- and light-requiring species. Many of these flower and fruit early in the spring before the tree canopy has fully leafed out. Fern richness is often high. Various sedges are present (particularly the Laxiflorae). These forests are differentiated from less-rich northern hardwood forests such as the *Acer saccharum* - *Betula alleghaniensis* - *Fagus grandifolia* / *Viburnum lantanoides* Forest (CEGL006631), primarily by their abundant and diverse herbaceous layer, as well as by the greater prominence of *Acer saccharum* and *Fraxinus* in the canopy and reduced importance of *Fagus grandifolia*.

CEGL007944—Ruderal Eastern White Pine Forest

[*Pinus strobus* Ruderal Forest]

This is an early-successional forest dominated by *Pinus strobus*, typically with a very dense canopy and little understory. It is considered ruderal because it is commonly associated with anthropogenic disturbances, such as former old fields and formerly cleared flats along streams, that have caused a mix of species not found with natural disturbances. Associated woody and herbaceous species vary with geography. In the northeastern United States, the tree canopy is often monotypic and even-aged, with occasional associates including *Acer rubrum*, *Fraxinus americana*, *Acer saccharum*, or scattered *Quercus rubra*. The understory is typically poorly developed or characterized by scattered individuals found in the canopy. The herbaceous cover is variable depending on the density of tree and shrub cover and may be characterized by ruderal or exotic species that favor openings or disturbance. In more open stands, typical species are those associated with old fields, including *Solidago rugosa*, *Solidago gigantea*, *Anthoxanthum odoratum*, *Poa pratensis*, *Schizachyrium scoparium*, *Elymus repens*, *Bromus inermis*, *Agrostis gigantea*, *Euthamia graminifolia*, *Achillea millefolium*, and *Daucus carota*. In stands that are more heavily forested, typical herbs include *Aralia nudicaulis*, *Ageratina altissima*, *Galium triflorum*, *Maianthemum canadense*, *Trientalis borealis*, *Mitchella repens*, *Polystichum acrostichoides*, and *Lycopodium species*. The site-level herb layer composition varies with geography. The substrate is usually covered by a thick layer of pine needle duff.

Wooded Wetlands

CEGL002485—Black Spruce Open Bog Woodland

[*Picea mariana* / *Ledum groenlandicum* / *Carex trisperma* / *Sphagnum* spp. Open Bog Woodland]

This *Picea mariana*-dominated raised bog community type is found in the subboreal to boreal regions of the Great Lakes, elsewhere in the boreal region of central Canada, and across to Maine. Stands are typically on the crests of raised bog landforms in large peatland complexes, as well as in basin bogs. Sites are poorly drained, with wet organic substrates. Tree cover forms at least 25 percent canopy (and may be very dense), varying in height from 3 m to over 10 m. *Picea mariana* is often the sole species in the canopy. *Larix laricina* may occasionally occur. The dwarf-shrub layer is dominated

by *Ledum groenlandicum* and other ericaceous shrubs, such as *Chamaedaphne calyculata*, *Vaccinium myrtilloides*, *Vaccinium oxycoccos*, *Kalmia polifolia*, *Kalmia angustifolia*, *Gaultheria hispidula*, and *Andromeda polifolia*. *Picea mariana* may also be found in scrub form in this layer. Ground cover consists of a species-poor herb layer, with *Carex trisperma*, *Eriophorum vaginatum*, and *Maianthemum trifolium* most prevalent. Moss cover is a *Sphagnum* carpet with patches of feathermoss (especially *Pleurozium schreberi*) and conifer litter beneath the trees. Dominant sphagnum species include *Sphagnum magellanicum*, *Sphagnum fuscum*, *Sphagnum recurvum*, and *Sphagnum angustifolium*, and less commonly, *Sphagnum capillifolium* and *Sphagnum girgensohnii*. Minerotrophic indicators, such as *Betula pumila*, *Carex stricta*, and *Carex aquatilis*, are absent.

CEGL005271—Black Spruce - Tamarack / Labrador-tea Poor Swamp

[*Picea mariana* - (*Larix laricina*) / *Ledum groenlandicum* / *Sphagnum* spp. Swamp Forest]

This community is found in the northern Great Lakes and Northern Appalachian/Boreal region of the United States and Canada and elsewhere in the boreal regions of central and eastern Canada. Sites are found on level, wet locations with organic soils, but not generally as components of large open peatlands. These sites are poorly drained and acidic, allowing a moderate-to-thick layer of peat to accumulate. Nutrient levels are very low. The overstory of this community is dominated by conifers. The tree canopy is closed to broken with a moderately well-developed low-shrub layer, sparse herbaceous layer, and a carpet of mosses. The canopy is often pure *Picea mariana*. *Abies balsamea* can be present as a codominant. The only other trees that are occasionally found are *Larix laricina* and *Pinus banksiana*. The shrubs are primarily ericaceous and include *Chamaedaphne calyculata*, *Gaultheria hispidula*, *Kalmia polifolia*, *Ledum groenlandicum*, and *Vaccinium* spp., as well as *Cornus canadensis*. In the Northeast, shrubs may include *Kalmia angustifolia*, *Ilex mucronata (= Nemopanthus mucronatus)*, *Viburnum nudum* var. *cassinoides*, or *Rhododendron canadense*. The few herbaceous species that live in this community include *Carex lasiocarpa*, *Carex trisperma*, *Eriophorum vaginatum* var. *spissum*, *Clintonia borealis*, *Coptis trifolia*, and *Maianthemum trifolium*. *Dicranum polysetum*, *Sphagnum* spp., and *Pleurozium schreberi* are the major species constituting the abundant moss layer. Localized minerotrophic areas may contain a more diverse herbaceous layer, including species such as *Osmunda cinnamomea*.

CEGL006007—Northern White-cedar Peatland Swamp Forest

[*Thuja occidentalis* / *Sphagnum* (*girgensohnii*, *warnstorfii*) Swamp Forest]

These cedar swamps are closed-canopy forests in enriched peatland basins in the Northern Appalachians and possibly adjacent Canada. They typically occur in small, forested basins, or along lakes or streams, but may rarely occur in the enriched portions of larger peatlands where there is an influence of minerotrophic groundwater. They often occur in areas of calcareous, or at least circumneutral, bedrock. The soils are organic and range widely in depth of the peat. Canopy closure ranges from somewhat open to closed, and the forest floor is typically dark and cool. Shrub and herb coverage may be sparse to locally dense, with increased cover in canopy gaps. Herbs are typically scattered thinly over the moss layer. Bryophytes are abundant and form a mossy carpet. *Thuja occidentalis* is the canopy dominant; associates include *Picea mariana*, *Abies balsamea*, and *Larix laricina*. *Tsuga canadensis*, *Picea rubens*, or *Pinus strobus* are occasionally present. Shrubs include *Lonicera canadensis*, *Ilex verticillata*, *Vaccinium corymbosum*, *Nemopanthus mucronatus*, and small amounts of *Kalmia angustifolia*. *Rhamnus alnifolia* is typical in the more enriched swamps. The herb layer is often diverse and features *Gaultheria hispidula*, *Carex trisperma*, *Carex disperma*, *Linnaea borealis*, *Mitella nuda*, *Mitella diphylla*, *Tiarella cordifolia*, *Orthilia secunda*, *Rumex acetosella*, *Gymnocarpium dryopteris*, *Phegopteris connectilis*, *Chrysosplenium americanum*, *Moneses uniflora*, *Cornus canadensis*, *Trientalis borealis*, *Carex leptalea*, *Carex pedunculata*, and *Coptis trifolia*, with the uncommon *Calypso bulbosa*, *Cypripedium reginae*, and *Cypripedium parviflorum* in some swamps. *Sphagnum* mosses, especially *Sphagnum girgensohnii* and *Sphagnum warnstorfii*, form a mixed moss layer with *Hylocomium splendens*, *Pleurozium schreberi*, *Thuidium delicatulum*, *Rhytidiadelphus triquetrus*, and *Bazzania trilobata*, with *Calliergon cordifolium*, *Calliergon giganteum*, *Rhizomnium punctatum*, *Rhytidiadelphus squarrosus*, *Leptodictyum riparium*, and *Campylium stellatum* in wet hollows. This association is related to the *Thuja occidentalis - (Picea rubens)* / *Tiarella cordifolia* Swamp Forest (CEGL006175) but occurs in basins rather than on slopes and has deep peat soils.

CEGL006009—Red Maple - Black Ash Rich Seepage Swamp Forest

[*Acer rubrum - Fraxinus nigra* - (*Larix laricina*) / *Rhamnus alnifolia* Swamp Forest]

These calcareous or circumneutral seepage swamps of the northeastern United States have moderate to closed canopies and a rich herb layer influenced by calcium-rich groundwater seepage. These can occur along streams or at headwaters in areas of calcareous bedrock. Soils are saturated

organic muck or peat that can be quite deep. The canopy is dominated by *Acer rubrum* and *Larix laricina*, with *Fraxinus nigra* sometimes prominent. Canopy associates include *Betula alleghaniensis*, *Tsuga canadensis*, *Pinus strobus*, *Carpinus caroliniana*, and *Picea rubens*, the latter especially in the north or at higher elevations. Shrub cover varies with canopy cover and can be quite dense; typical species include *Toxicodendron vernix*, *Rhamnus alnifolia*, *Cornus sericea*, *Salix candida*, *Ilex verticillata*, *Vaccinium corymbosum*, and occasionally *Dasiphora fruticosa* ssp. *floribunda* and *Betula pumila*. The diverse herb layer is characterized by *Caltha palustris*, *Geum rivale*, *Osmunda cinnamomea*, *Carex leptalea*, *Carex interior*, *Carex stricta*, *Carex lacustris*, *Carex flava*, *Iris versicolor*, *Thelypteris palustris*, *Dryopteris cristata*, and *Packera aurea*; plus, *Cypripedium reginae*, *Cypripedium parviflorum*, and *Platanthera dilatata*.

CEGL006062—Alluvial Alder Thicket

[*Alnus incana* - *Cornus* (*amomum*, *sericea*) / *Clematis virginiana* Shrub Swamp]

This vegetation type is covered in detail in the Open Wetlands section.

CEGL006098—Subboreal Black Spruce Semi-treed Bog

[*Picea mariana* / (*Vaccinium corymbosum*, *Gaylussacia baccata*) / *Sphagnum* sp. Swamp Woodland]

This black spruce bog association represents the southern range limit of the alliance, ranging from central New England to just south of the glacial border. This vegetation generally occurs in kettlehole basins and other well-defined topographic depressions and is characterized by relatively deep peat accumulation, indicating acidic, nutrient-poor conditions. The tree canopy ranges widely in closure. The dominant tree is *Picea mariana*, with associates including *Larix laricina* and *Abies balsamea*. The shrubs *Vaccinium corymbosum* and *Ilex mucronata* form a patchy tall-shrub layer. The dwarf-shrub layer is well-developed and characterized by many different heaths including *Chamaedaphne calyculata*, *Gaylussacia baccata*, *Kalmia angustifolia*, and *Vaccinium angustifolium*. Common herbs may include *Carex trisperma*, *Rhynchospora alba*, *Drosera rotundifolia*, *Sarracenia purpurea*, *Eriophorum virginicum*, *Coptis trifolia*, and *Maianthemum trifolium*. The well-developed bryophyte layer is dominated by *Sphagnum magellanicum*, *Sphagnum girgensohnii*, *Bazzania trilobata*, *Aulacomnium palustre*, and *Pleurozium schreberi*. This association is further characterized by the presence of one or more tree or shrub species of more southern distribution, including *Betula populifolia*, *Tsuga canadensis*, *Pinus rigida*, *Alnus incana*, *Rhododendron viscosum*, *Aronia* spp., or *Lyonia ligustrina*. Additional species that further indicate southern range affinity or the influence of slightly higher nutrient levels from adjacent uplands may be present, including *Carex folliculata*, *Carex crinita*, *Carex stricta*, *Osmunda cinnamomea*, *Symplocarpus foetidus*, *Iris versicolor*, or *Calla palustris*. Northern species, such as *Rhododendron canadense* or *Eriophorum vaginatum* var. *spissum*, are generally lacking. [The plants described in this association may be too southern in range for KAWW.]

CEGL006114—Terrace Hardwood Floodplain Forest

[*Acer saccharum* - *Fraxinus* spp. - *Tilia americana* / *Matteuccia struthiopteris* - *Ageratina altissima* Floodplain Forest]

These rich floodplain forests are found on slightly elevated alluvial terraces and active floodplains of larger rivers throughout the glaciated Northeast. The setting is a raised river terrace; however, this forest may occur very close to the riverbank, if the water channel is well-entrenched, and may even be on sloping banks along some river reaches. The alluvial soils are coarse and less regularly inundated than the soils supporting *Acer saccharinum* floodplain forests. Many of our examples occur on circumneutral to slightly calcareous soils. The canopy is closed to somewhat open, and unlike lower elevation floodplain forests, a subcanopy is often present. Shrubs are occasional, but do not form high cover. The herb layer is well-developed and seasonally variable, with spring ephemerals giving way to taller ferns, graminoids, and forbs. Bryoids are very minor. The canopy dominants can vary from site to site but are usually some combination of *Acer saccharum*, *Tilia americana*, *Quercus rubra*, *Ulmus americana*, *Fraxinus americana*, *Fraxinus pennsylvanica*, and *Prunus serotina*. Minor canopy associates include *Acer saccharinum* and *Acer rubrum* [*Ostrya virginiana* is a common understory tree in this type at KAWW]. Shrubs include *Corylus americana*, *Viburnum lentago*, and *Prunus virginiana*; vines, such as *Toxicodendron radicans*, *Parthenocissus* spp., or *Vitis* spp., may be locally common. The herb layer usually features *Matteuccia struthiopteris* and a mixture of other ferns, forbs, and graminoids. Characteristic species include *Ageratina altissima*, *Allium tricoccum*, *Allium canadense*, *Athyrium filix-femina*, *Caulophyllum thalictroides*, *Carex gracillima*, *Carex intumescens*, *Carex sprengelii*, *Deparia acrostichoides*, *Elymus virginicus*, *Elymus riparius*, *Elymus wiegandii*, *Onoclea sensibilis*, *Sanguinaria canadensis*, *Solidago flexicaulis*, *Solidago rugosa*, and *Solidago gigantea*, in addition to abundant spring ephemerals in the early growing season. These terrace forests are distinguished from lower floodplain forests by the reduced importance of *Acer saccharinum*; they differ from enriched northern hardwood forests, such as *Acer saccharum* - *Fraxinus americana* / *Acer spicatum* / *Caulophyllum thalictroides* Forest (CEGL006636) and *Acer saccharum* - *Tilia americana* / *Acer pensylvanicum* / *Caulophyllum thalictroides* Forest (CEGL006637), in

their alluvial soils and flooding regime; also, *Matteuccia struthiopteris* is generally not found in enriched northern hardwood forests.

CEGL006119—Red Maple / Upright Sedge Wet Woodland

[*Acer rubrum* / *Carex stricta* - *Onoclea sensibilis* Wet Woodland]

This association is a partly wooded, deciduous-canopy wetland of the northeastern United States. It occurs on muck soils or mineral soils with a surface organic layer in poorly drained depressions influenced by groundwater. It is also common in those streamside and lakeside settings where the hydrology is that of a basin setting rather than a floodplain. The community is typically flooded in spring, with pools and small streams persisting throughout much of the growing season; soils may remain saturated or may become dry on the surface over the course of the growing season. Hummock-and-hollow topography may be pronounced. The canopy consists of scattered trees, with as little as 25 percent overall cover. The shrub layer is patchy but may be extensive in places. The herb layer is typically well-developed, with ferns and graminoids dominant. The bryophyte cover is variable. *Acer rubrum* is dominant in the canopy, often with many standing dead trees, and may be the only canopy species present. Associated trees may include *Fraxinus nigra*, *Ulmus americana*, and occasional *Pinus strobus*, *Tsuga canadensis*, or *Picea rubens*. The shrub layer is characterized by *Vaccinium corymbosum*, *Spiraea alba* var. *latifolia*, and *Ilex verticillata*. The herbaceous layer is typically dominated by graminoids or ferns. *Sphagnum* spp. are the characteristic bryophytes, with non-sphagnous mosses as associates. These woodlands are ecologically similar to both *Acer rubrum* / *Ilex mucronata* - *Vaccinium corymbosum* Swamp Forest (CEGL006220) and *Picea rubens* - *Acer rubrum* / *Ilex mucronata* Swamp Forest (CEGL006198), but those are closed-canopy wetlands. This association does not include red maple wooded wetlands on deeper peat soils [see *Acer rubrum* / *Alnus incana* - *Ilex verticillata* / *Osmunda regalis* Woodland (CEGL006395) and *Acer rubrum* - *Fraxinus nigra* - *(Larix laricina)* / *Rhamnus alnifolia* Swamp Forest (CEGL006009)].

CEGL006175—Northern White-cedar - Spruce Seepage Forest

[*Thuja occidentalis* - (*Picea rubens*) / *Tiarella cordifolia* Swamp Forest]

These forests of *Thuja occidentalis* mixed with other boreal conifers are found on damp slopes in the cooler regions of the northeastern United States and adjacent Canada. They occur on gently sloping hillsides, or at slope bases, with significant seepage of cold calcium-enriched groundwater. The soils are mostly mineral, usually developed over circumneutral to calcareous bedrock, with little peat accumulation; peat, if present, is primarily sedge-derived. The canopy may be somewhat open but more often is closed (usually 65–95 percent), with a patchy shrub layer beneath. The herb layer is locally extensive and usually relatively species-rich. The bryoid layer is very well-developed, essentially continuous, with mossy hollows and hummocks of moss-covered decaying downed trees. The canopy may be strongly dominated by *Thuja occidentalis* or may be a mixture of *Thuja* with *Picea rubens*. Less abundant associates include *Abies balsamea*, *Acer rubrum*, *Fraxinus nigra*, and *Betula alleghaniensis*. Shrubs include *Lonicera canadensis*, *Lonicera oblongifolia*, *Viburnum nudum* var. *cassinoides*, and *Acer spicatum*. Particularly characteristic herbs are *Mitella nuda*, *Platanthera obtusata*, *Orthilia secunda*, and *Dalibarda repens*; common associates in the herb layer include *Cornus canadensis*, *Clintonia borealis*, *Gaultheria hispidula*, *Coptis trifolia*, *Oxalis montana*, *Linnaea borealis*, *Tiarella cordifolia*, and *Gymnocarpium dryopteris*. The bryophyte layer tends to have feathermosses (*Hylocomium splendens*, *Thuidium delicatulum*, and others), *Rhytidiadelphus triquetrus*, and *Bazzania trilobata* more abundant than *Sphagnum* spp., which are also present. This association is similar to the *Thuja occidentalis / Sphagnum (girgensohnii*, *warnstorfii)* Swamp Forest (CEGL006007), but that type occurs in basins that have deeper peat soils and generally lacks the more upland herb species found in this type.

CEGL006176—Silver Maple Floodplain Bottom Forest (Sensitive Fern Type)

[*Acer saccharinum* / *Onoclea sensibilis* - *Boehmeria cylindrica* Floodplain Forest]

These *Acer saccharinum* floodplain forests of the northeastern United States are typical of river bottoms, lake plains, and the inner floodplain of medium to large rivers, mostly at less than 245 m elevation. They are most typical of third- and fourth-order rivers. They are subjected to spring flooding of high frequency and duration; their soils are poorly drained and deep. They are generally associated with calcareous or sedimentary bedrock and with fine-grained surficial deposits but may occur in coarser soils or tills. The canopy ranges from closed to somewhat open (in small inclusions, it may be quite sparse) and is high and arching. Shrubs are few; the herb layer is very well-developed. Bryoids are minor. The overall effect is of tall, well-spaced trees over a lush carpet of herbs. The canopy is strongly dominated by *Acer saccharinum*. Associated trees include *Fraxinus pennsylvanica*, and *Ulmus americana*. *Prunus serotina*, *Picea glauca*, and *Acer rubrum* have been occasionally noted northward. The herb layer is seasonally variable, with spring ephemerals succeeded by dense cover of mixed ferns, forbs, and graminoids. Summer-dominant herbs include *Onoclea sensibilis* and *Boehmeria cylindrica*. This type differs from *Acer saccharinum* - *(Populus deltoides)* / *Matteuccia struthiopteris* - *Laportea canadensis* Floodplain Forest (CEGL006147) in its somewhat

more poorly drained soils, longer flood duration, and the reduced importance of *Matteuccia struthiopteris* relative to *Onoclea sensibilis* along with generally higher herb layer richness. It may be bordered on its upland edge by terrace forests dominated by *Acer saccharum*.

CEGL006198—Red Spruce - Red Maple Acidic Swamp Forest

[*Picea rubens - Acer rubrum* / *Ilex mucronata* Swamp Forest]

This *Picea rubens* and *Acer rubrum* swamp occurs in the glaciated Northeast. It occurs most commonly in basins or low flats with poor drainage, characterized by soils that are poorly drained organic muck or shallow peat over clay loam. The substrate is characterized by pronounced hummock-and-hollow microtopography with abundant slowly decomposing leaf/needle litter. The tree canopy is closed to partly open, and the tall-shrub layer is often well-developed. Dwarf-shrubs are sparse, but herbs typically form high cover. The ground layer features extensive *Sphagnum* and other bryophytes. The canopy is codominated by *Picea rubens* and *Acer rubrum*, in association with other trees such as *Betula alleghaniensis*, *Betula populifolia*, *Thuja occidentalis*, *Abies balsamea*, and, occasionally, *Tsuga canadensis*. The most abundant shrubs are *Ilex mucronata*, *Ilex verticillata*, *Spiraea alba*, and *Alnus incana*. The herbaceous layer is generally dominated by the ferns *Osmunda cinnamomea*, *Osmunda regalis*, *Onoclea sensibilis*, and *Thelypteris palustris*. Associated herbs include *Carex trisperma*, *Cornus canadensis*, *Doellingeria umbellata*, *Trientalis borealis*, *Oclemena acuminata*, and *Carex intumescens*. The bryophyte layer is dominated by *Sphagnum* spp. including *Sphagnum girgensohnii* and *Sphagnum magellanicum*. This association is differentiated from *Picea rubens - Abies balsamea* / *Gaultheria hispidula* / *Osmunda cinnamomea* / *Sphagnum* spp. Swamp Forest (CEGL006312) of the Northern Appalachian and adjacent ecoregions by its mixed canopy, lack of *Abies balsamea* and presence of *Ilex verticillata*.

CEGL006312—Northern Appalachian Spruce - Fir Swamp

[*Picea rubens - Abies balsamea* / *Gaultheria hispidula* / *Osmunda cinnamomea* / *Sphagnum* spp. Swamp Forest]

These *Picea rubens* and *Abies balsamea* fir swamps occur on wetland flats and basins across the Northern Appalachians. They are typically found in small basins, or along the margins of larger drainage basins or lowland slopes, usually in areas with some surface seepage. The substrate is saturated mineral soils, sometimes with a shallow peat layer. Shrubs and herbs of boreal affinity reflect the cool environmental conditions. The canopy ranges from partial (50 percent) to dense, with shrub and herb layers sparse to well-developed depending on available light. Canopy gaps are common, and shrubs may be locally dense. The canopy is dominated by *Picea rubens* and *Abies balsamea*, with smaller amounts of *Picea mariana*, *Picea glauca*, or *Larix laricina*. Characteristic shrubs are *Ilex mucronata*, *Sorbus americana*, *Alnus viridis*, and *Viburnum nudum* var. *cassinoides*. Heath shrubs such as *Gaultheria hispidula*, *Vaccinium angustifolium*, and *Kalmia angustifolia* are occasional, but not abundant. The most characteristic herb layer species are *Osmunda cinnamomea* and *Carex trisperma*; common associates include *Dalibarda repens*, *Coptis trifolia*, and *Clintonia borealis*. The bryophytes are dominated by *Sphagnum* spp. (typically including *Sphagnum girgensohnii*), but also include *Bazzania trilobata*, *Pleurozium schreberi*, and *Aulacomnium palustre*. This association is distinguished by the dominance of *Picea rubens* rather than *Picea mariana*, the mineral soil setting, and the low abundance of heath shrubs. *Picea mariana - Picea rubens* / *Pleurozium schreberi* Swamp Forest (CEGL006361) is similar but has *Picea mariana* abundant and occurs in more boreal settings, on poorly drained but not usually saturated soils.

CEGL006361—Northern Spruce - Fir Flats

[*Picea mariana - Picea rubens* / *Pleurozium schreberi* Swamp Forest]

This closed-canopy spruce-fir forest occurs in northern New England on imperfectly drained flats or stream drainages, often where cold air accumulates. This association is typically found along streams, swamp borders, low flats alongside lakes, or adjacent to boreal heathlands. Soils are acidic silts, loams, or sandy loams and imperfectly drained. In most settings they are seasonally wet; some may remain saturated. Only rarely are they peaty. The canopy is generally closed, but blowdown gaps are common. The dominant understory feature is the extensive bryoid layer. Shrubs are sparse, except in gaps. Herbs are well represented although rarely dense. The canopy is dominated by some combination of *Picea rubens*, *Picea mariana*, and *Abies balsamea*. Associates include *Betula alleghaniensis*, *Abies balsamea*, *Acer rubrum*, or *Thuja occidentalis*. Characteristic shrubs include *Viburnum nudum* var. *cassinoides*, *Kalmia angustifolia*, *Amelanchier bartramiana*, *Vaccinium angustifolium*, and *Vaccinium myrtilloides*. The herbaceous layer is characterized by *Osmunda cinnamomea*, *Osmunda claytoniana*, *Gaultheria hispidula*, *Maianthemum canadense*, *Cornus canadensis*, *Coptis trifolia*, *Clintonia borealis*, and *Dalibarda repens*. A well-developed bryophyte layer is characteristic of this association and includes *Pleurozium schreberi*, *Hylocomium splendens*, *Ptilium crista-castrensis*, *Bazzania trilobata*, and species of *Sphagnum*.

CEGL006380—Hardwood - Conifer Seepage Forest

[*Betula alleghaniensis - Acer rubrum* - (*Tsuga canadensis*, *Abies balsamea*) / *Osmunda cinnamomea* Swamp Forest]

This mixed forest type occurs in moist ecotonal areas between uplands and wetlands in New England and the Northern Appalachians. Settings include stream drainages, seepage channels, inactive river terraces, and slope bottoms, but not permanently saturated basins. Perennial seepage from upslope or an impervious soil layer keeps water near the surface. There is often pronounced hummock-and-hollow microtopography. The somewhat acidic to circumneutral mineral soils are typically saturated early in the season but may dry out as summer progresses. The canopy closure ranges from somewhat open to nearly closed. Shrubs are sparse; the herb layer is patchy and may be locally dense. The bryoid layer is typically sparse. The canopy is codominated by a mix of hardwoods such as *Betula alleghaniensis*, *Fraxinus americana*, and *Acer rubrum* (*Tsuga canadensis* is characteristic in some areas but not at KAWW). Less frequent species can include *Pinus strobus*, *Fraxinus pennsylvanica*, and *Fraxinus nigra*. *Picea rubens* may occur sporadically at the northern extent of this community. The shrub layer often includes *Viburnum lantanoides* and *Acer pensylvanicum* (with occasional *Corylus cornuta* at KAWW). The herb layer reflects the underlying moisture gradients, with *Osmunda cinnamomea*, *Osmunda claytoniana*, *Geum rivale*, *Impatiens capensis*, *Thelypteris palustris*, *Arisaema triphyllum*, *Symplocarpus foetidus*, *Hydrocotyle americana*, and *Cardamine pensylvanica* in moister areas, and *Coptis trifolia*, *Thelypteris noveboracensis*, *Athyrium filix-femina*, *Oclemena acuminata*, *Dryopteris intermedia*, *Cornus canadensis*, *Aralia nudicaulis*, and *Clintonia borealis* typical of the areas grading to upland. Bryophyte cover is variable and often includes *Sphagnum girgensohnii*, *Thuidium delicatulum*, *Bazzania trilobata*, and *Mnium* spp. These forests are somewhat similar to *Tsuga canadensis - Betula alleghaniensis* / *Ilex verticillata* / *Sphagnum* spp. Swamp Forest (CEGL006226), but occur on mineral soils, not in peaty basins, and have understory species that indicate somewhat more nutrient-enriched conditions.

CEGL006395—Red Maple Wooded Fen

[*Acer rubrum* / *Alnus incana - Ilex verticillata* / *Osmunda regalis* Woodland]

This open-canopy *Acer rubrum* wetland occurs as part of peatlands in central and northern New England. It occurs in basin peatlands at elevations below 305 m, typically in a peripheral area of a larger peatland. The soils are *Sphagnum*-derived organic soils that remain saturated. Some minerotrophy is evident; these are fens rather than true bogs. Canopy cover ranges from quite open to about 65 percent, and the shrub layer is generally well-developed. Herb cover varies but may be as high as 80 percent. The bryoid layer is usually more or less continuous. *Acer rubrum* is the dominant tree; associates may include *Picea mariana*, *Abies balsamea*, and *Larix laricina*. *Larix laricina* may be codominant with *Acer rubrum*, or dominant in occasional cases. The shrub layer is dominated by *Ilex verticillata*, in variable association with other species such as *Ilex mucronata*, *Viburnum nudum* var. *cassinoides*, *Alnus incana*, *Myrica gale*, and *Spiraea alba* var. *latifolia*. The herbaceous layer generally includes *Osmunda regalis*, *Osmunda cinnamomea*, *Coptis trifolia*, *Thelypteris palustris*, and *Onoclea sensibilis*. *Carex trisperma* is the most frequent and abundant sedge; *Carex canescens* is often present but less abundant. The bryophyte layer is characterized by *Sphagnum magellanicum*, *Sphagnum fimbriatum*, *Sphagnum centrale*, and others. This association is distinguished by its deep peat soils, peatland setting, open *Acer rubrum* -dominated canopy, and lack of any richness indicator calciphile plants.

CEGL006421—Northern Spruce / Heath Barrens

[*Picea mariana - Picea rubens* / *Rhododendron canadense* / *Cladonia* spp. Swamp Woodland]

This vegetation type is covered in detail in the Wooded Uplands section.

CEGL006502—Northern Hardwood - Hemlock Seepage Swamp Forest

[*Acer rubrum - Fraxinus nigra* - (*Tsuga canadensis*) / *Tiarella cordifolia* Swamp Forest]

This is a northern hardwood-conifer seepage forest of central New England. It typically occurs in basins or along streamsides that are associated with groundwater discharge or seeps at the wetland margin; pH is often circumneutral or at least not highly acidic. Stands often form at stream headwaters. Soil substrate is well-decomposed peat or muck of variable thickness, ranging from 20 cm to several meters thick. The canopy is dominated by *Acer rubrum* or codominated with *Fraxinus nigra*, which is generally indicative of mineral enrichment from groundwater in this region. Typical canopy associates include *Betula alleghaniensis* and *Tsuga canadensis* [uncommon at KAWW, *Picea glauca* is common however]; *Pinus strobus* and *Ulmus americana* may also be present. The shrub layer includes saplings of canopy tree species plus *Ribes americanum*, *Ilex verticillata*, and *Toxicodendron radicans* [*Alnus incana* at KAWW]. Common herbs include *Onoclea sensibilis*, *Osmunda cinnamomea*, *Impatiens capensis*, *Chrysosplenium americanum*, *Mitella nuda*, *Rubus pubescens*, *Geum rivale*, *Tiarella cordifolia*, *Carex leptalea*, *Carex leptonervia*, *Carex interior*, *Glyceria striata*, and *Dryopteris cristata*. In some cases, the ferns form an herbaceous “canopy” with the forbs and graminoids scattered among and below them. The nonvascular layer is usually

well-developed and includes *Thuidium delicatulum*, *Mnium* spp., *Rhytidiadelphus triquetrus*, and *Climacium dendroides* with *Calliergon cordifolium* in hollows.

CEGL006504—High-gradient Hardwood Floodplain Forest

[*Acer saccharum* / *Ostrya virginiana* / *Brachyelytrum erectum* Floodplain Forest]

Flashy, *Acer saccharum*-dominated floodplain forests on high-gradient or submontane portions of major rivers in northern New England define this community. Floods tend to be short-duration and high-disturbance events. Soils are alluvial sands or sandy loams over coarser substrates, sometimes interspersed with buried organic layers. *Acer saccharum* dominates the canopy, with other upland trees including *Quercus rubra* and *Betula alleghaniensis*. *Ostrya virginiana* is a common smaller tree. Shrubs are variable. The herb layer is lush, and features *Brachyelytrum erectum*, *Carex intumescens*, *Solidago caesia*, and *Danthonia spicata*. Unlike other floodplain forests, ferns are limited.

Open Uplands

CEGL005094—Blueberry Granite Barrens

[*Vaccinium angustifolium* - *Sorbus americana* / *Sibbaldiopsis tridentata* Dwarf-shrubland]

This northern or high-elevation acidic rock heath barren occurs in the glaciated northeastern States on rocky ridges, outcrops, and summits. It includes patches of shrub dominance as well as areas of bedrock-dominated sparse vegetation. The soils are shallow, well-drained, dry, acidic, coarse sands. Expanses of exposed bedrock are typical, with minimal soil development restricted to crevices or shelter areas. Elevations of known examples range from almost sea level on the Maine coast to about 825 m inland. The physiognomy of this community is patchy and variable, ranging from woodland to shrubland to sparsely vegetated rock. A tree canopy is absent or poorly developed, usually consisting of scattered and stunted trees with less than 10 percent cover. Tall shrubs are scattered, mostly in somewhat protected areas. Dwarf-shrubs are the most extensive layer, with up to 75 percent cover. Herbs are sparse and confined to rock crevices and depressions. The bryoid layer varies from sparse to well-developed, with both lichens and mosses represented. Tree species include *Picea rubens*, *Abies balsamea*, *Quercus rubra*, *Pinus strobus*, *Betula papyrifera*, *Betula populifolia*, or *Acer rubrum*. Scattered tall shrubs include *Sorbus americana*, *Viburnum nudum* var. *cassinoides*, *Ilex mucronata*, *Aronia melanocarpa*, *Comptonia peregrina*, or *Amelanchier* spp. Prominent dwarf heath shrubs include *Vaccinium angustifolium*, *Vaccinium myrtilloides*, *Vaccinium pallidum*, *Gaylussacia baccata*, *Arctostaphylos uva-ursi*, and *Kalmia angustifolia*. The sparse herb layer includes graminoids such as *Deschampsia flexuosa*, *Danthonia spicata*, *Carex lucorum*, *Schizachyrium scoparium*, and *Piptatheropsis pungens*, and the forbs *Sibbaldiopsis tridentata*, *Solidago simplex* var. *randii*, *Minuartia glabra*, *Maianthemum canadense*, *Gaultheria procumbens*, *Trientalis borealis*, and *Pteridium aquilinum*. Abundant mosses and lichens form a bryophyte layer characterized by *Polytrichum commune*, *Polytrichum juniperinum*, *Polytrichum piliferum*, *Dicranum polysetum*, and *Cladonia* lichens. These heath balds are distinguished by the presence of boreal species such as *Sorbus americana* and *Sibbaldiopsis tridentata* combined with temperate species such as *Quercus rubra*, *Quercus montana*, *Carex pensylvanica*, *Carex lucorum*, and *Betula populifolia*.

CEGL006107—Northeastern Old Field

[*Dactylis glomerata* - *Phleum pratense* - *Festuca* spp. - *Solidago* spp. Ruderal Meadow]

This broadly defined vegetation type includes pastures and post-agricultural fields [former log landings at KAWW] and is largely composed of non-native, cool-season grasses and herbs (generally of European origin) in the early stages of succession. Physiognomically, these grasslands are generally composed of mid-height (0.3–1 m tall) grasses and forbs, with occasional scattered shrubs. Species composition varies from site to site, depending on land-use history and perhaps soil type, but in general this vegetation is quite wide-ranging in northeastern States. Dominant grasses vary from site to site but generally feature the nominal species. Other graminoid associates may include *Agrostis stolonifera*, *Agrostis hyemalis*, *Elymus repens*, *Bromus inermis*, *Bromus tectorum*, *Lolium perenne*, *Poa pratensis*, *Poa compressa*, *Schizachyrium scoparium* (not in abundance), and *Anthoxanthum odoratum*. Forbs scattered among the grasses are varied but include *Hieracium* spp., *Oxalis stricta*, *Achillea millefolium*, *Asclepias syriaca*, *Solidago rugosa*, *Solidago nemoralis*, *Solidago juncea*, *Solidago canadensis*, *Solidago altissima*, *Euthamia graminifolia*, *Cerastium arvense*, *Oenothera biennis*, *Potentilla simplex*, *Symphyotrichum lateriflorum*, *Symphyotrichum novae-angliae*, *Symphyotrichum lanceolatum*, *Daucus carota*, *Ambrosia artemisiifolia*, *Vicia cracca*, *Trifolium* spp., and many others.

CEGL006451—Northeastern Ruderal Shrubland

[*Elaeagnus umbellata* - *Cornus racemosa* - *Rosa multiflora* - *Juniperus virginiana* Ruderal Shrubland]

This association comprises shrubby old fields dominated by thickets of *Elaeagnus angustifolia*, *Cornus racemosa*, *Lonicera japonica*, *Lonicera morrowii*, *Euonymus alatus*, *Rosa multiflora*, *Rhus glabra*, and *Rhus typhina*, with patches of herbaceous vegetation among the shrubs. Shorter shrubs include *Berberis thunbergii* and *Rubus* spp., and in some fields *Gaylussacia baccata*, *Vaccinium pallidum*, and/or *Vaccinium angustifolium*. Small trees are often present but

form <25 percent cover; they include *Juniperus virginiana*, *Betula populifolia*, *Prunus virginiana*, *Acer rubrum*, *Prunus serotina*, and *Fraxinus americana*. The herbaceous layer is variable depending on the density of shrub cover. Typical species are those associated with old fields, grasslands, and agricultural sites. Common species include *Solidago rugosa*, *Solidago gigantea*, *Solidago nemoralis*, *Monarda fistulosa*, *Anthoxanthum odoratum*, *Poa pratensis*, *Oxalis stricta*, *Viola sororia*, *Euthamia graminifolia*, *Festuca rubra*, *Schizachyrium scoparium*, *Pycnanthemum virginianum*, *Alliaria petiolata*, *Galium mollugo*, *Potentilla simplex*, *Achillea millefolium*, *Daucus carota*, *Trifolium repens*, *Bromus inermis*, *Agrostis gigantea*, and *Elymus repens*, among many others. Vines can be absent or dominant, sometimes covering the tall and short shrubs. Common vines are *Vitis labrusca*, *Toxicodendron radicans*, *Celastrus orbiculatus*, *Parthenocissus quinquefolia*, and *Lonicera japonica*.

CEGL006528—Northern Appalachian Acidic Cliff

[*Polypodium* (*virginianum*, *appalachianum*) Cliff Sparse Vegetation]

This sparsely vegetated cliff association occurs in the spruce-fir forest region of northern New England and New York, and adjacent Canadian provinces. The setting is dry vertical exposures of resistant acidic bedrock such as granite, quartzite, sandstone, or schist, with little or no soil development. These cliffs are mostly dry, but may contain small areas of seepy conditions, with associated floristic variation. The patchy vegetation is restricted to cracks and crevices and can vary from well-vegetated to barren across the cliff face. The association presents itself as a mixture of open rock, scrubby trees and shrubs, herbaceous plants, and bryoids. Typical woody species include *Picea rubens*, *Abies balsamea*, *Sorbus decora*, *Sorbus americana*, *Betula papyrifera* var. *papyrifera*, *Betula papyrifera* var. *cordifolia*, *Diervilla lonicera*, *Ribes triste*, *Acer rubrum*, *Acer spicatum*, and *Alnus viridis*. The herbaceous component may feature graminoids such as *Deschampsia flexuosa*, *Danthonia spicata*, or *Carex brunnescens*; wiry ferns, such as *Polypodium virginianum*, *Polypodium appalachianum*, *Cystopteris fragilis*, *Dryopteris marginalis*, *Dennstaedtia punctilobula*, and *Woodsia ilvensis*; and herbs, such as *Solidago simplex* var. *randii*, *Campanula rotundifolia*, and *Sibbaldiopsis tridentata*. *Paronychia argyrocoma* occurs on some cliffs. Bryoids are not well documented, but the lichen flora often includes *Umbilicaria* spp. This association differs from other northeastern cliff vegetation types by the absence of calciphiles and the characteristically subboreal flora, lacking *Quercus* spp. and *Juniperus virginiana*, and with little or no *Tsuga canadensis*. Cliffs intermediate between the acidic versus calcareous substrate and subboreal versus temperate setting do occur.

Open Wetlands

CEGL002265—Northern Sedge Poor Fen

[*Carex lasiocarpa* - *Carex oligosperma* / *Sphagnum* spp. Acidic Peatland]

This graminoid poor fen community is found in the Great Lakes region of the United States and Canada, as well as elsewhere in central Canada. Stands are found in peatlands with low exposure to mineral-rich groundwater, including basin fens, shores above the level of seasonal flooding, and larger peatlands. Water hydrology is saturated, and surface water is slightly acidic and nutrient poor. The vegetation is dominated by graminoids, with up to 25 percent shrub cover, and scattered trees. The dominant graminoid is *Carex lasiocarpa*, and typical associates include *Carex chordorrhiza*, *Carex limosa*, *Carex oligosperma*, *Rhynchospora alba*, *Trichophorum cespitosum*, and *Scheuchzeria palustris*. Forbs include *Arethusa bulbosa*, *Symphyotrichum boreale*, *Calopogon tuberosus*, *Pogonia ophioglossoides*, *Sarracenia purpurea*, and *Solidago uliginosa*. The low-shrub layer contains *Andromeda polifolia*, *Betula pumila*, *Chamaedaphne calyculata*, *Larix laricina*, *Salix discolor*, *Salix pedicellaris*, and *Vaccinium oxycoccos*. The moss layer is virtually continuous, and is dominated by *Sphagnum capillifolium*, *Sphagnum fuscum*, and *Sphagnum magellanicum*. Diagnostic features include the dominance of graminoids, particularly *Carex lasiocarpa*, the almost continuous layer of Sphagnum peat, and few minerotrophic indicators. [Note: KAWW is outside range for this type]

CEGL002386—Water-lily Aquatic Wetland

[*Nuphar advena* - *Nymphaea odorata* Aquatic Vegetation]

This rooted aquatic or open marsh community occupies shallow-water depressions, oxbow ponds, backwater sloughs of river floodplains, slow-moving streams, ponds, and small lakes throughout the central and eastern United States. It is dominated by rooted, floating-leaved aquatic species, with both submergent and emergent aquatics also present. *Nuphar advena* [*Nuphar variegata* at KAWW] and *Nymphaea odorata* are dominants, either in combination together, or each singly. Other species present may include *Brasenia schreberi*, various *Potamogeton* and *Stuckenia* spp., *Eleocharis robbinsii* and other *Eleocharis* spp., *Polygonum amphibium*, *Polygonum amphibium* var. *emersum*, *Sparganium americanum*, *Lemna* spp., *Spirodela polyrrhiza*, and *Typha latifolia*. Submerged aquatics more common in the southern part of the range include *Ceratophyllum demersum* and *Heteranthera dubia*.

CEGL005256—Open Graminoid / Sphagnum Bog

[*Carex oligosperma* - *Carex pauciflora* - *Eriophorum vaginatum* / *Sphagnum* spp. Acidic Peatland]

This open sedge/sphagnum bog type is found widely in the boreal/subboreal regions of the Great Lakes, and more widely in Canada. Stands occur in drainageways at margins of raised bogs in large peatland complexes, or occasionally on shores, but they are isolated from groundwater influence. The substrate is a saturated, fibric peat. The vegetation is either dominated by sedges, especially *Carex oligosperma*, or by *Sphagnum* spp. (sphagnum lawns). Shrub cover is less than 25 percent, and tree cover is less than 10 percent. Microtopography in more northern stands is high hummocks and weakly developed hollows, but some stands can be flat. The ground cover is a continuous layer of *Sphagnum* spp., including *Sphagnum angustifolium*, *Sphagnum fuscum*, and *Sphagnum magellanicum*. Graminoid-dominated examples contain *Carex oligosperma* and *Carex pauciflora*, as well as *Eriophorum vaginatum* and *Eriophorum virginicum*. Herbs include *Sarracenia purpurea* and *Scheuchzeria palustris*. Scattered low shrubs may occur, such as *Andromeda polifolia*, *Chamaedaphne calyculata*, *Kalmia polifolia*, *Ledum groenlandicum*, and *Vaccinium oxycoccos*. Minerotrophic indicators may be present at low cover when rooted in minerotrophic peat beneath the mat, such as *Betula pumila*, *Carex aquatilis*, and *Carex stricta*.

CEGL005448—Laurentian & Northeast Bluejoint Wet Meadow

[*Calamagrostis canadensis* - *Carex* spp. Laurentian & Northeast Wet Meadow]

This wet meadow vegetation is widespread in the Laurentian–Acadian and northeast regions of Canada and the United States. Stands occur on the floodplains of small streams, in poorly drained depressions, beaver meadows, levees, and lakeshores. Soils are typically mineral soil or well-decomposed peat, with a thick root mat. Water regime varies between temporarily and seasonally flooded. Graminoid cover is typically dense and can form hummocky microtopography. *Calamagrostis canadensis* is dominant, often occurring in almost pure stands or with tall sedges, such as *Carex aquatilis*, *Carex lacustris*, *Carex utriculata*, and *Carex stricta*. In fen transitions, *Carex lasiocarpa* can be present. *Agrostis gigantea*, *Glyceria grandis*, *Poa palustris*, *Poa compressa*, *Scirpus cyperinus*, and *Typha latifolia* are sometimes abundant. Forbs include *Campanula aparinoides*, *Epilobium leptophyllum*, *Eutrochium maculatum*, *Eupatorium perfoliatum*, *Impatiens capensis*, *Iris versicolor*, *Polygonum amphibium*, and *Comarum palustre*. Scattered shrubs, such as *Viburnum nudum*, *Viburnum dentatum*, *Spiraea alba*, *Cornus amomum*, *Alnus incana*, or *Alnus serrulata*, may be present. *Phalaris arundinacea* and/or *Lythrum salicaria* may be present, especially in disturbed examples.

CEGL006062—Alluvial Alder Thicket

[*Alnus incana* - *Cornus* (*amomum*, *sericea*) / *Clematis virginiana* Shrub Swamp]

These shrublands occur along large streams and rivers in New England, northern New York, and western Pennsylvania. They are found on river-margin alluvial deposits of moderate-energy reaches, where the flooding regime prevents forests from developing. The setting can range from flats to moderately steep banks; soils are usually sandy or silty and have little organic matter. Most are temporarily flooded, and the soils may not remain saturated through the entire growing season. Tall shrubs (1.5–3 m in height) dominate the vegetation, usually forming at least 50 percent cover and often creating a dense thicket. The amount of lower shrub and herb vegetation varies inversely with the tall-shrub canopy. Bryophytes are usually sparse but may be locally abundant in some settings. *Alnus incana* is a constant and usually dominant shrub. In some cases, *Alnus serrulata* (in more temperate settings) or *Alnus viridis* (in more boreal settings) may occur with or in place of *Alnus incana*. The ability of alders to bend under strong currents and their nitrogen-fixing root nodules may give them a competitive advantage over other shrubs in this setting. *Cornus sericea* or *Cornus amomum*, along with *Salix* spp., are frequent associates and may dominate in some areas. *Viburnum nudum* var. *cassinoides* is occasional but not abundant. *Acer rubrum*, *Prunus serotina*, *Ulmus americana*, and/or *Acer saccharinum* may be present, as sparse individuals; in more southerly examples of this type, *Acer negundo* and *Salix nigra* may occur. *Spiraea alba* is usually present and may be abundant as a lower shrub. *Clematis virginiana* is a typical vine, often clambering in tangles on the shrubs. This type is distinguished from other northeastern *Alnus*-dominated associations by its alluvial setting. Although common, this association is little studied and comprehensive surveys have yet to be undertaken.

CEGL006135—Oligotrophic Peatland Moss Lawn

[*Sphagnum rubellum* - *Vaccinium oxycoccos* Fen]

This open sphagnum moss lawn occurs within floating or grounded peat mats in very acidic (pH less than [<] 4) portions of open peatlands (such as oligotrophic kettle-holes) isolated from upland runoff or lake water. *Sphagnum rubellum* is strongly dominant. Vascular plant cover is usually <25 percent. *Vaccinium oxycoccos* is prominent, despite its diminutive stature. Stunted *Chamaedaphne calyculata* is always present with variable cover. Additional dwarf-shrubs can include *Vaccinium macrocarpon*, *Kalmia polifolia*, *Kalmia angustifolia*, *and Andromeda polifolia* var. *glaucophylla*. Herbaceous species often include *Sarracenia purpurea*, *Rhynchospora alba*, *Eriophorum virginicum*, *Drosera rotundifolia*, *Drosera intermedia*, *Xyris montana*, *Juncus pelocarpus*, *Utricularia cornuta*, and occasionally *Eriophorum vaginatum* var. *spissum*.

CEGL006142—Northern Appalachian Calcareous Riverside Seep

[*Triantha glutinosa* - *Carex garberi* Riverscour Wet Meadow]

This is an herb-dominated seepage community that develops on discharge areas of the shores of larger rivers in the glaciated northeastern United States and adjacent Canada. Semi-open conditions are maintained by ice-scouring and floodwaters. The circumneutral groundwater discharge supports a fen-like aspect, but on mineral soils rather than peat soils. The periodic disturbance and enriched nutrient conditions contribute to the high species richness of these seeps. The shore substrate may be sandy or gravelly, sometimes interspersed with bedrock. In some areas, the substrate is unconsolidated glacial material; in others, the substrate is sand and cobble held together by a tightly woven root mass. The vegetation is dominated by low to medium-height herbs, with cover usually 60–90 percent. Shrubs are usually present but are often reduced to sprouts only one or a few years old due to the annual disturbance. The bryophyte layer may be locally well-developed, although not extensive overall. Characteristic herbaceous species include *Lobelia kalmii*, *Parnassia glauca*, *Platanthera dilatata*, *Packera paupercula*, *Triantha glutinosa*, *Spiranthes lucida*, *Spiranthes romanzoffiana*, *Carex garberi*, *Carex viridula*, *Carex flava*, *Carex buxbaumii*, *Rhynchospora capillacea*, *Rhynchospora capitellata*, *Mentha arvensis*, *Equisetum arvense*, *Calamagrostis canadensis*, *Rubus pubescens*, *Doellingeria umbellata*, *Thalictrum pubescens*, and *Glyceria septentrionalis*. Common shrubs include *Alnus incana*, *Alnus viridis*, *Dasiphora fruticosa* ssp. *floribunda*, *Myrica gale*, *Spiraea alba*, *Salix eriocephala* and other *Salix* species, and *Cornus sericea*. Bryophytes have not been well sampled across this type's range; known bryophytes include many non-sphagnous species typical of fen conditions, including *Bryum pseudotriquetrum*, *Campylium stellatum*, *Philonotis fontana*, and *Drepanocladus* spp. The invasive exotics *Tussilago farfara* and *Lythrum salicaria* may occur in these seeps.

CEGL006153—Eastern Cattail Marsh

[*Typha* (*angustifolia*, *latifolia*) - (*Schoenoplectus* spp.) Eastern Marsh]

These tall emergent marshes are common throughout the northeastern United States and adjacent Canadian provinces. They occur in permanently flooded basins, often as part of a larger wetland mosaic and associated with lakes, ponds, or slow-moving streams. The substrate is muck over mineral soil. Lacustrine *Typha* spp. marshes typically have a muck-bottom zone bordering the shoreline, where cattails are rooted in the bottom substrate, and a floating mat zone, where the roots grow suspended in a buoyant peaty mat. Tall graminoids dominate the vegetation; scattered shrubs are often present (usually totaling less than 25 percent cover) and are frequently shorter than the graminoids. Trees are absent. Bryophyte cover varies and is rarely extensive; bryophytes are mostly confined to the hummocks. *Typha angustifolia*, *Typha latifolia*, or their hybrid *Typha x glauca* dominate, either alone or in combination with other tall emergent marsh species. Associated species vary widely; sedges, such as *Carex aquatilis*, *Carex lurida*, *Carex pellita*, *Carex rostrata*, *Carex stricta*, *Scirpus cyperinus*, and bulrushes, such as *Schoenoplectus americanus* and *Schoenoplectus acutus*, occur along with patchy grasses, such as *Calamagrostis canadensis*. Broad-leaved herbs include *Asclepias incarnata*, *Calla palustris*, *Impatiens capensis*, *Onoclea sensibilis*, *Sagittaria latifolia*, *Scutellaria lateriflora*, *Sparganium eurycarpum*, *Symplocarpus foetidus*, *Thelypteris palustris*, and *Verbena hastata*. Floating aquatics, such as *Lemna minor*, may be common in deeper zones. Shrub species vary across the geographic range of this type; in the northern part of its range, *Myrica gale*, *Ilex verticillata*, and *Spiraea alba* are common. The invasive exotic plants *Lythrum salicaria* and *Phragmites australis* may be abundant in parts of some occurrences. This association is distinguished from other northeastern freshwater marshes by the strong dominance of *Typha* spp.

CEGL006158—Northern Peatland Shrub Swamp

[*Alnus incana* ssp. *rugosa* - *Ilex mucronata* / *Sphagnum* spp. Acidic Peatland]

This alder-dominated community is associated with peatlands across northern New England and adjacent Canada. It is most often found at the landward edge of acidic peat mats (such as the lagg), where it receives slightly more enriched waters than those of the adjacent oligotrophic or ombrotrophic peatland. Nitrogen levels are higher than in other peatland communities, presumably as a result of nitrogen fixing by the alders. Occasionally, it occurs in a montane setting (above 730 m) on thin organic soils over coarse cryic soils. Tall shrubs are the dominant physiognomy, with at least 50 percent cover; trees may be present but are sparse. Herb cover varies from sparse to extensive depending on the shrub cover. The bryophyte layer is well-developed, usually with at least 50 percent cover. *Alnus incana* ssp. *rugosa* is the dominant or characteristic tall shrub; *Ilex verticillata* or *Ilex mucronata* are often present and sometimes abundant. Other shrubs include *Alnus viridis*, *Viburnum nudum* var. *cassinoides*, *Vaccinium corymbosum*, or *Spiraea tomentosa*. A tree canopy is lacking, but there may be scattered trees of *Acer rubrum*, *Picea mariana*, *Thuja occidentalis*, or *Abies balsamea*. Dwarf-shrub cover is variable, with *Rhododendron canadense* and *Chamaedaphne calyculata* the most typical, and *Kalmia angustifolia*, *Gaylussacia baccata*, and *Ledum groenlandicum* often also present. The most characteristic herbs are *Carex trisperma*, *Calla palustris*, and *Osmunda cinnamomea*; other species include *Triadenum virginicum*, *Carex intumescens*, *Carex magellanica* ssp. *irrigua*, *Doellingeria umbellata*, *Iris versicolor*, *Gaultheria hispidula*, *Lysimachia terrestris*,

Maianthemum trifolium, *Onoclea sensibilis*, *Sarracenia purpurea*, *Thalictrum pubescens*, and *Trientalis borealis*. The bryoid layer consists of *Sphagnum* spp., including *Sphagnum recurvum*, *Sphagnum palustre*, *Sphagnum fallax*, and *Sphagnum magellanicum*. The combination of *Alnus incana* dominance with *Ilex mucronata* and understory plants characteristic of peatlands is diagnostic.

CEGL006191—Northeastern Leafy Forb Marsh

[*Pontederia cordata - Peltandra virginica - Sagittaria latifolia* Marsh]

This emergent marsh is dominated by broad-leaved, aerenchymatous plants along pond shores, lakeshores, impoundments, and quiet riverbanks in the northeastern United States and elsewhere. This marsh occurs in shallow to deep standing water usually on muck soils. Common species include *Pontederia cordata*, *Sagittaria latifolia*, *Peltandra virginica*, and *Sparganium* spp. Additional emergent species include *Eleocharis palustris*, *Schoenoplectus tabernaemontani*, *Acorus calamus*, *Nuphar variegata*, *Nymphaea odorata*, *Sium suave*, and submerged species including *Ceratophyllum demersum* and *Utricularia macrorhiza*.

CEGL006196—Open Water Marsh with Mixed Submergents/Emergents

[*Vallisneria americana - Potamogeton perfoliatus* Aquatic Vegetation]

This aquatic vegetation of sheltered bays of the northeastern United States occurs on lakes and streams where it is not highly disturbed by wave action. The vegetation is dominated by submergent or emergent plants with only minor floating-leaved components. Characteristic species may include *Vallisneria americana*, *Potamogeton perfoliatus*, *Potamogeton epihydrus*, *Potamogeton nodosus*, *Heteranthera dubia*, *Myriophyllum* spp., *Elodea canadensis*, *Utricularia* spp., and *Eriocaulon aquaticum*.

CEGL006225—Raised Dwarf-shrub Bog

[*Kalmia angustifolia - Chamaedaphne calyculata* - (*Picea mariana*) / *Cladonia* spp. Acidic Peatland]

These are the true ombrotrophic dwarf-shrub bogs of northern New England and Canada, occurring on the raised and relatively well-drained portions of raised peatlands. Peat accumulation has caused plant growth to be raised above the water table, and virtually all nutrients come from precipitation and deposition. The peat is typically saturated with water throughout the growing season, although standing water is often not apparent. Conditions are highly acidic, pH usually between 3.8 and 4.8. The classic vegetation pattern is drier hummocks and wet hollows across the peatland surface. Dwarf-shrubs dominate the vegetation, with overall heights usually 0.3–0.6 m. Trees are sparse and stunted; tall shrubs, if present, are usually confined to pockets near the peatland's upland border. Herb cover is low, usually <25 percent. The bryoid layer is very well-developed and forms the substrate for the vascular plants. *Kalmia angustifolia* is a constant and usually dominant shrub; *Gaylussacia baccata* may be important in some peatlands. Other important dwarf-shrubs include *Ledum groenlandicum*, *Rhododendron canadense*, and *Chamaedaphne calyculata*. *Kalmia polifolia*, *Vaccinium angustifolium*, and *Vaccinium oxycoccos* are often present, but less abundant. Scattered stunted trees of *Picea mariana* (or, less commonly, *Larix laricina* or *Pinus strobus*) may be present, and there are often circular islands of shrub-form *Picea mariana* that has reproduced by layering. Frequent herbs include *Sarracenia purpurea*, *Drosera rotundifolia*, *Carex trisperma*, and *Eriophorum vaginatum* var. *spissum*. *Calopogon tuberosus* is a typical orchid. *Sphagnum fuscum* is the diagnostic and usually dominant moss; others include *Sphagnum magellanicum* and *Sphagnum capillifolium*. *Polytrichum strictum* is common on the hummocks. In the drier portions of the raised heath, fruticose lichens may be important, including *Cladonia rangiferina*, *Cladonia arbuscula* ssp. *mitis*, *Cladonia crispata*, *Cladonia cristatella*, *Cladonia verticillata*, and *Cladonia uncialis*. This association is distinguished from other dwarf-shrub bog associations by the raised bog setting and the greater importance of *Kalmia angustifolia* compared to *Chamaedaphne*.

CEGL006302—Medium Fen

[*Myrica gale - Chamaedaphne calyculata* / *Carex* (*lasiocarpa*, *utriculata*) - *Utricularia* spp. Fen]

This fen vegetation is found in peatlands and peaty lakesides of the northeastern United States. It occurs in acidic waters receiving weakly minerotrophic input from surface water inflow or seepage from surrounding uplands. The substrate may be flooded at high water and remains saturated through the growing season. The pH is acidic to circumneutral, 4.8–6.8. Tall, rhizomatous sedges dominate the vegetation, with shrubs often shorter than the graminoids. Bryophyte cover is variable. Scattered shrubs of *Alnus incana* and *Spiraea alba* may protrude above the graminoid cover; shorter shrubs such as *Myrica gale*, *Andromeda polifolia* var. *glaucophylla*, *Vaccinium macrocarpon*, and *Chamaedaphne calyculata* grow among the sedges. The dominant sedges are usually *Carex lasiocarpa* or *Carex utriculata*; associates include *Carex oligosperma*, *Carex exilis*, *Carex vesicaria*, *Carex limosa*, *Carex canescens*, *Carex lacustris*, *Carex stricta* (non-tussock form), *Carex oligosperma*, *Rhynchospora alba*, *Calamagrostis canadensis*, *Cladium mariscoides*, *Eriophorum angustifolium*, *Eriophorum virginicum*, and *Dulichium arundinaceum*. Forbs include *Lysimachia terrestris*, *Triadenum virginicum*, *Osmunda regalis*, *Comarum palustre*, *Drosera intermedia*, *Utricularia intermedia*, and *Pogonia ophioglossoides*. The bryophyte layer is dominated by

species of *Sphagnum*, including *Sphagnum fallax*, *Sphagnum papillosum*, *Sphagnum cuspidatum*, *Sphagnum fimbriatum*, *Sphagnum centrale*, *Sphagnum lescurii*, and others. This fen vegetation is distinguished by the dominance of *Carex lasiocarpa* and the absence of any richness indicators such as *Dasiphora fruticosa* ssp. *floribunda*.

CEGL006349—Northeastern Woolgrass Wet Meadow

[*Scirpus cyperinus* Wet Meadow]

This seasonally flooded marsh occurs in the northeastern United States. It is dominated or characterized by *Scirpus cyperinus*, but composition is variable. Associates include *Glyceria* spp. and *Thelypteris palustris*, as well as other species of *Scirpus*, including *Scirpus microcarpus* and *Scirpus atrovirens*.

CEGL006412—Eastern Upright Sedge Wet Meadow

[*Carex stricta* - *Carex vesicaria* Wet Meadow]

These tussock sedge meadows are distributed across the northeastern United States. They occur in seasonally flooded basins or on stream or lake margins. The substrate is peat or muck of variable depth overlying mineral soil. Standing water may be present only at the beginning of, or through much of, the growing season depending on the site and the year's precipitation; even when the water level drops, the soils remain saturated. Microtopography is characterized by large tussocks, particularly when the hydroperiod is extended. The physiognomy is strongly herbaceous, or in some cases, herbs mixed with shrubs (up to 25 percent shrub cover); trees are absent. Bryophyte cover is usually sparse but may occasionally reach over 50 percent. *Carex stricta*, in its tussock form, is the usual dominant. *Carex vesicaria*, *Carex utriculata*, and *Calamagrostis canadensis* may also be locally abundant. Associated graminoids include *Carex atlantica*, *Carex canescens*, *Carex comosa*, *Carex folliculata*, *Carex scoparia*, *Carex stipata*, *Carex vulpinoidea*, *Glyceria canadensis*, *Dulichium arundinaceum*, *Juncus effusus*, *Leersia oryzoides*, and *Scirpus cyperinus*; forbs and ferns include *Asclepias incarnata*, *Thelypteris palustris*, *Eutrochium maculatum*, *Campanula aparinoides*, *Osmunda regalis*, *Comarum palustre*, *Lysimachia terrestris*, *Angelica atropurpurea*, *Eupatorium perfoliatum*, *Lycopus americanus*, *Polygonum hydropiperoides*, *Polygonum sagittatum*, *Galium tinctorium*, and others. *Lythrum salicaria* may be invasive in some settings. Shrub associates vary with geography. In the northern part of the range, *Alnus incana*, *Myrica gale*, *Ilex verticillata*, *Chamaedaphne calyculata*, and *Spiraea alba* are often present. Bryophytes, where present, include *Sphagnum magellanicum*, *Sphagnum girgensohnii*, *Sphagnum palustre*, *Drepanocladus aduncus*, and others. This association is differentiated from other wet meadows by the strong dominance of *Carex stricta*.

CEGL006512—Sweetgale Mixed Shrub Fen

[*Myrica gale* - *Spiraea alba* - *Chamaedaphne calyculata* Fen]

This association is a mixed shrub fen in the Northern Appalachians region of the northeastern United States and adjacent Canada. It occurs in weakly to moderately minerotrophic settings, such as stream, lake, or pond margins, adjacent to marshes, peatlands, or swamps, or on wet acidic colluvium at the base of slopes. The slowly moving, open water associated with this type creates somewhat minerotrophic conditions even though the pH is low (around 4.5 on average). The substrate is well-decomposed peat or muck overlying mineral soils; at most sites, standing water is present through most or all of the growing season. The shrub stratum is the dominant layer, usually with over 80 percent cover. The herb layer varies from sparse to well-developed. Bryophyte cover may be sparse overall, but bryophytes are locally extensive in the openings among the shrubs. Characteristic shrubs are *Myrica gale*, *Spiraea alba*, *Spiraea tomentosa*, and *Chamaedaphne calyculata*, in association with others, such as *Rhododendron canadense*, *Kalmia angustifolia*, *Alnus incana*, *Rosa palustris*, and saplings of *Acer rubrum*, *Larix laricina*, or, less commonly, *Picea mariana*. The herbaceous layer is relatively diverse, and may include *Calamagrostis canadensis*, *Carex stricta*, *Carex utriculata*, *Carex lasiocarpa*, *Carex canescens*, *Carex oligosperma*, *Oclemena nemoralis*, *Osmunda regalis*, *Typha latifolia*, *Triadenum virginicum*, *Triadenum fraseri*, *Dulichium arundinaceum*, *Juncus canadensis*, *Comarum palustre*, and *Lysimachia terrestris*. The bryophyte layer is characterized by *Sphagnum fimbriatum*, *Sphagnum fallax*, *Sphagnum magellanicum*, *Sphagnum subsecundum*, *Sphagnum teres*, and others. The dense shrub cover of about 1 meter high, with *Myrica gale* and *Spiraea* spp. as important components, is diagnostic.

CEGL006513—Leatherleaf Boggy Fen

[*Chamaedaphne calyculata* / *Eriophorum virginicum* / *Sphagnum rubellum* Acidic Peatland]

These nutrient-poor fens are found across the glaciated northeastern United States and likely adjacent Canada. Physiognomy is that of a dwarf-shrubland of variable cover over a bryophyte carpet. They occur as floating or quaking mats in peat-accumulating basins, either closed basins or, if in open basins, with very restricted water movement. Kettleholes in glacial deposits are a classic setting. Conditions are acidic, with pH averaging about 4.0, and nutrient availability is very limited. Often referred to as “bogs,” these are technically fens because the vegetation is in contact with groundwater. Trees and tall shrubs, if present, are sparse, and the vegetation is

dominated by bryophytes and the dwarf-shrub layer, the latter typically with 40–80 percent cover. Herb cover is variable but is less than the dwarf-shrub cover. The bryophyte layer is essentially continuous. *Chamaedaphne calyculata* dominates the dwarf-shrub layer; *Andromeda polifolia* var. *glaucophylla* is usually present, a good indicator, and may occasionally approach codominance. *Myrica gale*, *Kalmia polifolia*, *Ledum groenlandicum*, and *Kalmia angustifolia* are frequent, although not at high cover. Scattered tall shrubs (usually near the upland margin) and stunted trees may include *Gaylussacia baccata*, *Lyonia ligustrina*, *Picea mariana*, and *Larix laricina*. Prominent sedges are *Eriophorum vaginatum* var. *spissum* (on hummocks), *Eriophorum virginicum*, and *Rhynchospora alba* (on *Sphagnum* mats), and, under the wettest conditions, *Eriophorum angustifolium*. *Carex oligosperma*, *Carex utriculata*, or *Carex pauciflora* may also be present. *Vaccinium oxycoccos* grows as a trailing shrub on the *Sphagnum* mats, where *Sphagnum rubellum* and/or *Sphagnum magellanicum* usually dominate. Other common *Sphagnum* spp. include *Sphagnum fallax* and *Sphagnum angustifolium*. Diagnostic characteristics include the dominance of *Chamaedaphne calyculata* and presence of *Vaccinium oxycoccos* in a setting that is not a raised bog, with lower abundance of graminoids than shrubs.

CEGL006519—Mixed Graminoid Wet Meadow

[*Calamagrostis canadensis* - *Scirpus* spp. - *Dulichium arundinaceum* Wet Meadow]

The vegetation is dominated by robust graminoids or graminoids mixed with shrubs. Shrub cover can range up to 50 percent, but graminoid cover typically exceeds woody cover, and in some cases, shrubs are absent. The herbaceous layer is well-developed, often over 40 percent cover and up to nearly 100 percent cover. Bryophyte cover is usually little to none but may occasionally be extensive. The herbaceous layer is often dominated by some combination of *Calamagrostis canadensis*, *Scirpus* spp. (including *Scirpus cyperinus*, *Scirpus expansus*, and *Scirpus atrovirens*), and *Dulichium arundinaceum*. Other locally common species may include *Acorus calamus*, *Agrostis gigantea (= Agrostis alba)*, *Carex lacustris*, *Carex lupulina*, *Carex lupuliformis*, *Carex lurida*, *Carex stricta*, *Carex utriculata*, *Glyceria canadensis*, *Glyceria grandis*, *Iris versicolor*, *Hypericum ellipticum*, *Juncus canadensis*, *Leersia oryzoides*, *Leersia virginica*, *Lysimachia terrestris*, *Onoclea sensibilis*, *Osmunda regalis*, *Phalaris arundinacea*, *Poa palustris*, and *Triadenum fraseri*. *Typha latifolia* may occasionally be present, but these wetlands are usually slightly higher (relative to the water table) than typical cattail marsh. *Lythrum salicaria* may be locally invasive. Shrub species typically include *Spiraea alba* and *Salix* spp. Other shrub constituents vary from site to site, and may include *Alnus incana*, *Alnus serrulata*, *Cephalanthus occidentalis*, *Cornus sericea*, *Ilex verticillata*, *Myrica gale*, *Salix pedicellaris*, *Spiraea tomentosa*, or *Viburnum dentatum*.

CEGL006524—Few-seed Sedge - Leatherleaf Fen

[*Carex* (*oligosperma*, *exilis*) - *Chamaedaphne calyculata* Shrub Acidic Peatland]

This association forms sedge-shrub lawns in weakly minerotrophic peatlands of northern New England and adjacent Canada. It occurs on wet flats and peat-accumulating depressions at low to moderate elevations, generally over acidic bedrock or till. The peat substrate is constantly saturated, and pH is usually in the 4.0–5.4 range. The vegetation is dominated by an expanse of low to mid-sized sedges mixed with dwarf ericaceous shrubs, with sedges usually more abundant. Trees and tall shrubs are sparse or absent. The bryophyte layer is continuous. *Chamaedaphne calyculata* and *Andromeda polifolia* var. *glaucophylla* are the most typical dwarf-shrubs and are often overtopped by the sedges. Other shrubs include *Kalmia polifolia*, *Kalmia angustifolia*, *Myrica gale*, *Ilex mucronata*, *Vaccinium oxycoccos*, *Vaccinium macrocarpon*, and (occasionally, northward) *Betula pumila*. Graminoid species include *Carex oligosperma*, *Carex exilis*, *Carex michauxiana*, *Carex utriculata*, *Carex chordorrhiza*, *Eriophorum* spp. (most typically *Eriophorum angustifolium*), *Rhynchospora alba*, *Trichophorum cespitosum*, and *Scheuchzeria palustris*. Other herbaceous associates include *Solidago nemoralis*, *Oclemena nemoralis*, *Drosera intermedia*, *Drosera rotundifolia*, *Pogonia ophioglossoides*, and *Maianthemum trifolium*. The bryophyte layer is characterized by a mixture of species, with characteristic peatmosses including *Sphagnum angustifolium*, *Sphagnum fallax*, *Sphagnum magellanicum*, *Sphagnum papillosum*, *Sphagnum pulchrum*, *Sphagnum recurvum*, and *Sphagnum rubellum*. This association is differentiated from the *Chamaedaphne calyculata* / *Eriophorum virginicum* / *Sphagnum rubellum* Acidic Peatland (CEGL006513), which can be floristically similar, by the increased cover of sedges and decreased cover of shrubs.

CEGL006536—Northeastern Temperate Cobble Scour Rivershore

[*Carex torta* - *Apocynum cannabinum* - *Cyperus* spp. Riverbed Vegetation]

This herbaceous vegetation is found from New England south through New York and Pennsylvania and occurs on large coarse substrates deposited along medium- to high-energy river channels and, less frequently, exposed lakeshores with heavy wave action. Seasonal flooding and ice-scour maintain the open nature of these communities; generally, they develop in areas of the active channel that are exposed at low water or in drought years. Vegetation can be sparse to dense depending on degree of flooding and length of exposure. Characteristic perennial species that tolerate inundation and flood scouring include *Carex torta* and low *Salix* spp. Associated species tend to vary widely from site to site, can be diverse, and may be sparse; they include *Apocynum cannabinum*, *Verbena hastata*, *Symphyotrichum puniceum*, *Doellingeria umbellata*,

Solidago rugosa, *Solidago canadensis*, *Solidago gigantea*, *Calamagrostis canadensis*, *Phalaris arundinacea*, *Scirpus expansus*, *Scirpus cyperinus*, *Thelypteris palustris*, *Scutellaria lateriflora*, *Agrostis stolonifera*, *Dichanthelium clandestinum*, *Eutrochium maculatum*, *Eupatorium perfoliatum*, *Elymus riparius*, *Cyperus strigosus* and other *Cyperus* spp., *Eleocharis* spp., *Lobelia cardinalis*, *Onoclea sensibilis*, *Viola* spp., *Clematis virginiana*, *Polygonum amphibium*, *Polygonum hydropiper*, *Polygonum pensylvanicum*, *Polygonum sagittatum*, *Polygonum persicaria*, *Polygonum punctatum*, *Polygonum lapathifolium*, *Schizachyrium scoparium*, *Andropogon gerardii*, and occasionally *Sanguisorba canadensis*. Battered and stunted shrubs and trees can occur, including *Salix sericea*, *Salix eriocephala*, *Cornus amomum*, and *Populus deltoides*. Nonvascular plants can be sparse, but where present can include *Bryum* spp. Invasive, exotic species can be problematic in these areas, especially *Tussilago farfara*, *Lythrum salicaria*, *Polygonum cuspidatum*, *and Polygonum persicaria*.

CEGL006571—Ruderal Steeplebush / Reed Canarygrass Wet Shrubland

[*Spiraea tomentosa* - *Rubus* spp. / *Phalaris arundinacea* Ruderal Wet Shrubland]

This tall successional shrub community typically floods early in the growing season and may be saturated to near the surface for some of the growing season, but it is generally dry for much of the year. It typically occurs in low-lying areas of old fields or pastures, or the edges of beaver-impacted wetlands or impoundments. The vegetation is dominated by tall shrubs, usually 2–4 m in height. This is a successional community in transition between a successional old field and a modified successional forest. Vegetation can be highly variable, and no one species is dominant. *Cornus amomum*, *Cornus sericea*, *Viburnum dentatum*, *Spiraea alba* var. *latifolia*, *Rosa multiflora*, *Rubus allegheniensis*, and *Rubus hispidus* are all typically present and abundant. *Salix* spp. may also be present but are less common. Scattered individuals of *Acer rubrum* or *Fraxinus pennsylvanica* may also occur within the shrubland. Herbaceous species are inversely proportional to shrub cover; they can be dense where the shrub canopy is open. Species can include *Solidago rugosa*, *Solidago gigantea*, *Eupatorium maculatum*, *Phragmites australis*, *Phalaris arundinacea*, *Apocynum cannabinum*, and *Onoclea sensibilis*.

CEGL006839—Alder Shrub Swamp

[*Alnus incana* Shrub Swamp]

This alder swamp community is widespread in the midwestern and northeastern United States and southern Canada. Stands occur on shores, edges of beaver meadows in stream floodplains, and broad or narrow corridors along small streams in peatlands. Soils are well-decomposed peat, muck, or mineral soils. The hydrology is typically seasonally flooded, with most sites remaining saturated. The vegetation is dominated by tall shrubs, 2–5 m in height, with a moderately open to dense shrub canopy. There is an understory of shorter shrubs and herbaceous species. The density of the understory varies inversely with the tall-shrub canopy. The overstory is usually overwhelmingly dominated by *Alnus incana*, but in the more southeastern portions of this type's range, *Alnus serrulata* can occur with *Alnus incana*. Where alder is not as dominant, other shrubs, such as *Cornus sericea*, *Ilex verticillata*, *Rubus idaeus*, *Salix* spp., *Spiraea alba*, *Spiraea tomentosa*, and *Viburnum* spp., can be found. The herbaceous layer contains species such as *Symphyotrichum lanceolatum* var. *lanceolatum*, *Symphyotrichum puniceum*, *Calamagrostis canadensis*, *Caltha palustris*, *Carex lacustris*, *Carex trisperma*, *Doellingeria umbellata*, *Eutrochium maculatum*, *Glyceria melicaria*, *Glyceria striata*, *Impatiens capensis*, *Lycopus uniflorus*, *Onoclea sensibilis*, *Osmunda cinnamomea*, *Rubus pubescens*, *Scirpus atrovirens*, *Symplocarpus foetidus*, *Thelypteris palustris*, *Typha* spp., and *Viola* spp. Mosses include *Climacium dendroides* and *Sphagnum* spp. Where the tall-shrub canopy is open, graminoids can become dense. Scattered trees are found in many stands, including *Acer rubrum*, *Fraxinus nigra*, and *Thuja occidentalis*.

Appendix 3. Map-Class Descriptions

Appendix 3 provides descriptions of the 33 map classes used to map the vegetation of the Seboeis Unit of Katahdin Woods and Waters National Monument (KAWW) for the National Park Service. Of these 33 map classes, 28 map classes combine to represent 50 of the 62 U.S. National Vegetation Classification (USNVC) associations expected to occur within the KAWW; 12 associations were determined to occur within the broader KAWW and were included within the field key to vegetation but were not found in the Seboeis Unit. (Some map classes represent more than one association, whereas others represent a single association.) Another 2 map classes represent cultural vegetation types (developed) in the USNVC, and 3 map classes represent non-vegetation open water (non-USNVC).

Each map-class description provides the formal map-class code and name used for mapping. For those map classes representing a single vegetation type in the USNVC, the type's common name was used (for example, the Ruderal Sugar Maple - Northern Hardwood Forest). For those map classes representing more than one vegetation type, a comparable name that encompassed all the vegetation types was derived (for example, the Low-Elevation Spruce - Fir Forest map class for the collective USNVC associations of the Lowland Red Spruce - Fir Forest and the Northern Spruce - Fir Flats). For map classes representing cultural vegetation, a generic name, such as Developed Lands, was derived. For the map classes representing non-USNVC features, a generic name, such as Flowing and Ponded Water, was derived.

For all map classes representing USNVC associations, the USNVC classification name(s) and code(s) that the map class represents are provided at the beginning of each map-class description. Each map class is described with a focus on how it presents in the Seboeis Unit landscape, noting that this type of description may not reflect how the various USNVC types present across their range. Descriptions are from a mapping, rather than an ecological, perspective, but ecological concepts relevant to the mapping effort were integrated into the map-class description.

The term "hardwood trees" refers to all deciduous tree species. Furthermore, unless otherwise noted, the herbaceous types have greater than 10 percent herbaceous cover and less than 25 percent total tree and shrub canopy closure, shrubland types have greater than 25 percent shrub canopy closure and less than 25 percent tree canopy closure, woodlands have greater than 25 percent tree canopy closure, and forests typically have greater than 60 percent tree canopy closure.

When map-class signatures or presentations are discussed, unless otherwise specified, they are in reference to the color-infrared component of the 4-band aerial imagery used during the mapping process.

When accuracy assessment (AA) results are reported in the map-class description, two views are discussed—mapped too aggressively and mapped too conservatively. The view of "mapped too aggressively" refers to errors in the users' accuracy. The users' accuracy reports on the probability that an AA site in the tested map class does not have a vegetation type that is represented by the map class. This is an error of commission indicating where too much of the Seboeis Unit was mapped as the tested map class. The lower the users' accuracy for a map class, the higher the likelihood that the map class was overmapped (meaning mapped too aggressively). The view of "mapped too conservatively" refers to errors in the producers' accuracy. The producers' accuracy reports on the probability that an AA site in a different map class has a vegetation type that is represented by the tested map class. This is an error of omission indicating where too little area of the Seboeis Unit was mapped as the tested map class. The lower the producers' accuracy for a map class, the higher the likelihood that the map class was undermapped (meaning mapped too conservatively).

Straight accuracies are listed for users' and producers' in the reporting of AA results. When straight accuracies are below 80 percent, the 90-percent confidence intervals are provided to present where the interval range is in regard to the 80-percent accuracy standard set by the National Park Service Vegetation Mapping Inventory Program. Because of the reduced sampling effort for the AA, the number of potential AA sites were restricted. This results in some map classes having a wide range in confidence intervals.

Along with text descriptions of the map classes, images from digital field photographs are provided, when possible, to visually depict the vegetation types and non-vegetation features that the map classes represent. Note that the images are a partial representation; capturing all variations within a map class would not be possible.

Minimum Mapping Units

The National Park Service Vegetation Mapping Inventory Program's standard Minimum Mapping Unit (MMU) of 0.5 hectare (ha) was applied to mapping forest and cultural vegetation types. For woodland, shrubland, herbaceous, and non-vegetated open-water map classes, an MMU of 0.25 ha was applied. The 0.25-ha MMU was applied to woodland map classes because woodland map classes are generally rare within the Seboeis Unit. The 0.25-ha MMU was applied to shrubland and herbaceous vegetation map classes because the map classes frequently interface with each other and because the map classes are generally rare within the Seboeis Unit.

For polygons that represent vegetation crossing outside the boundary for the Seboeis Unit vegetation mapping project, mappers allowed the polygons to be mapped less than the MMU if the vegetation continued over the project boundary, was contiguous, and covered at least the standard MMU for that map class. In these instances, map classes with a 0.5-ha MMU were mapped down to 0.1 ha and map classes with a

0.25-ha MMU were mapped down to 0.05 ha. For example, a 0.18-ha polygon of the Northern Hardwood Forest (FNHW) map class would be mapped inside the project boundary if at least 0.32 ha of contiguous connected FNHW was outside the boundary.

No Map Class

In total, 12 vegetation associations in the USNVC were not found within the Seboeis Unit but are expected to exist within the KAWW. The 12 associations are as follows:

- *Vaccinium angustifolium* - *Sorbus americana* / *Sibbaldiopsis tridentata* Dwarf-shrubland (CEGL005094),
- *Pinus resinosa* / *Gaylussacia baccata* - *Vaccinium angustifolium* Woodland (CEGL006010),
- *Acer rubrum* / *Carex stricta* - *Onoclea sensibilis* Wet Woodland (CEGL006119),
- *Picea rubens* - *Abies balsamea* / *Sorbus americana* Forest (CEGL006128),
- *Typha* (*angustifolia*, *latifolia*) - (*Schoenoplectus* spp.) Eastern Marsh (CEGL006153),
- *Acer saccharinum* / *Onoclea sensibilis* - *Boehmeria cylindrica* Floodplain Forest (CEGL006176),
- *Kalmia angustifolia* - *Chamaedaphne calyculata* - (*Picea mariana*) / *Cladonia* spp. *Acidic Peatland* (CEGL006225),
- *Picea rubens* / *Ribes glandulosum* Woodland (CEGL006250),
- *Picea mariana* - *Picea rubens* / *Rhododendron canadense* / *Cladonia* spp. Swamp Woodland (CEGL006421),
- *Quercus rubra* - *Acer rubrum* - *Betula* spp. - *Pinus strobus* Ruderal Forest (CEGL006506),
- *Polypodium* (*virginianum*, *appalachianum*) Cliff Sparse Vegetation (CEGL006528), and
- *Pinus strobus* Ruderal Forest (CEGL007944).

Inclusions (small clumps) of each of these 12 associations may exist within appropriate habitats with the Seboeis Unit, but none were documented.

Map-Class Description Index

FNHW—Northern Hardwood Forest

The Northern Hardwood Forest (FNHW) map class represents the following three associations in the USNVC:

- *Acer saccharum* - (*Fraxinus americana*) / *Arisaema triphyllum* Forest (CEGL006211),
- *Acer saccharum* - *Betula alleghaniensis* - *Fagus grandifolia* / *Viburnum lantanoides Forest* (CEGL006631), and
- *Acer saccharum* - *Fraxinus americana* / *Acer spicatum* / *Caulophyllum thalictroides* Forest (CEGL006636).

This map class represents a mix of northern hardwood forests within the Seboeis Unit dominated or codominated by sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), and American beech (*Fagus grandifolia*). The FNHW map class covers 136.2 ha (2.8 percent of the Seboeis Unit).

The FNHW map class is a complex mix of both rich and typic northern hardwood forests with a highly variable composition ranging from enriched forests dominated by large sugar maples to unenriched mixed-species stands primarily composed of yellow birch and beech (fig. 3.1).

Common in the Seboeis Unit, the limiting factor for this map class is tree age. Much, or all, of the Seboeis Unit has been harvested in the last 200 years with a large proportion harvested within the last 30 years. Although forests dominated by these species less than 30 years old are predominantly succeeding into the vegetation associations of the FNHW map class, they may succeed to other vegetation types, so they were mapped separately based upon apparent tree age in the imagery.

Crown morphology is variable with many different shapes, textures, and colors based on stand age, composition, local conditions, and geographic location. Crowns of red, orange, yellow, tan, pink, and white commonly intermix, although monotypic stands, especially of pink and white-crowned sugar maple, are present. Tree crowns are generally much larger and taller than recently harvested stands with harvest boundaries or roads often providing a clear delineation between map classes. Not a mixed forest, this map class cannot have greater than 25 percent total conifer cover in the canopy.

The AA results indicate that FNHW was mapped with a users' accuracy of 75 percent (90-percent confidence interval of 27–123 percent) and a producers' accuracy of 100 percent. The AA shows one instance where FNHW was mapped too aggressively to the Hardwood - Conifer Seepage Forest (FSHC) map class, where wetland influence was underestimated.

Figure 3.1. Two examples of the Northern Hardwood Forest (FNHW) map class showing associations *Acer saccharum* - *Betula alleghaniensis* - *Fagus grandifolia* / *Viburnum lantanoides* Forest (CEGL006631) association (upper) and *Acer saccharum* - *Fraxinus americana* / *Acer spicatum* / *Caulophyllum thalictroides* Forest (CEGL006636) association (lower). Both examples show a closed northern hardwood canopy over varied shrub and herb layers.

FHRS—Red Spruce - Northern Hardwood Forest

The Red Spruce - Northern Hardwood Forest (FHRS) map class represents the *Betula alleghaniensis - Picea rubens / Dryopteris campyloptera* Forest (CEGL006267) association in the USNVC. The forest association that makes up this map class occurs throughout the Seboeis Unit. The FHRS map class covers 204.8 ha (4.2 percent of the Seboeis Unit), making it the third most common map class.

Codominated to dominated (25–75 percent canopy cover, each) by red spruce (*Picea rubens*) and northern hardwood tree species, especially yellow birch (*Betula alleghaniensis*), this map class is a ubiquitous part of the forested landscape in Maine. Balsam fir (*Abies balsamea*) was occasionally associated to codominant (10–25 percent canopy cover) in some examples (fig. 3.2).

The FHRS map class generally presents as a mixed conifer-hardwood forest of red spruce, with dark-purple conical crowns, and of northern hardwoods, with fuzzy crowns of white, tan, yellow, orange, and pink.

The AA results indicate that FHRS was mapped well with a users' accuracy of 100 percent and a producers' accuracy of 86 percent.

Figure 3.2. An example of the Red Spruce - Northern Hardwood Forest (FHRS) map class showing the *Betula alleghaniensis - Picea rubens / Dryopteris campyloptera* Forest (CEGL006267) association dominated by a mix of northern hardwood and red spruce. Note the UMESC staffer in the lower right for scale.

FHWP—Northern Hardwood - White Pine Forest

The Northern Hardwood - White Pine Forest (FHWP) map class represents the *Acer saccharum - Pinus strobus / Acer pensylvanicum* Forest (CEGL005005) association in the USNVC. In the Seboeis Unit, the forest association that makes up this map class was only mapped on the slopes along the Seboeis River. The FHWP map class covers 24.9 ha (0.5 percent of the Seboeis Unit).

The FHWP map class is a dry-mesic mixed eastern white pine and northern hardwood forest (fig. 3.3). Generally, this is an older, larger-crowned map class compared to the Ruderal Eastern White Pine Forest (CEGL007944) association; this association was not observed within the Seboeis Unit but was repeatedly noted in the surrounding landscape during field work. The FHWP map class generally presents as a mix of broad and diffusely branching emergent (super canopy) dark-purple eastern white pine intermingled with a variety of northern hardwoods with red, white, pink, and tan crowns.

The AA results indicate that FHWP was mapped well with a users' and producers' accuracy of 100 percent.

Figure 3.3. An example of the Northern Hardwood - White Pine Forest (FHWP) map class showing the *Acer saccharum - Pinus strobus / Acer pensylvanicum* Forest (CEGL005005) association with a mix of eastern white pine and mixed northern hardwoods.

WCRS—Mixed Conifer Ridge and Slope Woodland

The Mixed Conifer Ridge and Slope Woodland (WCRS) map class represents two associations in the USNVC—the *Picea rubens* / *Vaccinium angustifolium* / *Sibbaldiopsis tridentata* Woodland (CEGL006053) and the *Thuja occidentalis* - *Fraxinus pennsylvanica* / *Acer pensylvanicum* Woodland (CEGL006508). The woodland associations that make up this map class are limited to the tops of rocky ridges and dry rocky slopes. The WCRS map class covers 10.3 ha (0.2 percent of the Seboeis Unit).

The WCRS map class is on upper slopes and ridge tops where bedrock is at the surface (fig. 3.4). Often exclusively dominated by red spruce (*Picea rubens*), which present as dark-red-to-purple pointy cones of similar size and height, this map class is generally an open and patchy woodland with large areas of open shrub, herb, and bedrock visible in the canopy gaps. Additionally, within this spruce matrix, field crews found areas dominated by northern white-cedar (*Thuja occidentalis*) on top of mesic rock outcrops within the Seboeis Unit. Mappers were unable to reliably see this difference, so these two different vegetation associations were combined to form a single dry slope and ridgetop woodland map class.

The AA results indicate that WCRS was mapped well with a users' and producers' accuracy of 100 percent.

Figure 3.4. An example of the red spruce dominated woodland, *Picea rubens* / *Vaccinium angustifolium* / *Sibbaldiopsis tridentata* Woodland (CEGL006053) association, over bedrock exemplifying the Mixed Conifer Ridge and Slope Woodland (WCRS) map class.

FHSH—Hemlock - Spruce - Hardwood Forest

The Hemlock - Spruce - Hardwood Forest (FHSH) map class represents the *Tsuga canadensis* - (*Betula alleghaniensis*) - *Picea rubens* / *Cornus canadensis* Forest (CEGL006129) association in the USNVC. The forest association that makes up this map class occurs in the southern half of the Seboeis Unit generally in the corridors of small to medium creeks. The FHSH map class covers 8.1 ha (0.2 percent of the Seboeis Unit).

Codominated to dominated by eastern hemlock (*Tsuga canadensis*), with 25–75 percent canopy cover; by red spruce (*Picea rubens*), with less than 50 percent cover; and with codominant (greater than 25 percent canopy cover) northern hardwood tree species, this map class was very uncommon in the Seboeis Unit due to the scarcity of eastern hemlock (fig. 3.5).

The FHSH map class generally presents as a mixed conifer-hardwood forest of eastern hemlock, with dark-purple fluffy conical crowns; of red spruce, with dark-purple flat conical crowns; and of northern hardwoods, with fuzzy crowns of red, white, tan, yellow, and pink.

The AA results indicate that FHSH was mapped with a users' accuracy of 50 percent (90-percent confidence interval of –33 to 133 percent) and a producers' accuracy of 100 percent. The AA shows one instance where FHSH was mapped too aggressively to the Low-Elevation Spruce - Fir Forest (FLSF) map class, where eastern hemlock cover was overestimated.

Figure 3.5. An example of the Hemlock - Spruce - Hardwood Forest (FHSH) map class showing a mixed canopy of eastern hemlock, red spruce, and northern hardwood found in the *Tsuga canadensis* - (*Betula alleghaniensis*) - *Picea rubens* / *Cornus canadensis* Forest (CEGL006129) association.

FLSF—Low-Elevation Spruce - Fir Forest

The Low-Elevation Spruce - Fir Forest (FLSF) map class represents two associations in the USNVC—the *Picea rubens - Abies balsamea - Betula papyrifera* Forest (CEGL006273) and the *Picea mariana - Picea rubens / Pleurozium schreberi* Swamp Forest (CEGL006361). The forest associations that make up this map class occur broadly across the Seboeis Unit. The FLSF map class covers 136.5 ha (2.8 percent of the Seboeis Unit).

Dominated (greater than 50 percent canopy cover) by red spruce (*Picea rubens*), the FLSF map class often approaches 100 percent red spruce canopy; can have associated balsam fir (*Abies balsamea*) or black spruce (*Picea mariana*); and generally lacks (less than 25 percent canopy) northern hardwood tree species, eastern hemlock (*Tsuga canadensis*), and eastern white pine (*Pinus strobus*) (fig. 3.6). This map class generally presented as sea of red spruce with dark-red-to-purple pointy cone-shaped crowns of similar size and height interspersed with the fuzzy white, yellow, and pink crowns of northern hardwoods.

Although the swamp forest association CEGL006361 is included in this upland map class, in practice CEGL006361 presents an identical signature to association *Picea rubens - Abies balsamea - Betula papyrifera* Forest (CEGL006273) because CEGL006361 is not a basin forest, but forms on extensive flats where shallow water sits close to the surface over an extended area. No usable indication of ponding or flowing water was visible in the project imagery, and the topographic variations were too slight to reliably split apart these associations.

The AA results indicate that FLSF was mapped with a users' accuracy of 100 percent and a producers' accuracy of 67 percent (90-percent confidence interval of 27–107 percent). The AA shows two instances where FLSF was mapped too conservatively, once from the Hemlock - Spruce - Hardwood Forest (FHSH) map class and once from the White Pine - Hemlock - Red Spruce Forest (FPHS) map class. In both cases eastern hemlock cover was overestimated.

Figure 3.6. Two examples of the Low-Elevation Spruce - Fir Forest (FLSF) map class showing a version on a flat (top) and a version on a slope (bottom).

FPHS—White Pine - Hemlock - Red Spruce Forest

The White Pine - Hemlock - Red Spruce Forest (FPHS) map class represents the *Pinus strobus - Tsuga canadensis - Picea rubens* Forest (CEGL006324) association in the USNVC. The forest association that makes up this map class was primarily mapped on the slopes along the Seboeis River with remnant pockets found in several other small drainages in the Seboeis Unit. The FPHS map class covers 33.6 ha (0.7 percent of the Seboeis Unit).

Codominated to dominated (25–75 percent canopy cover, each) by eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and eastern hemlock (*Tsuga canadensis*) (fig. 3.7), FPHS generally presents as a mixed forest of eastern hemlock, with dark-purple fluffy conical crowns; of red spruce, with dark-red-to-purple pointy cones; and of eastern white pine, with a broad and diffusely branching dark-purple crown emergent (super canopy) from the hemlock. In the Seboeis Unit, eastern hemlock cover was generally low and sometimes altogether lacking.

The AA results indicate that FPHS was mapped with a users' accuracy of 75 percent (90-percent confidence interval of 27–123 percent) and a producers' accuracy of 100 percent.

Figure 3.7. Two examples of the White Pine - Hemlock - Red Spruce Forest (FPHS) map class showing a view from under the canopy (upper) and a view of the canopy from the bank of the Seboeis River (lower). In both cases the mixed-conifer canopy is apparent.

The AA shows one instance where FPHS was mapped too aggressively to the FLSF map class, where hemlock cover was overestimated.

FRWP—White Pine - Red Pine Forest

The White Pine - Red Pine Forest (FRWP) map class represents the *Pinus strobus* - *Pinus resinosa* / *Cornus canadensis* Forest (CEGL006253) association in the USNVC. The forest association that makes up this map class was only mapped on the slopes along the Seboeis River in the Seboeis Unit. The FRWP map class covers 2.2 ha (0.04 percent of the Seboeis Unit).

Codominated to dominated by both red pine (*Pinus resinosa*) and eastern white pine (*Pinus strobus*) and occasionally completely dominated by red pine (fig. 3.8), this map class generally presents as a mixed conifer forest of red pine, with compact and spherical tan-pink to tan-red crowns and of eastern white pine, with broad and diffusely branching dark-purple crowns. Often, sparse red spruce (*Picea rubens*) and mixed northern hardwoods were also present in the canopy, but never at greater than 25 percent total canopy cover.

The AA results indicate that FRWP was mapped well with a users' and producers' accuracy of 100 percent.

Figure 3.8. An example of the White Pine - Red Pine Forest (FRWP) map class showing a mixed canopy of red pine and eastern white pine. Due to an extended time since the last fire in this site, many young red spruce have invaded the site.

FXAB—Ruderal Aspen - Birch Woodland

The Ruderal Aspen - Birch Woodland (FXAB) map class represents the *Populus* (*tremuloides*, *grandidentata*) - *Betula* (*populifolia*, *papyrifera*) Ruderal Woodland (CEGL006303) association in the USNVC. The forest association that makes up this map class primarily represents ruderal northern hardwood forest dominated by aspen (*Populus* spp.). The FXAB map class covers 37.6 ha (0.8 percent of the Seboeis Unit).

The FXAB map class presents a consistent signature in the project imagery. This signature is related to the single-age, single-species recolonization of the site by aspen (fig. 3.9) forming a consistent yellow, gray, or white group of relatively identical crowns.

This map class is most often associated with logging sites next to roads where the soil was likely disturbed down to the mineral layer facilitating the establishment of aspen.

The AA results indicate that FXAB was mapped well with a users' accuracy of 100 percent and producers' accuracy of 80 percent.

Figure 3.9. An example of the Ruderal Aspen - Birch Woodland (FXAB) map class showing the *Populus* (*tremuloides*, *grandidentata*) - *Betula* (*populifolia*, *papyrifera*) Ruderal Woodland (CEGL006303) association. This example shows a ruderal canopy over a young, native shrub and herb layer with evidence of recent disturbance.

FXNH—Ruderal Sugar Maple - Northern Hardwood Forest

The Ruderal Sugar Maple - Northern Hardwood Forest (FXNH) map class represents the *Acer saccharum* - *Betula* spp. - *Fagus grandifolia* Ruderal Forest (CEGL006628) association in the USNVC. This forest association represents ruderal northern hardwood forest within the Seboeis Unit. The FXNH map class covers 1,680.1 ha (34.6 percent of the Seboeis Unit), making it the second most common map class.

The FXNH map class presents a variable signature in the project imagery. This signature is related to the conditions present when the site was recolonized by trees, but in all instances this map class is a younger forest. The uniting factor is that these are ruderal forest stands dominated by a variety of northern hardwood tree species (fig. 3.10). In general, the northern hardwoods in this map class present as small- to medium-fuzzy crowns of white, yellow, orange, and pink. Additionally, this map class can have associated (less than 25 percent canopy cover) young conifers that include eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and balsam fir (*Abies balsamea*), which provides a level of confusion and complexity. The most difficult aspect of this map class was splitting it from the Successional Mixed Spruce - Fir - Hardwood Forest (FXSH) map class. This splitting was accomplished using leaf-off imagery that revealed the amount and age of associated understory conifer cover, which was otherwise obscured in the leaf-on project imagery.

The AA results indicate that FXNH was mapped well with a users' accuracy of 83 percent and producers' accuracy of 100 percent.

Figure 3.10. An example of the Ruderal Sugar Maple - Northern Hardwood Forest (FXNH) map class showing the *Acer saccharum* - *Betula* spp. - *Fagus grandifolia* Ruderal Forest (CEGL006628) association with a ruderal canopy over a young, native shrub and herb layer with evidence of recent disturbance.

FXSH—Successional Mixed Spruce - Fir - Hardwood Forest

The Successional Mixed Spruce - Fir - Hardwood Forest (FXSH) map class represents the *Picea rubens* - *Abies balsamea* - *Betula* spp. - *Acer rubrum* Forest (CEGL006505) association in the USNVC. This forest association represents ruderal mixed northern hardwood-conifer and conifer forest within the Seboeis Unit. The FXSH map class covers 2,064.7 ha (42.5 percent of the Seboeis Unit), making it the most common map class.

Dominated (greater than 50 percent canopy cover, together) by red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*), this map class often approaches 100-percent conifer canopy but can have associated or codominant (less than 50-percent canopy cover) northern hardwood tree species (fig. 3.11). This map class generally presents as red spruce, with dark-red-to-purple pointy cones of similar size and height, and as balsam fir, with red and rounded crowns, interspersed with the fuzzy white, yellow, and pink crowns of northern hardwood tree species.

Figure 3.11. An example of the Successional Mixed Spruce - Fir - Hardwood Forest (FXSH) map class showing a very young stand of doghair red spruce in an upland setting.

This canopy composition was potentially identical to the non-ruderal FHRS and FLSF map classes, so care was taken to split the ruderal FXSH out. This splitting was accomplished using canopy closure and age (generally less than 30 years) in combination with landscape cues such as remnant logging roads and log landing areas, which tend to persist on the landscape for a few decades.

The AA results indicate that FXSH was mapped well with a users' accuracy of 100 percent and a producers' accuracy of 86 percent.

FFHG—High-gradient Hardwood Floodplain Forest

The High-gradient Hardwood Floodplain Forest (FFHG) map class represents the *Acer saccharum* / *Ostrya virginiana* / *Brachyelytrum erectum* Floodplain Forest (CEGL006504) association in the USNVC. The forest association that makes up this map class was mapped in the floodplains of Seboeis River and Kimball Brook in the Seboeis Unit. The FFHG map class covers 14.9 ha (0.3 percent of the Seboeis Unit).

This mixed northern hardwood tree species riparian map class is dominated by sugar maple (*Acer saccharum*) growing over rocky substrate in the active floodplain of high-gradient small streams (fig. 3.12). Generally, this map class presents as a hardwood forest with a mixed crown morphology of sizes and shapes ranging in color from white to tan to orange to pink. Often, white spruce (*Picea glauca*) were found in this vegetation type, but never with more than 25-percent cover. This map class was distinguished from the very similar Terrace Hardwood Floodplain Forest (FFTH) using field notes, relative position to the watercourse, and elevation within the floodplain.

Figure 3.12. An example of the High-gradient Hardwood Floodplain Forest (FFHG) map class showing the active floodplain dominated by sugar maple.

The AA results indicate that FFHG was mapped well with both a users' and producers' accuracy of 100 percent.

FFTH—Terrace Hardwood Floodplain Forest

The Terrace Hardwood Floodplain Forest (FFTH) map class represents the *Acer saccharum* - *Fraxinus* spp. - *Tilia americana* / *Matteuccia struthiopteris* - *Ageratina altissima* Floodplain Forest (CEGL006114) association in the USNVC. The forest association that makes up this map class was mapped in the floodplains of Seboeis River in the Seboeis Unit. The FFTH map class covers 29.7 ha (0.6 percent of the Seboeis Unit).

This mixed northern hardwood tree species riparian map class is dominated by northern hardwood tree species growing in the active floodplain of low-gradient large streams and rivers (fig. 3.13). Generally, this map class presents as a hardwood forest with a mixed crown morphology of sizes and shapes ranging in color from white to tan to orange to pink. This map class was distinguished from the very similar High-gradient Hardwood Floodplain Forest (FFHG) using field notes, relative position to the watercourse, and elevation within the floodplain.

The AA results indicate that FFTH was mapped well with both a users' and producers' accuracy of 100 percent.

Figure 3.13. An example of the Terrace Hardwood Floodplain Forest (FFTH) map class showing the active floodplain dominated by northern hardwood tree species over a consistent layer of ostrich fern (*Matteuccia struthiopteris*).

Figure 3.14. An example of the Red Maple Swamp and Fen (FSRM) map class showing the *Acer rubrum* - *Fraxinus nigra* - (*Larix laricina*) / *Rhamnus alnifolia* Swamp Forest (CEGL006009) association with a hardwood swamp forest.

FSRM—Red Maple Swamp and Fen

The Red Maple Swamp and Fen (FSRM) map class represents two associations in the USNVC—the *Acer rubrum* - *Fraxinus nigra* - (*Larix laricina*) / *Rhamnus alnifolia* Swamp Forest (CEGL006009) and the *Acer rubrum* / *Alnus incana* - *Ilex verticillata* / *Osmunda regalis* Woodland (CEGL006395). This map class primarily represents hardwood tree dominated swamp woodlands and forests. The FSRM map class covers 59.5 ha (1.2 percent of the Seboeis Unit).

The FSRM map class is a complex mix of wet woodlands and forest (fig. 3.14). These wetlands are often disturbed from beaver and human activity resulting in sparse canopy cover. The signature and landscape position of FSRM is a basin or seepage swamp dominated by hardwood trees with occasional conifers. Often, this map class would present as a diffuse, fuzzy canopy of yellow-, orange-, and red-crowned hardwood trees sometimes intermixed and sometimes only a single color. Conifers, especially red spruce (*Picea rubens*), were occasionally present, but conifer cover could not exceed 25 percent.

The AA results indicate that FSRM was mapped with a users' accuracy of 25 percent (90-percent confidence interval of –23 to 73 percent) and a producers' accuracy of 100 percent. The AA discloses three instances where FSRM was mapped too aggressively, once each to the Ruderal Aspen - Birch Woodland (FXAB), Successional Mixed Spruce - Fir - Hardwood Forest (FXSH), and Herbaceous Graminoid Sedge Marsh (HMGS) map classes. Because of the small sample size, none of the confusion was consistent to one map class, leaving a poorly mapped map class with no definitive route for improvement. Mappers think that the influence of water in disturbed hardwood forests was overestimated for the FXAB and FXSH errors, whereas total tree cover was overestimated for the HMGS error.

FSHC—Hardwood - Conifer Seepage Forest

The Hardwood - Conifer Seepage Forest (FSHC) map class represents the following three associations in the USNVC:

- *Picea rubens* - *Acer rubrum* / *Nemopanthus mucronatus* Swamp Forest (CEGL006198),
- *Betula alleghaniensis* - *Acer rubrum* - (*Tsuga canadensis*, *Abies balsamea*) / *Osmunda cinnamomea* Swamp Forest (CEGL006380), and
- *Acer rubrum* - *Fraxinus nigra* - (*Tsuga canadensis*) / *Tiarella cordifolia* Swamp Forest (CEGL006502).

This map class represents a mix of hardwood and mixed hardwood-conifer swamp forests across the Seboeis Unit. The FSHC map class covers 54.0 ha (1.1 percent of the Seboeis Unit).

The FSHC map class ranges from hardwood dominated to a mixed-hardwood-and-conifer swamp woodland or forest where conifer cover is between 0 and 75 percent with the remaining cover composed of hardwood tree species (fig. 3.15). The signature and landscape position of FSHC is a basin or seepage swamp. The hardwoods in this map class present as diffuse, fuzzy yellow-, orange-, and red-crowned trees sometimes intermixed and sometimes only a single color. The conifers, especially red spruce (*Picea rubens*), present as dark red-to-purple conical trees.

The AA results indicate that FSHC was mapped with a users' accuracy of 100 percent and a producers' accuracy of 73 percent (90-percent confidence interval of 46–99 percent). The AA discloses three instances where FSHC was mapped too conservatively, once from the Northern Hardwood Forest

Figure 3.15. Two examples of the Hardwood - Conifer Seepage Forest (FSHC) map class showing the *Picea rubens - Acer rubrum / Nemopanthus mucronatus* Swamp Forest (CEGL006198) association with a closed canopy (upper) and *Betula alleghaniensis - Acer rubrum - (Tsuga canadensis, Abies balsamea) / Osmunda cinnamomea* Swamp Forest (CEGL006380) association with a much more open canopy (lower).

(FNHW) and twice from the Northern Appalachian Spruce - Fir Swamp Forest (FSFS). In the case of FNHW, the wetness of the forest was underestimated. In the case of the FSFS, conifer cover was overestimated.

FSWC—Northern White-cedar Swamp

The Northern White-cedar Swamp (FSWC) map class represents two associations in the USNVC—the *Thuja occidentalis / Sphagnum* (*girgensohnii*, *warnstorfii*) Swamp Forest (CEGL006007) and the *Thuja occidentalis - (Picea rubens) / Tiarella cordifolia* Swamp Forest (CEGL006175). The swamp forest associations that make up this map class occur sparsely in enriched wetlands around the Seboeis Unit. The FSWC map class covers 1.2 ha (0.02 percent of the Seboeis Unit).

This map class occurs on flat, wet ground and occasionally forms complexes in association with other swamp map classes in depressional wetlands. Dominated by arborvitae (also known as northern white-cedar, *Thuja occidentalis*), this map class will often have other swamp conifers and northern hardwoods associated or even codominant (less than 50 percent canopy cover) (fig. 3.16). The northern white-cedar in this map class generally present soft, tannish-purple to mauve cone-shaped crowns that often form a completely closed canopy.

The AA results indicate that FSWC was mapped with a users' accuracy of 100 percent and a producers' accuracy of 33 percent (90-percent confidence interval of –28 to 95 percent). The AA discloses two instances where FSWC was mapped too conservatively from the Black Spruce - Tamarack Bog (FBST) and Northern Appalachian Spruce - Fir Swamp Forest (FSFS) map classes. In both instances, the mapper misinterpreted northern white-cedar dominated wetlands as spruce (*Picea* spp.) dominated wetlands.

Figure 3.16. An example of the Northern White-cedar Swamp (FSWC) map class showing the *Thuja occidentalis - (Picea rubens) / Tiarella cordifolia* Swamp Forest (CEGL006175) association with a developed shrub and herb layer under a northern white-cedar canopy.

FSFS—Northern Appalachian Spruce - Fir Swamp Forest

The Northern Appalachian Spruce - Fir Swamp Forest (FSFS) map class represents the *Picea rubens - Abies balsamea / Gaultheria hispidula / Osmunda cinnamomea / Sphagnum* spp. Swamp Forest (CEGL006312) association

in the USNVC. The forest association that makes up this map class was mapped in the basin swamps of the Seboeis Unit. The FSFS map class covers 12.6 ha (0.3 percent of the Seboeis Unit).

This map class occurs on flat, wet ground and occasionally forms complexes in association with other swamp map classes in depressional wetlands. Dominated by red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*), this map class will often have other swamp conifers and northern hardwoods associated (less than 25 percent canopy cover) (fig. 3.17). The conifers, especially red spruce, present as dark red-to-purple conical trees whereas the balsam fir present as a brighter red conical tree.

The AA results indicate that FSFS was mapped with a users' and producers' accuracy of 0 percent. The AA discloses three instances where FSFS was mapped too aggressively, twice to the Hardwood - Conifer Seepage Forest (FSHC) and once to the Northern White-cedar Swamp (FSWC) map classes. Because of the small sample size, none of the confusion was sufficiently consistent to one map class, leaving a poorly mapped map class with no definitive route for improvement. Mappers think that conifer species and cover density were both judged incorrectly for the FSHC and FSWC errors.

Figure 3.17. An example of the Northern Appalachian Spruce - Fir Swamp Forest (FSFS) map class showing the *Picea rubens - Abies balsamea / Gaultheria hispidula / Osmunda cinnamomea / Sphagnum* spp. Swamp Forest (CEGL006312) association dominated by red spruce.

FBST—Black Spruce - Tamarack Bog

The Black Spruce - Tamarack Bog (FBST) map class represents the following three associations in the USNVC:

- *Picea mariana* / *Ledum groenlandicum* / *Carex trisperma* / *Sphagnum* spp. Open Bog Woodland (CEGL002485),
- *Picea mariana* - (*Larix laricina*) / *Ledum groenlandicum* / *Sphagnum* spp. Swamp Forest (CEGL005271), and
- *Picea mariana* / (*Vaccinium corymbosum*, *Gaylussacia baccata*) / *Sphagnum* spp. Swamp Woodland (CEGL006098).

This map class represents a mix of open and closed bog woodlands and forests found in basin swamps in the Seboeis Unit. The FBST map class covers 15.9 ha (0.3 percent of the Seboeis Unit).

Initially, two different map classes were used to separate these vegetation associations based upon the degree of canopy closure. However, modifications to the field key to vegetation and initial AA results showed systemic confusion between the two map classes. This resulted in the merging of the two map classes into a single map class defining these three vegetation associations.

The FBST map class is possible in any basin within the Seboeis Unit. This map class is defined by a short-to-medium-statured open to closed canopy of black spruce (*Picea mariana*) or tamarack (*Larix laricina*) over sphagnum moss (*Sphagnum* spp.) (fig. 3.18). This map class generally presents as an open canopy of short conifers over a bog mat that has a distinctive flat orange appearance. Often, the conifers in this map class also have an open branching pattern, which indicates continually stressed trees because of poor growing conditions.

The AA results indicate that FBST was mapped well with a users' accuracy of 86 percent and a producers' accuracy of 100 percent.

SXNE—Ruderal Mesic Old-field and Shrubland

The Ruderal Mesic Old-field and Shrubland (SXNE) map class represents two associations in the USNVC—the *Dactylis glomerata - Phleum pratense - Festuca* spp. - *Solidago* spp. Ruderal Meadow (CEGL006107) and the *Elaeagnus umbellata - Cornus racemosa - Rosa multiflora - Juniperus virginiana* Ruderal Shrubland (CEGL006451). The ruderal shrub and herb vegetation that make up this map class represent highly disturbed lands regenerating into herbs, shrub, and short trees. The SXNE map class covers 55.4 ha (1.1 percent of the Seboeis Unit).

The SXNE map class is a highly variable mix of primarily native ruderal herb, shrub, and tree species with less than 25 percent tree cover, although trees were only counted as trees if they were taller than 5 m (fig. 3.19). This map class is primarily limited to areas affected by logging, such as log landing areas, abandoned logging roads, and skidder tracks where the landscape has been sufficiently modified to interrupt natural succession.

Figure 3.18. Two examples of the Black Spruce - Tamarack Bog (FBST) map class showing the *Picea mariana* / *Ledum groenlandicum* / *Carex trisperma* / *Sphagnum* spp. Open Bog Woodland (CEGL002485) association with a black spruce dominated canopy (upper) and the *Picea mariana* - (*Larix laricina*) / *Ledum groenlandicum* / *Sphagnum* spp. Swamp Forest (CEGL005271) association with a tamarack dominated canopy (lower).

Figure 3.19. Two examples of the Ruderal Mesic Old-field and Shrubland (SXNE) map class showing a former log landing area dominated by short shrubs and ferns (upper) and a recently disturbed logging road colonized by a random assortment of shrub-height trees and mixed herbs and shrubs (lower).

The SXNE map class presents a variable signature that is related to the conditions present when the site was recolonized, the surrounding landscape, and the severity of the disturbance, but in all instances this map class is in very disturbed areas. The uniting factor is that these are ruderal areas dominated by a variety of colonizer species.

The AA results indicate that SXNE was mapped well with both a users' and producers' accuracy of 100 percent.

SMSL—Sweetgale - Leatherleaf Shrub Marsh

The Sweetgale - Leatherleaf Shrub Marsh (SMSL) map class represents two associations in the USNVC—the *Myrica gale* - *Spiraea alba* - *Chamaedaphne calyculata* Fen (CEGL006512) and the *Chamaedaphne calyculata* / *Eriophorum virginicum* / *Sphagnum rubellum* Acidic Peatland (CEGL006513). This mixed evergreen shrub swamp map class occurs in acidic basin settings across the Seboeis Unit. The SMSL map class covers 24.5 ha (0.5 percent of the Seboeis Unit).

The SMSL map class is defined by a short and dense canopy of evergreen and deciduous wetland shrubs with the evergreen leatherleaf (*Chamaedaphne calyculata*) and the

deciduous sweetgale (*Myrica gale*) being the most characteristic (fig. 3.20). This map class presents a characteristic lumpy pink signature in basin swamps, often intermixed with flat, tan wetland herbs, and open water. In lacustrine settings this map class will often form a ring between the open water and the upland.

The AA results indicate that SMSL was mapped well with both a users' and producers' accuracy of 100 percent.

Figure 3.20. An example of the Sweetgale - Leatherleaf Shrub Marsh (SMSL) map class showing a sweetgale-dominated wet shrub swamp that is characteristic of the *Myrica gale* - *Spiraea alba* - *Chamaedaphne calyculata* Fen (CEGL006512) association.

SSAL—Alder Shrub Swamp

The Alder Shrub Swamp (SSAL) map class represents the following three associations in the USNVC:

- *Alnus incana* - *Cornus* (*amomum*, *sericea*) / *Clematis virginiana* Shrub Swamp (CEGL006062),
- *Alnus incana* ssp. *rugosa* - *Ilex mucronata* / *Sphagnum* spp. Acidic Peatland (CEGL006158), and
- *Alnus incana* Shrub Swamp (CEGL006839).

This deciduous wet shrub swamp map class occurs in basins, along stream and river margins, and along pond and lake edges throughout the Seboeis Unit. The SSAL map class covers 104.9 ha (2.2 percent of the Seboeis Unit).

The SSAL map class is defined by an open to closed canopy of gray alder (*Alnus incana*) over wet ground in basin or riparian settings (fig. 3.21). Association CEGL006062 is generally a riparian swamp, CEGL006158 is generally a basin swamp, and CEGL006839 is generally a lacustrine swamp,

Figure 3.21. Two examples of the Alder Shrub Swamp (SSAL) map class showing the more basin-based *Alnus incana* ssp. *rugosa* - *Ilex mucronata* / *Sphagnum* spp. Acidic Peatland (CEGL006158) association (upper) and the more riparian-based *Alnus incana* - *Cornus* (*amomum, sericea*) / *Clematis virginiana* Shrub Swamp (CEGL006062) association (lower).

and the three types were often intermixed with no clear line in the imagery to distinguish them, especially in areas with ongoing American beaver (*Castor canadensis*) activity.

Generally, the SSAL map class presents as a shrub swamp dominated by a short to tall fluffy tannish-pink to bright-pink deciduous shrub with hardwood and conifer trees sparsely intermixed. Shrub cover was generally over 75 percent, but occasionally was as low as 25 percent, with larger areas of herbaceous wetland vegetation, dead and downed trees, and open water intermixed.

The AA results indicate that SSAL was mapped well with both a users' and producers' accuracy of 100 percent.

SXSM—Ruderal Steeplebush / Reed Canarygrass Wet Shrubland

The Ruderal Steeplebush / Reed Canarygrass Wet Shrubland (SXSM) map class represents the *Spiraea tomentosa* - *Rubus* spp. / *Phalaris arundinacea* Ruderal Wet Shrubland (CEGL006571) association in the USNVC. This ruderal mixed shrub wetland vegetation map class is closely associated with American beaver (*Castor canadensis*) activity in the Seboeis Unit. The SXSM map class covers 10.2 ha (0.2 percent of the Seboeis Unit).

The SXSM map class is defined by ruderal wetlands with only occasional inundation, where a diverse mix of ruderal wetland shrubs and mixed herbaceous vegetation intermingle due to disturbance from American beaver (fig. 3.22). The vegetation can appear to have many varying signatures based upon the length and depth of inundation, the prior vegetation types, time since dewatering, and many other variables. The uniting factor is a disturbed wetland with evident of past or ongoing American beaver activity.

The AA results indicate that SXSM was mapped well with both a users' and producers' accuracy of 100 percent.

Figure 3.22. Two examples of the Ruderal Steeplebush / Reed Canarygrass Wet Shrubland (SXSM) map class, both showing the *Spiraea tomentosa* - *Rubus* spp. / *Phalaris arundinacea* Ruderal Wet Shrubland (CEGL006571) association with an example of recent dewatering and a mixed-graminoid-dominated landscape (upper) and a site dewatered several seasons ago with a mix of herbaceous and shrub vegetation (lower).

SMML—Oligotrophic Peatland Moss Lawn

The Oligotrophic Peatland Moss Lawn (SMML) map class represents the *Sphagnum rubellum* - *Vaccinium oxycoccos* Fen (CEGL006135) association in the USNVC. The dwarf wetland shrub association occurs along the margin of acidic basin swamps of the Seboeis Unit. The SMML map class covers 0.4 ha (0.007 percent of the Seboeis Unit), making it the least common vegetation map class.

This map class represents a floating peat lawn populated by very short shrubs that appear otherwise "flat" in the project 3D mapping imagery (fig. 3.23). Presenting as a strikingly different, orange-colored wetland along the margins of basin ponds; many areas much below the 0.25-ha Minimum Mapping Unit (MMU) were noted; two areas were deemed large enough to map, although one of those is still well below the established MMU.

The AA results indicate that SMML was mapped well with both a users' and producers' accuracy of 100 percent.

HMBF—Herbaceous Mixed Graminoid and Shrub Bog and Fen

The Herbaceous Mixed Graminoid and Shrub Bog and Fen (HMBF) map class represents the following three associations in the USNVC:

- *Carex oligosperma* - *Carex pauciflora* - *Eriophorum vaginatum* / *Sphagnum* spp. Acidic Peatland (CEGL006302),
- *Myrica gale* - *Chamaedaphne calyculata* / *Carex* (*lasiocarpa*, *utriculata*) - *Utricularia* spp. Fen (CEGL005256), and
- *Carex* (*oligosperma*, *exilis*) - *Chamaedaphne calyculata* Shrub Acidic Peatland (CEGL006524).

This map class represents a mix of northern mixed herbaceous-shrub wetlands that commonly intermix in the Seboeis Unit. The HMBF map class covers 7.7 ha (0.2 percent of the Seboeis Unit).

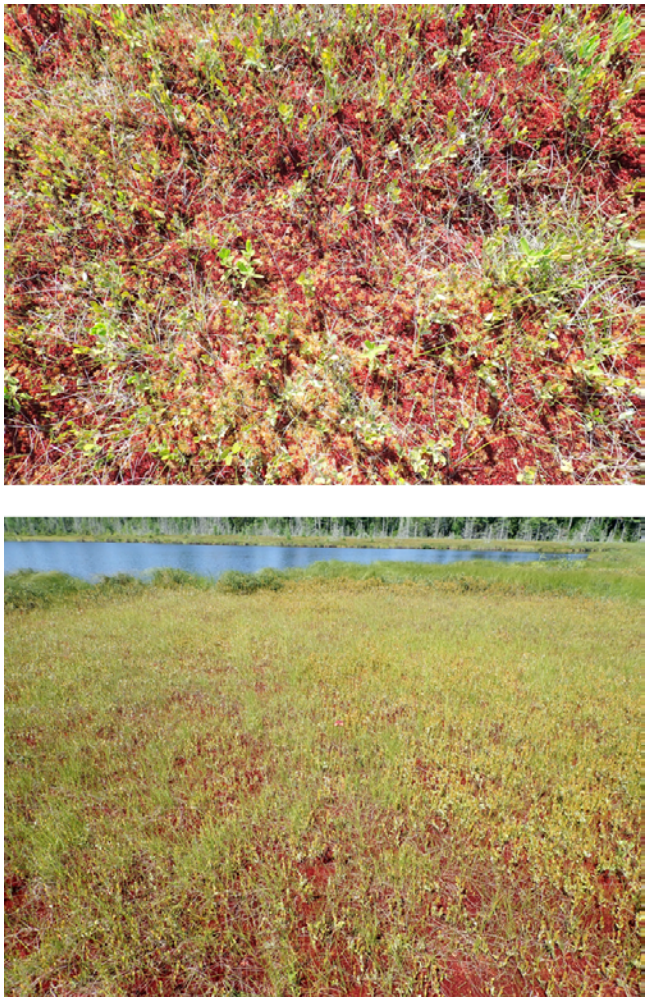

Figure 3.23. Two examples of the Oligotrophic Peatland Moss Lawn (SMML) map class both showing the *Sphagnum rubellum* - *Vaccinium oxycoccos* Fen (CEGL006135) association closeup (upper) and more broadly on the landscape (lower). In both cases this is a dwarf shrubland over a floating mat of sphagnum moss (*Sphagnum* spp.).

Figure 3.24. Two examples of the Herbaceous Mixed Graminoid and Shrub Bog and Fen (HMBF) map class, both showing the *Carex oligosperma* - *Carex pauciflora* - *Eriophorum vaginatum* / *Sphagnum* spp. Acidic Peatland (CEGL006302) association with low shrubs dispersed and hidden under tall sedges (upper) and a more clumped shrub and sedge patchwork (lower).

The HMBF map class is defined by mixed sedge (*Carex* spp.) and low-shrub marsh vegetation that may or may not have greater than 25-percent shrub cover below the sedges (fig. 3.24). Additionally, although the associations tolerate different degrees of acidity, this does not sufficiently vary their appearance in the project imagery. Finally, the shrub layer can be completely covered by the overarching sedges, thus making the separation of these three associations impossible.

Generally, the HMBF map class presents as an open herbaceous marsh with medium-height and mostly flat and soft-looking vegetation in a patchy mix of gray, tan, and pink, with occasional patches of open water or meandering streams and sparse wetland shrubs or trees.

The AA results indicate that HMBF was mapped with a users' accuracy of 50 percent (90-percent confidence interval of –4 to 104 percent) and a producers' accuracy of 100 percent. The AA discloses two instances where HMBF was mapped too aggressively, twice to the Herbaceous Graminoid Sedge Marsh (HMGS) map class. This error results from an overly aggressive estimation of shrub cover in the wetland.

HMGS—Herbaceous Graminoid Sedge Marsh

The Herbaceous Graminoid Sedge Marsh (HMGS) map class represents the following six associations in the USNVC:

- *Carex lasiocarpa* - *Carex oligosperma* / *Sphagnum* spp. Acidic Peatland (CEGL002265),

- *Calamagrostis canadensis* - *Carex* spp. Laurentian & Northeast Wet Meadow (CEGL005448),
- *Pontederia cordata* - *Peltandra virginica* - *Sagittaria latifolia* Marsh (CEGL006191),
- *Scirpus cyperinus* Wet Meadow (CEGL006349),
- *Carex stricta* - *Carex vesicaria* Wet Meadow (CEGL006412), and
- *Calamagrostis canadensis* - *Scirpus* spp. - *Dulichium arundinaceum* Wet Meadow (CEGL006519).

Figure 3.25. Two examples of the Herbaceous Graminoid Sedge Marsh (HMGS) map class showing the *Carex stricta* - *Carex vesicaria* Wet Meadow (CEGL006412) association (upper) and the *Calamagrostis canadensis* - *Scirpus* spp. - *Dulichium arundinaceum* Wet Meadow (CEGL006519) association (lower). In each case, the marsh is a diverse mix of herbaceous wetland vegetation.

The wet herbaceous associations that make up this map class occur within a wide variety of wetland habitats in the Seboeis Unit. The HMGS map class covers 42.1 ha (0.9 percent of the Seboeis Unit).

The HMGS map class is defined by mixed graminoid and forb marshes and by sparse wetland shrubs and trees (less than 25 percent cover, each) (fig. 3.25).

Generally, the HMGS map class presents as an open herbaceous marsh with medium-height and often lumpy vegetation in a patch matrix of gray, tan, pink, and red, with occasional areas of open water or meandering streams and sparse wetland shrubs and trees.

The AA results indicate that HMGS was mapped with a users' accuracy of 100 percent and a producers' accuracy of 57 percent (90-percent confidence interval of 19–95 percent) The AA discloses three instances where HMGS was mapped too conservatively, twice to the Herbaceous Mixed Graminoid and Shrub Bog and Fen (HMBF) map class and once to Red Maple Swamp and Fen (FSRM) map class. The HMBF errors result from an overly aggressive estimation of wetland shrub cover whereas the FSRM error results from an overly aggressive estimation of wetland tree cover.

HNCS—Northeastern Temperate Cobble Scour Rivershore

The Northeastern Temperate Cobble Scour Rivershore (HNCS) map class represents two associations in the USNVC—the *Triantha glutinosa* - *Carex garberi* Riverscour Wet Meadow (CEGL006142) and the *Carex torta* - *Apocynum cannabinum* - *Cyperus* spp. Riverbed Vegetation (CEGL006536). The herbaceous associations that make up this map class in the Seboeis Unit only occur along the Seboeis River. The HNCS map class covers 1.1 ha (0.02 percent of the Seboeis Unit).

This map class is defined by narrow bands of herbaceous vegetation in the active riparian zone of large streams and small rivers, with sparse shrubs and trees (fig. 3.26). The HNCS map class generally presents as an area of taller tan, orange, and pink herbaceous vegetation (less than 25-percent cover of shrubs and short trees, each) within the active riparian zone.

The AA results indicate that HNCS was mapped well with both a users' and producers' accuracy of 100 percent.

HAWL—Water-lily Aquatic Wetland

The Water-lily Aquatic Wetland (HAWL) map class represents the *Nuphar advena* - *Nymphaea odorata* Aquatic Vegetation (CEGL002386) association in the USNVC. This herbaceous aquatic vegetation map class can occur in any

Figure 3.26. An example of the Northeastern Temperate Cobble Scour Rivershore (HNCS) map class along the Seboeis River showing the *Carex torta - Apocynum cannabinum - Cyperus* spp. Riverbed Vegetation (CEGL006536) association.

ponded or slowly flowing water body in the Seboeis Unit. The HAWL map class covers 1.0 ha (0.02 percent of the Seboeis Unit).

The HAWL map class is defined by open water with floating aquatic vegetation covering greater than 1 percent (fig. 3.27). Generally, the HAWL map class presents as open water with patches of tan, pink, and red floating vegetation covering at least 1 percent of the area. Although 1-percent vegetation cover seems low, this level of vegetation visible in the project imagery indicates substantial additional vegetation is present on the ground.

The AA results indicate that HAWL was mapped well with both a users' and producers' accuracy of 100 percent.

Figure 3.27. An example of the Water-lily Aquatic Wetland (HAWL) map class showing the floating emergent vegetation of association *Nuphar advena - Nymphaea odorata* Aquatic Vegetation (CEGL002386) association.

HOWM—Open Water Marsh with Mixed Submergent/Emergent Vegetation

The Open Water Marsh with Mixed Submergent/Emergent Vegetation (HOWM) map class represents the *Vallisneria americana - Potamogeton perfoliatus* Aquatic Vegetation (CEGL006196) association in the USNVC. This herbaceous aquatic vegetation map class can occur in any ponded or slowly flowing water body in the Seboeis Unit. The HOWM map class covers 13.6 ha (0.3 percent of the Seboeis Unit).

The HOWM map class is defined by open water with submerged aquatic vegetation covering greater than 1 percent (fig. 3.28). Generally, the HOWM map class presents as open water with patches of red, dark-red, and purple submerged vegetation covering at least 1 percent of the area. Although 1-percent vegetation cover seems low, this level of vegetation visible in the project imagery indicates substantial additional vegetation is present on the ground.

The AA results indicate that HOWM was mapped well with both a users' and producers' accuracy of 100 percent.

NOSR—Open Water Stream & River

The Open Water Stream & River (NOSR) map class represents unvegetated streams and rivers. This open water map class was only mapped on the Seboeis River in the Seboeis Unit and covers 28.2 ha (0.6 percent of the Seboeis Unit).

Figure 3.28. An example of the Open Water Marsh with Mixed Submergent/Emergent Vegetation (HOWM) map class showing the *Vallisneria americana - Potamogeton perfoliatus* Aquatic Vegetation (CEGL006196) association with American eelgrass (*Vallisneria americana*) visible on the surface.

This map class is defined by streams and rivers large enough to not be completely covered by overarching vegetation. Wetland vegetation—aquatic and emergent—may be present (usually in shallow waters close to shorelines), but this vegetation should contribute less than 1-percent cover; however, small areas (less than an MMU) of wetland vegetation having greater than 10-percent cover—including herbaceous vegetation, shrubs, and trees—may be present (fig. 3.29). Because of the very low reflectivity of water, this map class generally presents as a very dark and usually linear feature. In instances of shallow or clear water, the riverbed is often visible.

Because the NOSR map class is an open water map class, NOSR was not assessed for accuracy.

Figure 3.29. An example of the Open Water Stream & River (NOSR) map class showing the Seboeis River in the Seboeis Unit.

NOWL—Open Water Lake

The Open Water Lake (NOWL) map class represents unvegetated lakes larger than 8 ha. This open water map class covers 0.6 ha (0.01 percent of the Seboeis Unit).

This map class is defined by areas of generally non-flowing open water over 8 ha in area that have less than 1-percent cover of wetland or aquatic vegetation. Within the Seboeis Unit, the only water body this large is Lower Shin Pond. Wetland vegetation—aquatic and emergent—may be present (usually in shallow waters close to shorelines), but the vegetation should contribute less than 1-percent cover; however, small areas (less than a MMU) of wetland vegetation having greater than 10-percent cover—including herbaceous vegetation, shrubs, and trees—may be present (fig. 3.30). Because of the very low reflectivity of water, this map class generally presents as a very dark and completely flat area. When wetland vegetation is distinct from the immediate surroundings, wetland vegetation types occurring in patches less than the size of the standard MMU were mapped.

Figure 3.30. An example of the Open Water Lake (NOWL) map class as represented by Lower Shin Pond on the northern border of the Seboeis Unit.

Because the NOWL map class is an open water map class, NOWL was not assessed for accuracy.

NOWP—Open Water Pond

The Open Water Pond (NOWP) map class represents unvegetated lakes smaller than 8 ha. Ponds smaller than 8 ha occur scattered throughout the Seboeis Unit. This open water map class covers 8.6 ha (0.2 percent of the Seboeis Unit).

This map class is defined by areas of generally non-flowing open water under 8 ha in area that have less than 1-percent cover of wetland or aquatic vegetation. Wetland vegetation—aquatic and emergent—may be present (usually in shallow waters close to shorelines), but this vegetation should contribute less than 1-percent cover; however, small areas (less than a MMU) of wetland vegetation having greater than 10-percent cover—including herbaceous vegetation, shrubs, and trees—may be present (fig. 3.31). Because of the very low reflectivity of water, this map class generally presents as a very dark and completely flat area. When wetland vegetation is distinct from the immediate surroundings, wetland vegetation types occurring in patches less than the size of the standard MMU were mapped.

Because the NOWP map class is an open water map class, NOWP was not assessed for accuracy.

Figure 3.31. An example of the Open Water Pond (NOWP) map class as represented by one of the many small ponds found throughout the Seboeis Unit.

CBRN—Barren Land

The Barren Land (CBRN) map class represents unvegetated lands disturbed by human activity. This map class is very limited in the Seboeis Unit. This cultural map class covers 0.3 ha (0.007 percent the Seboeis Unit).

This map class is defined by areas actively undergoing development or modification that leaves large areas denuded of vegetation (which will not be planted to a crop). The CBRN landscape is generally transitory in nature because it is being actively modified for some sort of human activity, such as construction, forestry, mining or quarrying, or infrastructure. Just one instance of CBRN was noted in the Seboeis Unit in association with active forestry activities. Upon further review, Monument staff determined that the mapping boundary included areas outside the official boundary.

Because the CBRN map class is a cultural vegetation map class, CBRN was not assessed for accuracy.

An example ground image of the CBRN map class was not taken during the project and no ground image of this map class is available.

CDVA—Developed Area

The Developed Area (CDVA) map class represents areas consisting mostly of vegetation and landscapes in the form of areas actively or formerly maintained for active human use. This map class is widely scattered within the Seboeis Unit. This cultural map class covers 29.4 ha (0.6 percent of the Seboeis Unit).

This map class is defined by areas where people are actively using the landscape or have in the recent past (fig. 3.32). This map class is generally permanent in nature and primarily represents roads, parking areas, and log-landing sites in the Seboeis Unit. Additionally, this map class includes some private inholdings and structures found near the northeast corner of the Seboeis Unit along Lower Shin Pond.

Because the CDVA map class is a cultural vegetation map class, CDVA was not assessed for accuracy.

Figure 3.32. An example of the Developed Area (CDVA) map class showing one of the many gravel roads that course through the Seboeis Unit.

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