Ecological Atlas
of the
Upper Androscoggin River Watershed
2nd edition

Appalachian Mountain Club

— Credits —

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Preface

A wealth of new information, changes in land ownership and protection, and greater continuity in the available ecological data between New Hampshire and Maine called for an update of the first edition of the **Ecological Atlas of the Upper Androscoggin River Watershed (2003)**. This 2nd edition also includes new chapters on watersheds, land use and land cover, recreation, energy development, land ownership change, and forest carbon sequestration. The Appalachian Mountain Club thanks all of those who are working to ensure an ecologically and economically sustainable future for the upper Androscoggin River watershed and its communities. It is a place with a rich history and extensive open spaces that is becoming increasingly rare today. Hopefully the 2nd edition of the **Ecological Atlas of the Upper Androscoggin River Watershed** will continue to contribute to a sense of place and better understanding of this invaluable landscape, its heritage, and future preservation.

Acknowledgements

Lisa St. Hillaire of the Maine Natural Areas Program, Sara Cairns of the New Hampshire Natural Heritage Inventory, and John Perry and Donald Katnik of Maine Department of Inland Fisheries and Wildlife provided valuable information on rare plants and animals occurring in the upper Androscoggin River watershed. Barbara Barbieri of the Northern Forest Heritage Park provided access to the park's collection of historical photographs for the first edition. Other photos are by Appalachian Mountain Club staff unless otherwise indicated. Dave Thurlow, Joe Homer, Andy Cutko, Emily Pinkham, Sue Gawlor, and Marcel Polak provided valuable reviews of portions of the 1st edition, and Mike Jones with the 2nd edition. Patrick Lynch assisted with graphics for the 2nd edition.

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Cover photo:
Mooselookmeguntic-Cupsuptic Lake from ME Route 17 “Height of Land”
by Ken Kimball

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— Introduction —

***Androscoggin:** The Abenaki Indians called it Amascogin, which means "fish coming in the spring." The seven Indian tribes that lived along the Androscoggin River had over 60 names and meanings of the Androscoggin River; all 60 of them referred either to the vast fast-water stretches of river or the large numbers of sea-run fish that were present there.*

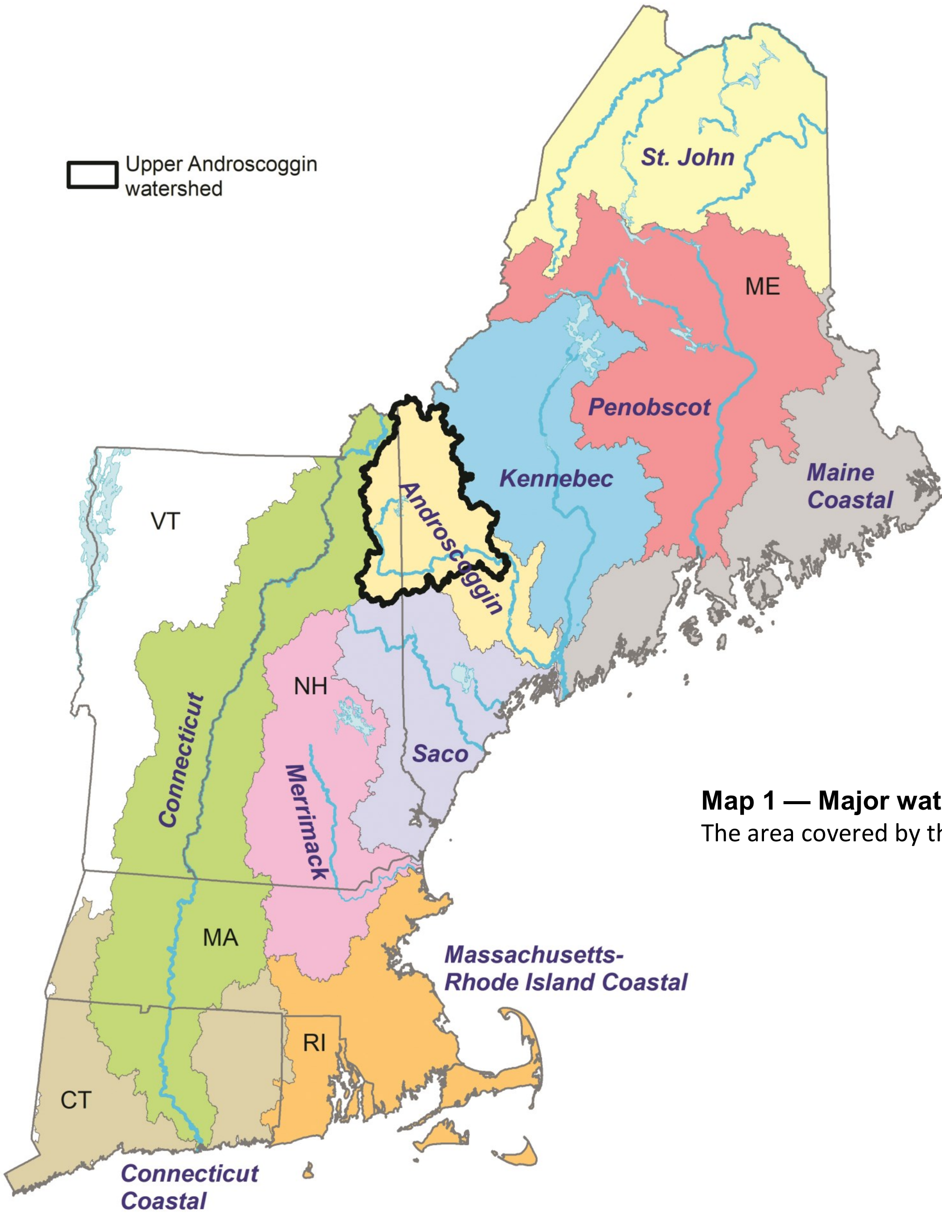
—From "Fishery Management in the Androscoggin River" by S.E. DeRoche. 1967.

The Androscoggin is one of New England's great rivers, draining an area of more than 3,500 square miles in northern New Hampshire and western Maine (Map 1). Its watershed lies between the Connecticut River watershed to the west and the Kennebec River watershed to the east, with the smaller Saco and Presumpscot River watersheds lying to the south.

The water that flows down the Androscoggin begins its journey on the south slopes of low mountains along the Canadian border. There, many miles from the nearest human settlement, rainfall and snowmelt collect into small streams on the forested hillsides. Eventually they combine to form the northern tributaries of the river—the Swift and Dead Diamond, Magalloway, Cupsuptic and Kennebago rivers. These rivers eventually flow into the great lakes of the Rangeley Lakes chain—Rangeley, Mooselookmeguntic, Cupsuptic, Upper and Lower Richardson, Aziscohos and Umbagog lakes.

It is at Lake Umbagog, straddling the Maine/ New Hampshire border, that the Androscoggin River itself begins. Leaving the marshy wetlands of this broad shallow lake, it flows south through the scenic 13 Mile Woods, past the rural villages of Errol and Milan and the historic paper mill city of Berlin. Eventually it comes up against the great bulk of the White Mountains and makes a sharp turn to the east toward the Maine border. Along this stretch it joins with other tributaries—the Sunday, Bear, Ellis, Swift and Webb rivers from the north, and the Peabody, Wild and

Lakes, mountains and undeveloped forests define the landscape of the upper Androscoggin watershed.

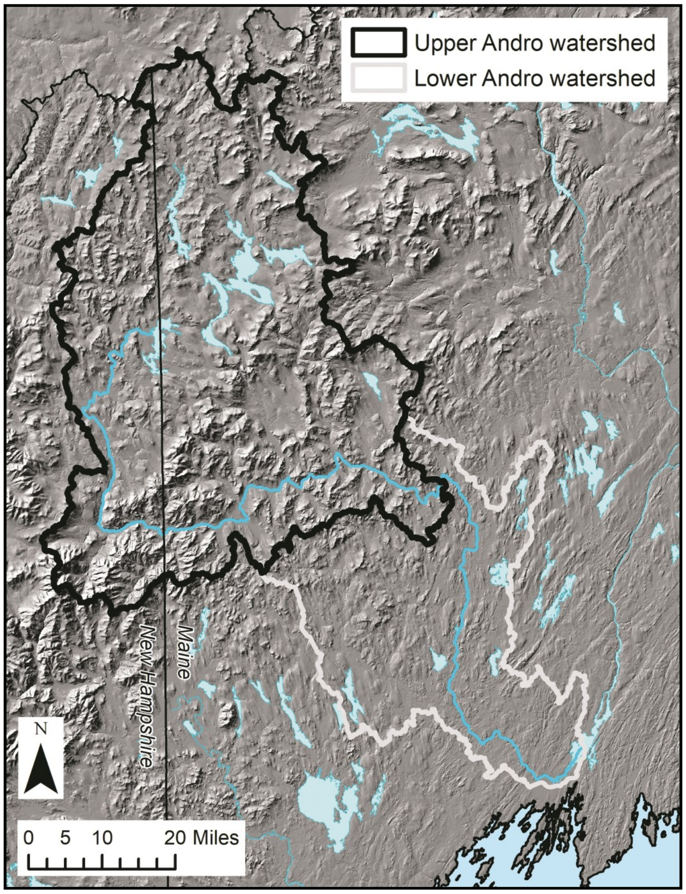


Map 1 — Major watersheds of New England
The area covered by this atlas is outlined in black.

Pleasant rivers from the south. After passing Rumford, the second great mill city along its length, it resumes its southward course in the vicinity of Jay. From this point onward it flows through a more heavily developed landscape, past the twin cities of Auburn and Lewiston, eventually joining with the Kennebec in Merrymeeting Bay near the city of Brunswick before entering the Gulf of Maine and Atlantic Ocean.

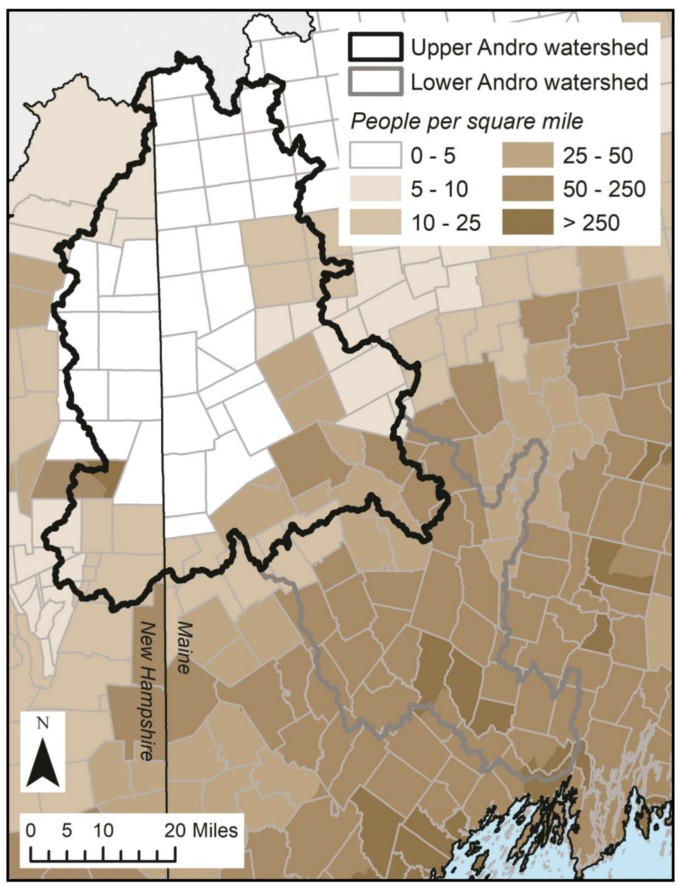
This watershed, extending from the wild unpopulated forests of the north country to the bustling cities of the coast, represents the divide that characterizes much of northern New England. It encompasses two distinctly different landscapes, as can be seen by looking at several characteristics (Maps 2 – 5). In addition to the differences shown on these maps, the forests themselves change. As one moves into the more heavily settled southern part of the watershed, species such as red spruce, balsam fir, sugar maple, and white and yellow birch become less dominant, while white pine, hemlock, red maple and red oak become more dominant. Less common northern species such as white and black spruce, tamarack and northern white cedar disappear, while species such as white oak, hickory, eastern red cedar and pitch pine appear.

The area covered by this Atlas is the transition zone and wilder northern part of the watershed, including parts of Coos County in New Hampshire and Franklin and Oxford counties in Maine. It encompasses the Androscoggin River watershed upstream of the Riley Dam on the Androscoggin River. This Atlas encompasses more than 2,445 square miles—more than twice the size of Rhode Island. This is the Great North Woods—a land of vast forests and undeveloped lakes, where moose roam and loons call out across misty waters. It is a land that echoes with the ghosts of old logging camps and keystone predators such as the grey wolf and mountain lion—an area rich in history and holding much promise for the future.



Map 2 — Topography
The shape of the land has had a strong influence on the distribution of roads, population and land use within the watershed. The upper watershed is a region of rugged mountains, steep slopes and narrow valleys. The lower watershed, consisting of the gentler Appalachian foothills and the Gulf of Maine coastal plain, is much more suited to widespread agriculture, settlement and development.

Map 3 — Population density
The lower watershed is much more heavily populated. Large parts of the upper watershed have no permanent population, and only the Berlin-Gorham area in New Hampshire and the Rumford-Mexico area in Maine have population densities approaching that found throughout much of the lower portion.



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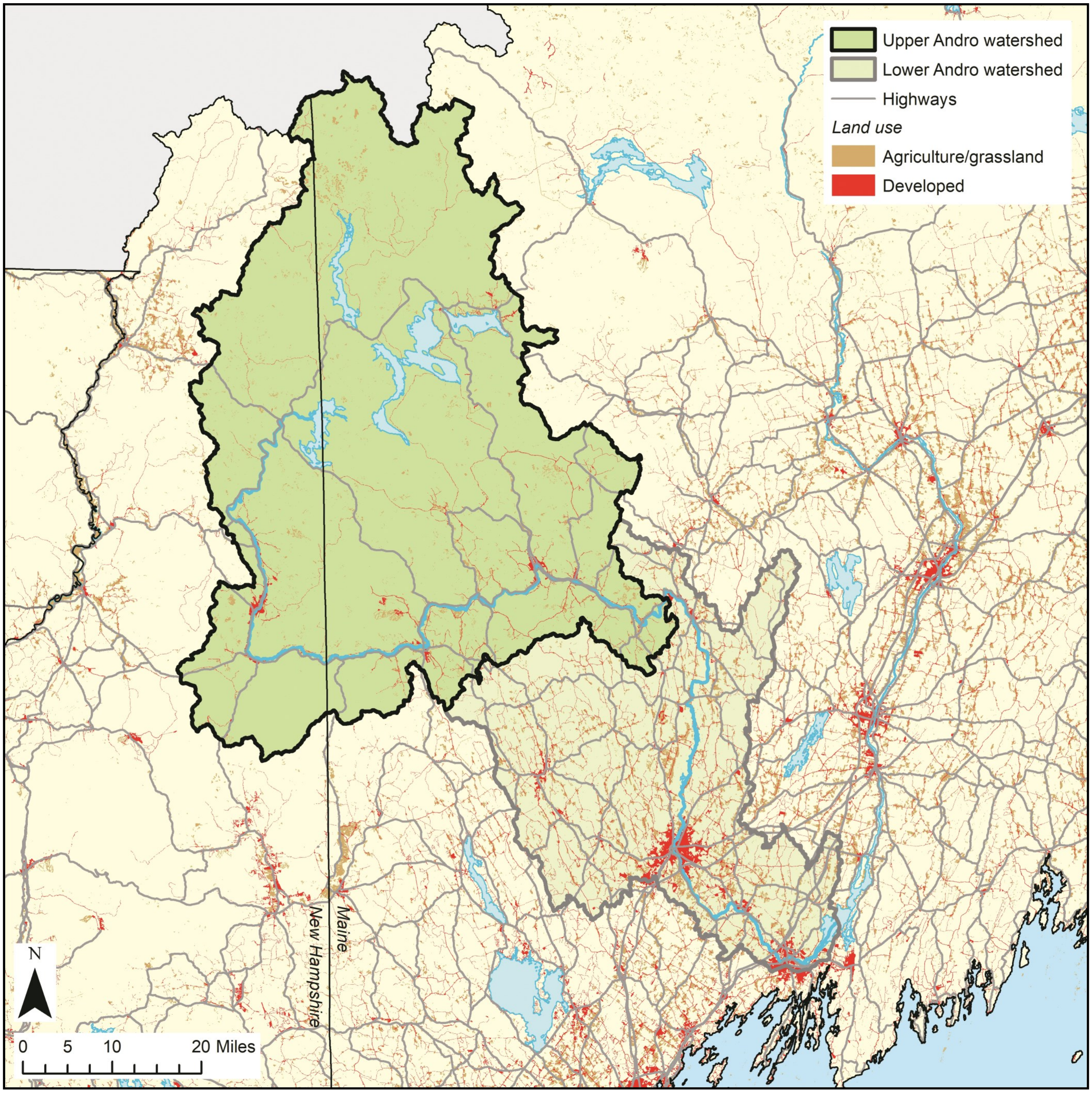

Map 4 — Highways and land use

The lower (southern) part of the watershed is criss-crossed by an extensive network of roads and highways connecting the cities and towns of the region. The upper (northern) part has far fewer highways, and large parts have no public roads at all. Large areas of forest in the lower watershed have been cleared for urban or residential development and agriculture. Most of the existing forest has regrown from land previously used for agriculture, and is fragmented into small blocks by public roads and settlements. In contrast, the overwhelming portion of the northern watershed remains in forest. Much of this land was never cleared for agriculture, and extensive areas of forest are broken only by private gravel logging roads.

— Topography —

Richardson and Mooselookmeguntic lakes

The upper Androscoggin River watershed is one of the most rugged landscapes in New England (Maps 2 and 5). From an elevation of just over 354 feet above sea level at the Riley Dam, the land rises more than a vertical mile to the summit of Mount Washington, at 6,288 feet the highest point in the northeastern US.

The watershed contains two mountainous regions separated by a valley that stretches from the Berlin/Milan/Errol, New Hampshire region across the Rangeley Lakes, extending to Flagstaff and Moosehead lakes. South of this valley lie the great ranges of the White Mountains (the Presidential, Carter-Moriah and Caribou-Speckled ranges), the Mahoosuc Range, and Bemis and Elephant mountains. This range (sometimes called the Longfellow Mountains) continues northeast across the Saddleback-Sugarloaf and Barren-Chairback-Whitecap ranges before ending at Mount Katahdin. To the north lie the high peaks of northern Coos County (including Kelsey, Crystal, Magalloway and Rump mountains) as well as the Kennebago Divide and Mount Snow in northwestern Maine. These mountains (known in Maine as the Boundary Mountains) continue along the Maine/Quebec border as far as Boundary Bald Mountain north of Jackman.

Within (or along the boundary of) the watershed lie more than 100 distinct peaks rising above 2700 feet in elevation, with 36 of these exceeding 3500 feet and 9 (all within the White Mountain National Forest) exceeding 4000 feet (see Subalpine and Alpine Ecosystems, pg. 41). More than six percent of the land in the watershed (almost 100,000 acres) lies above 2700 feet. Of all the watersheds in northern New England, only the Pemigewasset River watershed, which drains the heart of the White Mountains, has a greater proportion of its area in high-elevation land.

The mountainous nature of the landscape is also reflected in the slope of the land. Only about a third of the land in the watershed is relatively flat (less than 10% slope[1]). Outside of the intermountain Rangeley Lakes valley, the largest areas of flat ground are in the valleys of the Ellis and Webb rivers, and Canton Point. More than seven percent of the watershed consists of steep ground (greater than 35% slope). The greatest extent of steep ground is not surprisingly in the White Mountains, and the Longfellow and Boundary Mountain Ranges, though steep slopes can be found on most of the watershed's mountains. Within Maine and New Hampshire, only the Pemigewasset watershed has less flat ground and more steep slopes.

The shape of the landscape has profoundly affected the uses to which people have put the land. Because of the difficult access, the upper Androscoggin region was one of the last places in New England to be settled (outside of some remote areas of northwestern Maine, which have only been sparsely settled). The steep ground (along with the harsh climate and infertile soils) limited the amount of land available for agriculture and development, and throughout its post-settlement history the primary use for most of the land in the watershed has been timber harvesting.

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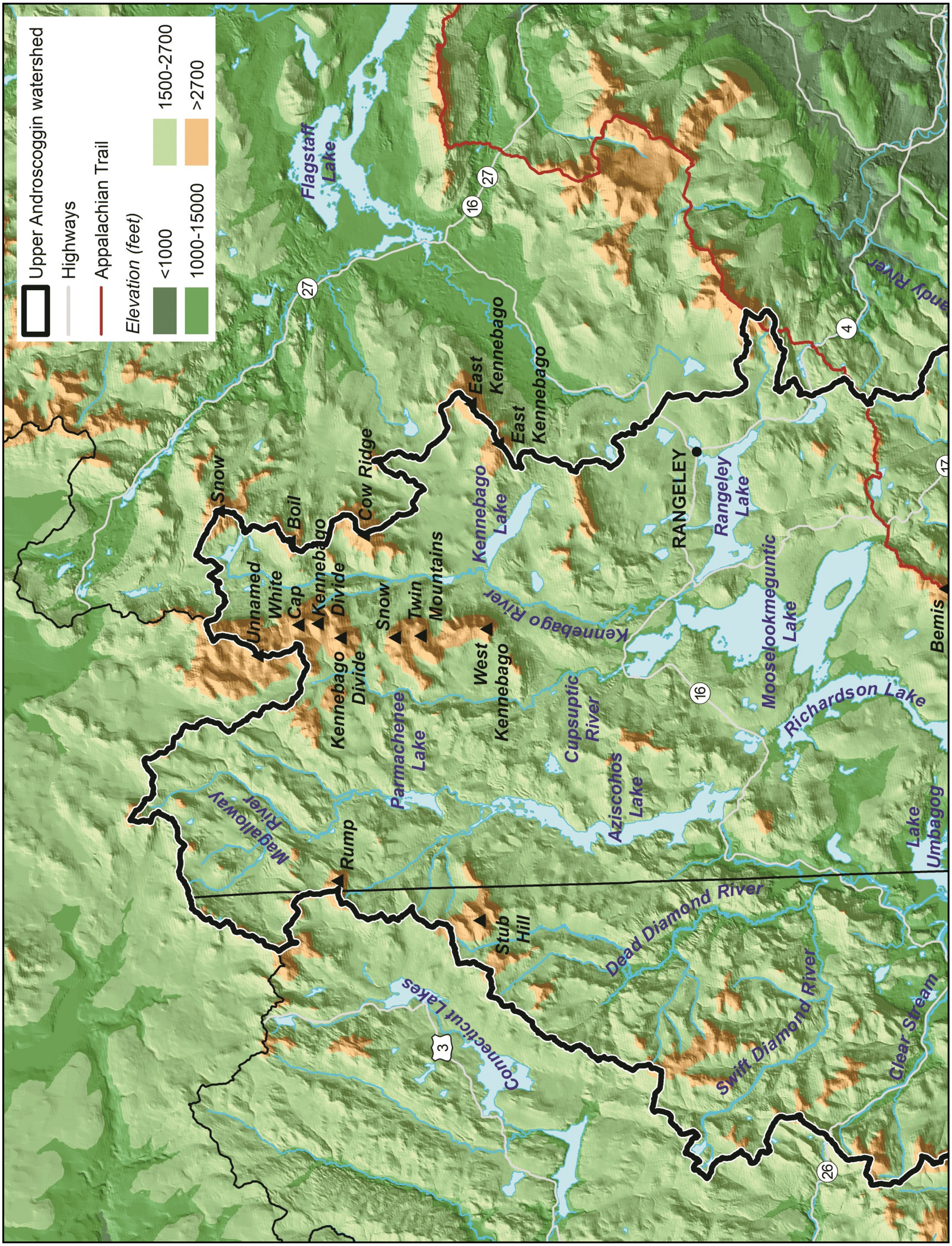
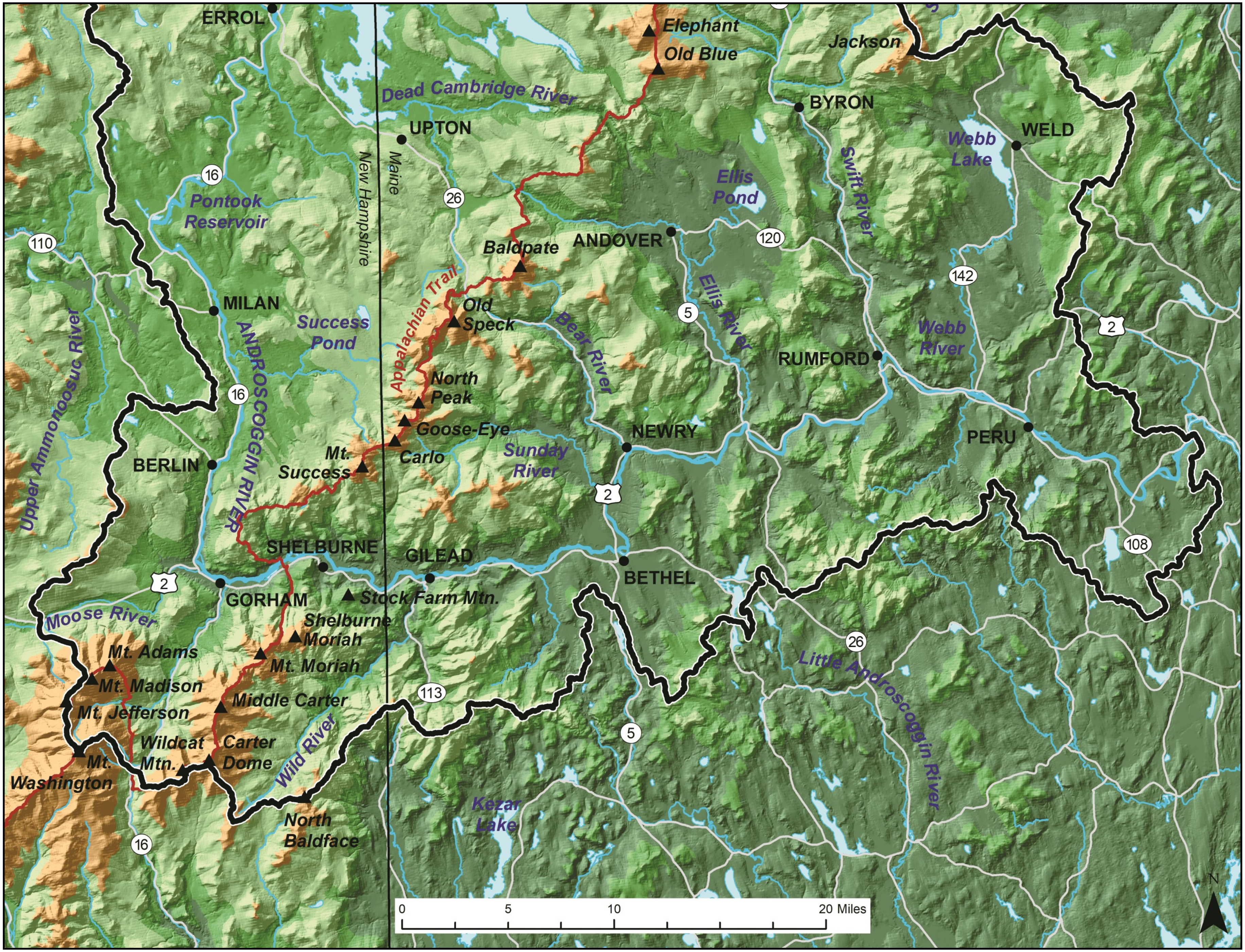
[1] Slope as measured in percent reflects the elevation gain across a specified distance. A 10% slope means that the land rises 1 vertical foot for every 10 horizontal feet. A slope of 100% is the same as 45 degrees - 10 vertical feet for every 10 horizontal feet - very steep!



Upper Androscoggin watershed
Highways
Appalachian Trail
Elevation (feet)
<1000
1000-15000
1500-2700
>2700
Flagstaff Lake
27
16
27
East Kennebago
East Kennebago
Snow
Boil
Cow Ridge
Kennebago Lake
RANGELEY
Rangeley Lake
4
17
Unnamed White Cap
Kennebago Divide
Kennebago Divide
Snow
Twin Mountains
Kennebago River
Mooselookmeguntic Lake
Bemis
West Kennebago
Cupsuptic River
16
Parmachenee Lake
Magalloway River
Aziscohos Lake
Richardson Lake
Lake Umbagog
Rump
Stub Hill
Dead Diamond River
Connecticut Lakes
3
Swift Diamond River
Clear Stream
26



Map 5 — Upper Androscoggin River watershed
The area covered in this atlas is outlined in black, and includes the watershed upstream of the Riley Dam in Jay, Maine.

— Watersheds —

Watersheds. A watershed, sometimes referred to as a drainage, river or watershed basin, is an area of land where precipitation collects and drains downslope into a single, common outlet, such as a river, lake or pond. Watersheds are naturally determined by topography as circumscribed by the highest ridgeline that meets at the lowest point of land where water flows out. Watersheds connect into other drainage (watershed) basins at lower elevations in a hierarchical pattern. Maine law classifies watersheds larger than 100 square miles as "major river basins," and those less than this as "minor river basins."

Watersheds are not determined by town, state or even national boundaries, however political boundaries at times are based on natural features such as rivers or watershed boundaries. Political boundaries based on watershed boundaries commonly use the phrase "height of land," which refers to the divide between two drainage basins. This "doctrine of natural boundaries" developed in Western culture in the 17th century with the evolving concepts of nationalism, and the "natural" ideas of a Genevan philosopher, Jean-Jacques Rousseau. For example, the United States-Canadian boundary at the northern edge of the upper Androscoggin watershed is defined as the height of land between the headwaters of the upper Magalloway and Cupsuptic rivers and their counterpart drainages in Canada.

Hydrologic units. The United States Geological Survey (USGS) and the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) have created a standardized system called the National Watershed Boundary Dataset (WBD), a hierarchical system of nested drainage areas called hydrologic units. It divides and subdivides the country into progressively smaller hydrologic Levels (Table 1). These hydrologic units are assigned numeric codes called Hydrological Unit Codes (HUC). To achieve the same relative size in a physiographic region, each Level's hydrologic units may have multiple inlets and outlets making them similar but not always identical to classical watersheds as described earlier.

Table 1 — The hierarchical structure of the Watershed Boundary Dataset

Level	Name	HUC Digits	Avg. Size $miles^2$ (acres)
1	Region	2	178,000 (113,920,000)
2	Sub-region	4	17,000 (10,880,000)
3	Basin	6	11,000 (7,040,000)
4	Sub-basin	8	1,000 (640,000)
5	Watershed	10	60-400 (38,400-256,000)
6	Sub-watershed	12	10-60 (6,400-38,400)

Within the 2-digit *New England Region* (HUC 01) is the 4-digit *Androscoggin River Subregion* (HUC 0104). This Atlas covers 2,445 square miles (Map 6) of the 3,530 square mile *Androscoggin River Subregion*, and includes eleven HUC 10-digit Watersheds and 71 HUC 12-digit Sub-watersheds (Maps 7 – 17).

Stream Order. Stream order, similar to hydrologic units, is standardized in a National Hydrologic Dataset (NHD), using Strahler stream order. In hydrography the hierarchy of streams with year-round flow is from the source (or headwaters) downstream. The headwaters are the first order, and downstream segments are defined at confluences (two streams running into each other) (Figure 1). At a confluence, if the two streams are not of the same order then the highest numbered order is maintained on the downstream segment. At a confluence of two streams with the same order, the downstream segment gets the next highest numbered order.

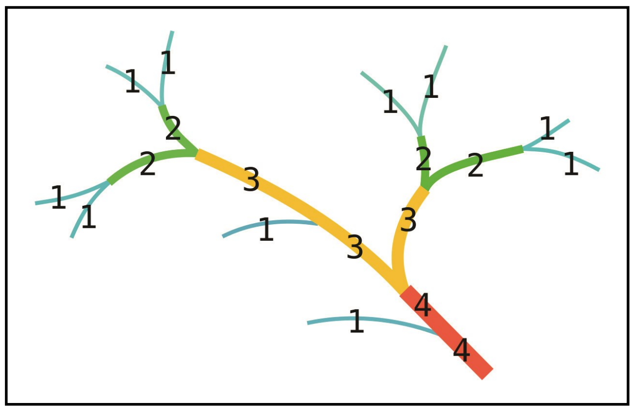
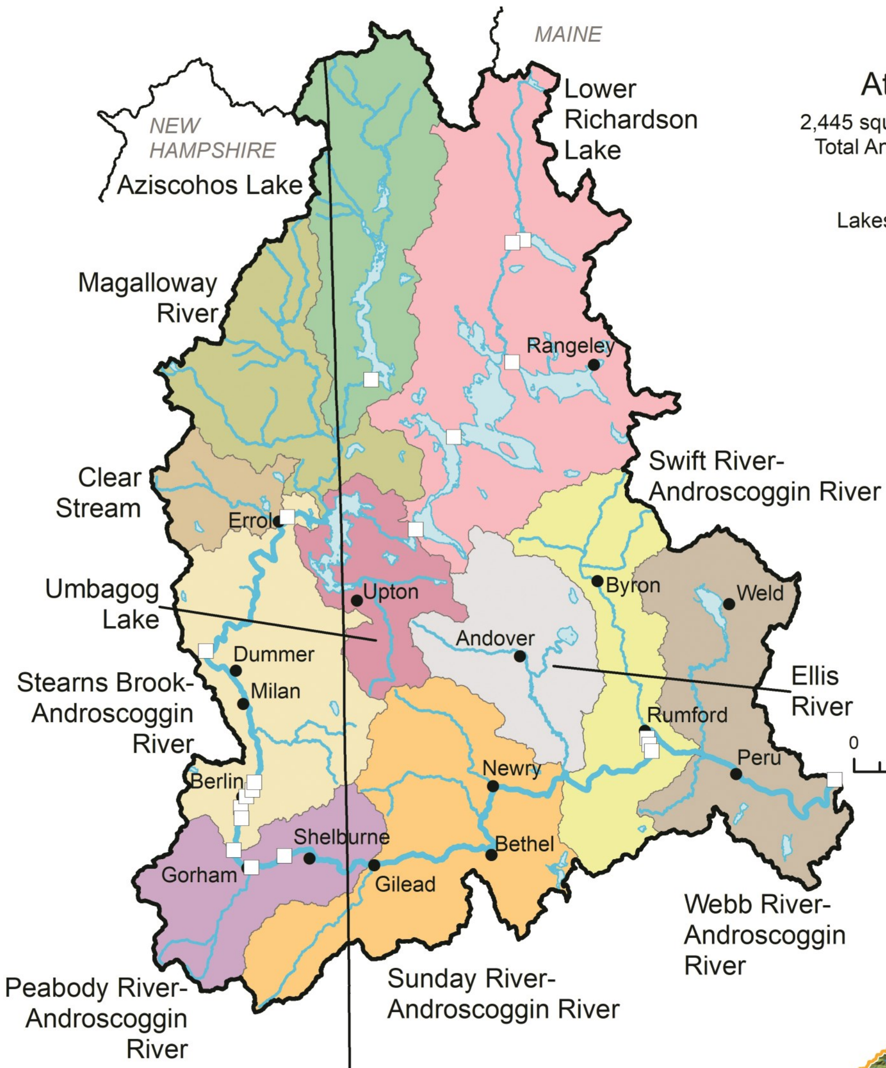


Figure 1 — Stream order

First, second and third order streams, sometimes called brooks, typically but not always are waterways in the upper reaches of the watershed and are of steeper gradient. Unlike smaller order streams, 4th order and higher streams usually achieve the name of river, are less steep, flow slower, and have larger volumes of runoff. Some 3rd order streams are also named as "rivers." Stream order is used as the basis of some laws and rules; for example, the New Hampshire Shoreland Water Quality Protection Act only pertains to designated protected rivers and all other streams of 4th order or higher. The upper Androscoggin River watershed covered in this Atlas has more than 3,700 miles of 1st order or higher streams.



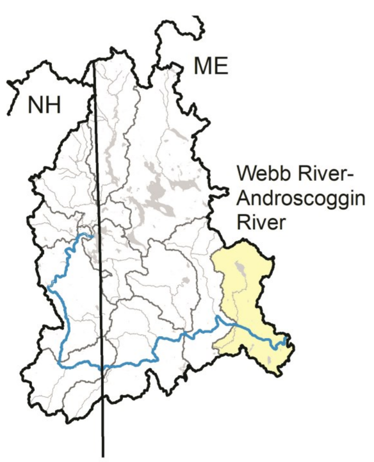
Atlas Drainage area:

2,445 square miles (1,565,219 acres)
Total Androscoggin River miles: 107
Total stream miles
1st order & greater: 3,737
Lakes & Ponds 10 acres or larger
Number: 125
Total acres: 62,412

Elevation:

maximum: 6,288 feet
minimum: 354 feet

Large Dams □



USGS watershed name:
Webb River-Androscoggin River

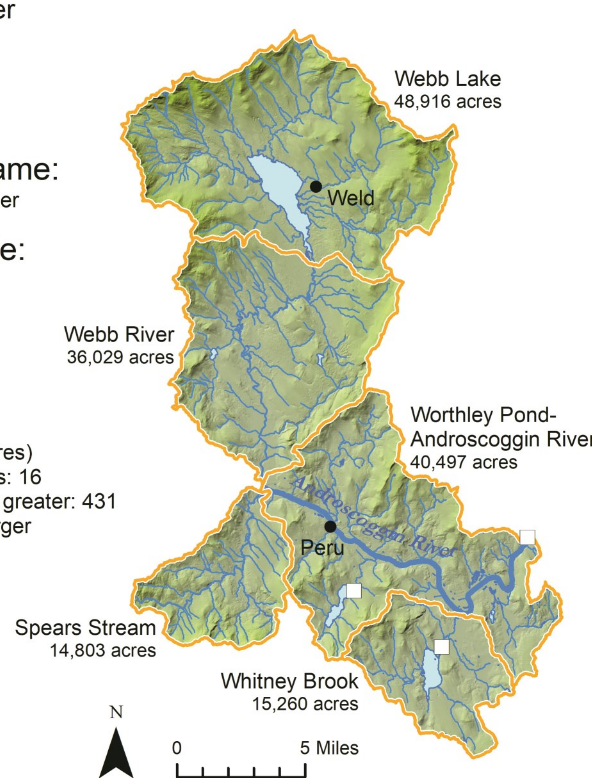
Hydrologic Unit Code:
0104000205

Number of USGS Subwatersheds: 5

Drainage area:
243 square miles (155,505 acres)
Total Androscoggin River miles: 16
Total stream miles 1st order & greater: 431
Lakes & Ponds 10 acres or larger
Number: 8
Total acres: 3,338

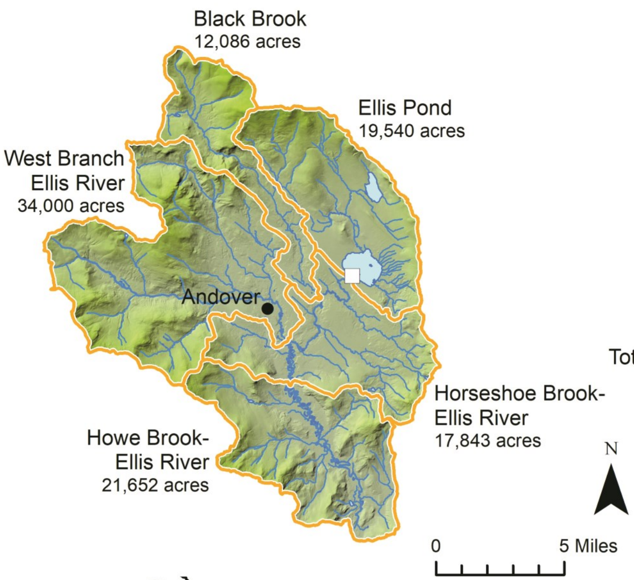
Elevation:
maximum: 3,554 feet
minimum: 354 feet

Dams □: 3



Map 6 (above) The eleven USGS 10-digit watersheds covered in this Atlas

Map 7 (below) Webb River-Androscoggin River watershed



USGS watershed name:
Ellis River

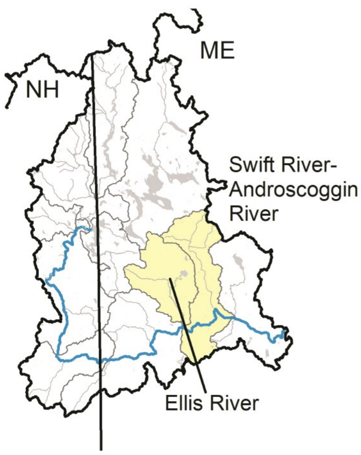
Hydrologic Unit Code:
0104000203

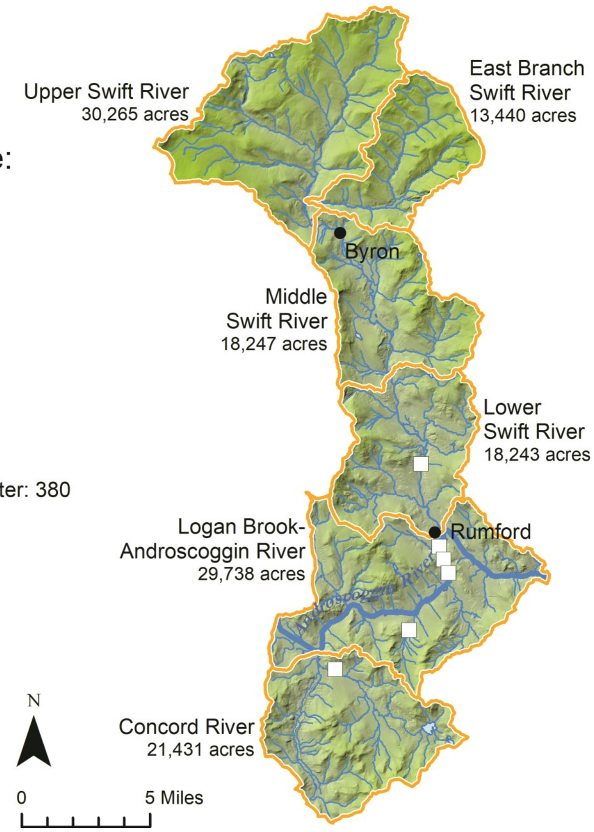
Number of USGS Subwatersheds: 5

Drainage area:
164 square miles (105,121 acres)
Total Androscoggin River miles: 0
Total stream miles 1st order & greater: 261
Lakes & Ponds 10 acres or larger
Number: 5
Total acres: 1,252

Elevation:
maximum: 3,812 feet
minimum: 605 feet

Dams □: 1





USGS watershed name:
Swift River-Androscoggin River

Hydrologic Unit Code:
0104000204

Number of USGS Subwatersheds: 6

Drainage area:
205 square miles (131,364 acres)
Total Androscoggin River miles: 16
Total stream miles 1st order & greater: 380
Lakes & Ponds 10 acres or larger
Number: 8
Total acres: 243

Elevation:
maximum: 3,765 feet
minimum: 395 feet

Dams □: 6

Map 8 (above) Ellis River watershed

Map 9 (below) Swift River-Androscoggin River watershed

USGS watershed name:
Peabody River-Androscoggin River

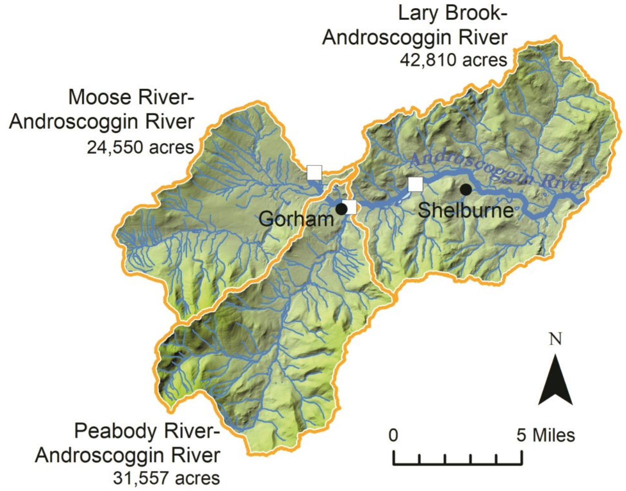
Hydrologic Unit Code:
0104000201

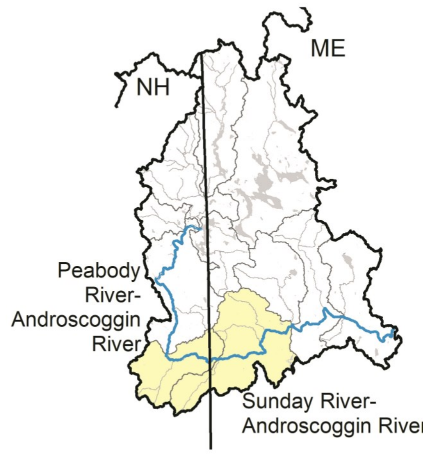
Number of USGS Subwatersheds: 3

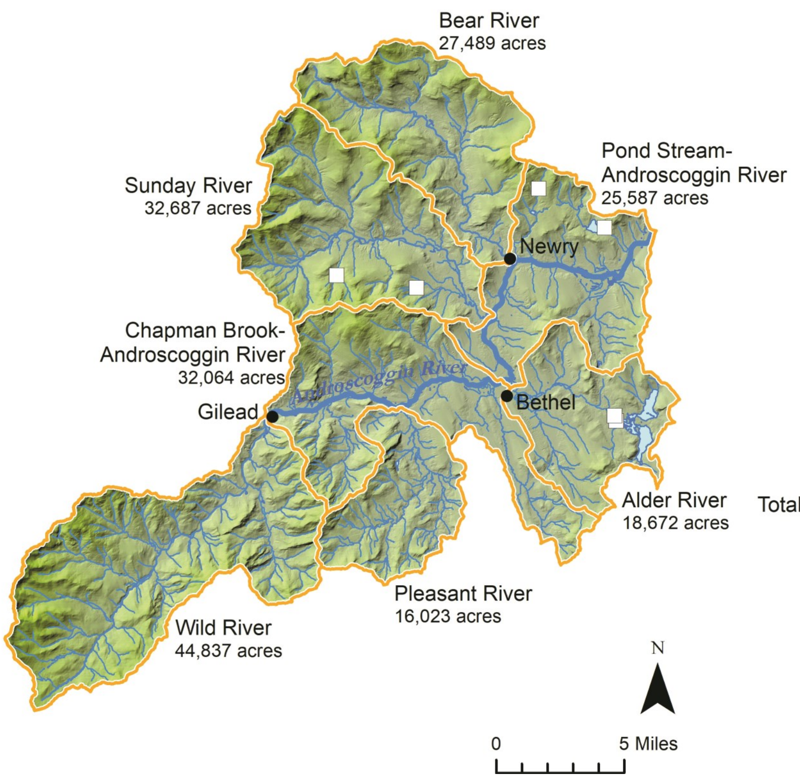
Drainage area:
155 square miles (98,917 acres)
Total Androscoggin River miles: 14
Total stream miles 1st order & greater: 376
Lakes & Ponds 10 acres or larger
Number: 4
Total acres: 96

Elevation:
maximum: 6,288 feet
minimum: 678 feet

Dams □: 3







USGS watershed name:
Sunday River-Androscoggin River

Hydrologic Unit Code:
0104000202

Number of USGS Subwatersheds: 7

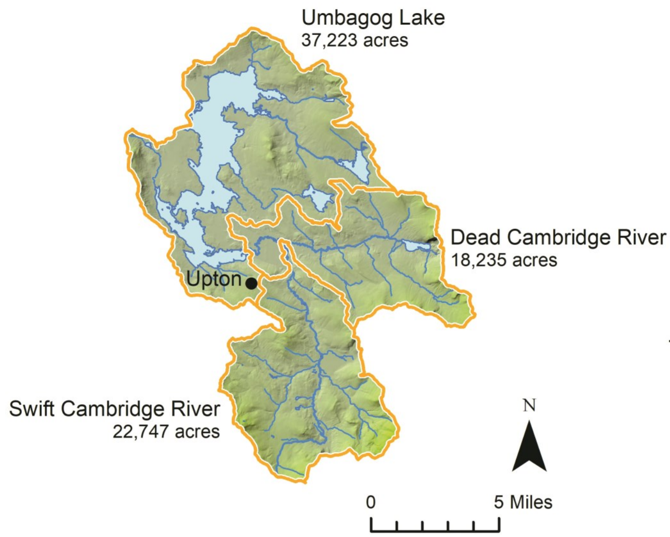
Drainage area:
308 square miles (197,359 acres)
Total Androscoggin River miles: 24
Total stream miles 1st order & greater: 622
Lakes & Ponds 10 acres or larger
Number: 7
Total acres: 948

Elevation:
maximum: 4,829 feet
minimum: 604 feet

Dams □: 6

Map 10 (above) Peabody River-Androscoggin River watershed

Map 11 (below) Sunday River-Androscoggin River watershed



USGS watershed name:
Umbagog Lake

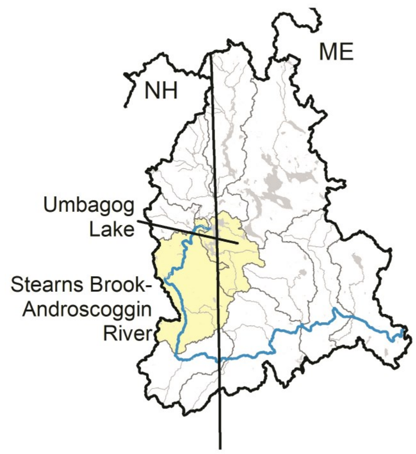
Hydrologic Unit Code:
0104000102

Number of USGS Subwatersheds: 3

Drainage area:
122 square miles (78,205 acres)
Total Androscoggin River miles: 0
Total stream miles 1st order & greater: 103
Lakes & Ponds 10 acres or larger
Number: 6
Total acres: 8,690

Elevation:
maximum: 3,812 feet
minimum: 1,241 feet

Dams □: 0



USGS watershed name:
Stearns Brook-Androscoggin River

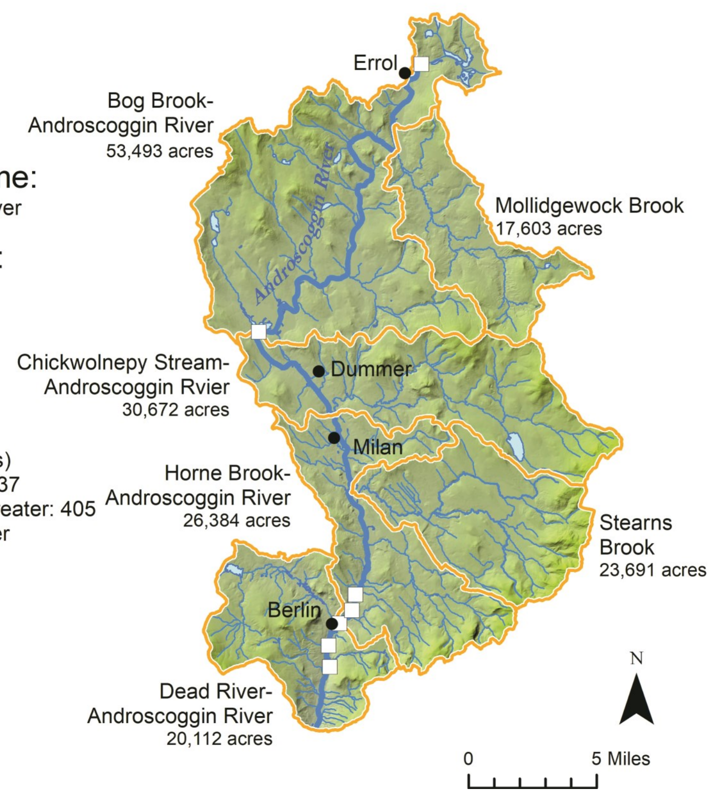
Hydrologic Unit Code:
0104000106

Number of USGS Subwatersheds: 6

Drainage area:
269 square miles (171,955 acres)
Total Androscoggin River miles: 37
Total stream miles 1st order & greater: 405
Lakes & Ponds 10 acres or larger
Number: 16
Total acres: 1,307

Elevation:
maximum: 4,036 feet
minimum: 803 feet

Dams □: 7



Map 12 (above) Umbagog Lake watershed

Map 13 (below) Stearns Brook-Androscoggin River watershed

USGS watershed name:
Magalloway River

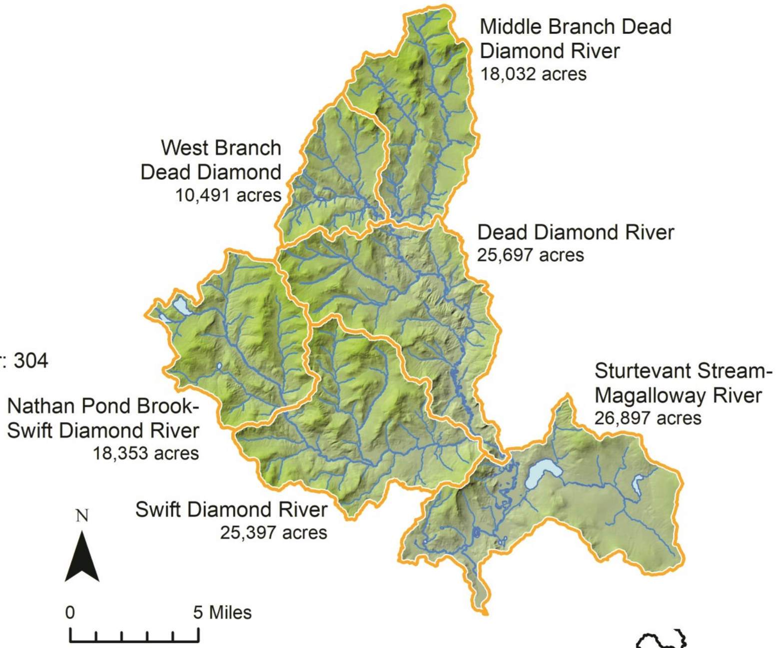
Hydrologic Unit Code:
0104000104

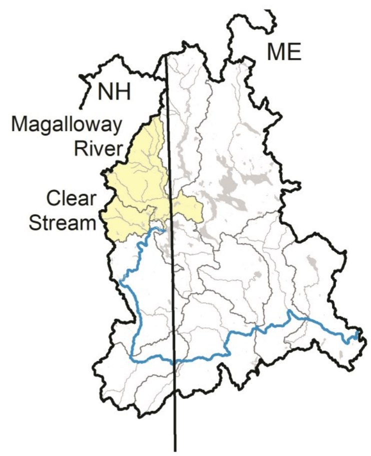
Number of USGS
Subwatersheds: 6

Drainage area:
195 square miles (124,867 acres)
Total Androscoggin River miles: 0
Total stream miles 1st order & greater: 304
Lakes & Ponds 10 acres or larger
Number: 9
Total acres: 965

Elevation:
maximum: 3,631 feet
minimum: 1,232 feet

Dams ☐: 0





USGS watershed name:
Clear Stream

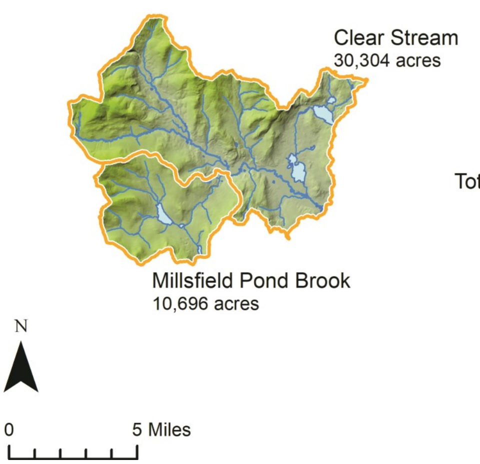
Hydrologic Unit Code:
0104000105

Number of USGS
Subwatersheds: 2

Drainage area:
64 square miles (41,000 acres)
Total Androscoggin River miles: 0
Total stream miles 1st order & greater: 75
Lakes & Ponds 10 acres or larger
Number: 7
Total acres: 770

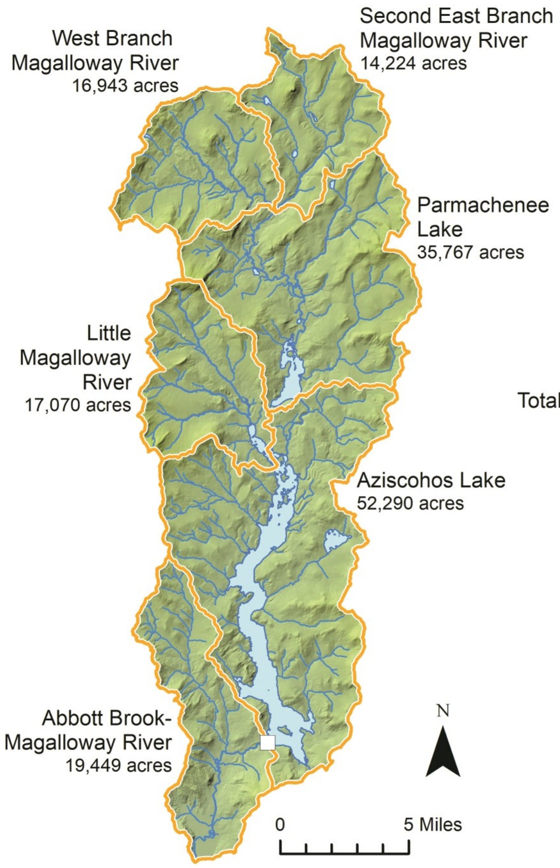
Elevation:
maximum: 3,472 feet
minimum: 1,219 feet

Dams ☐: 0



Map 14 (above) Magalloway River watershed

Map 15 (below) Clear Stream watershed



USGS watershed name:
Aziscohos Lake

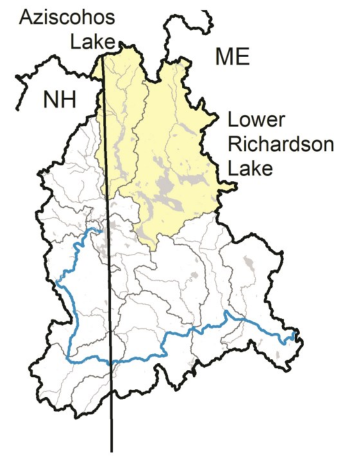
Hydrologic Unit Code:
0104000103

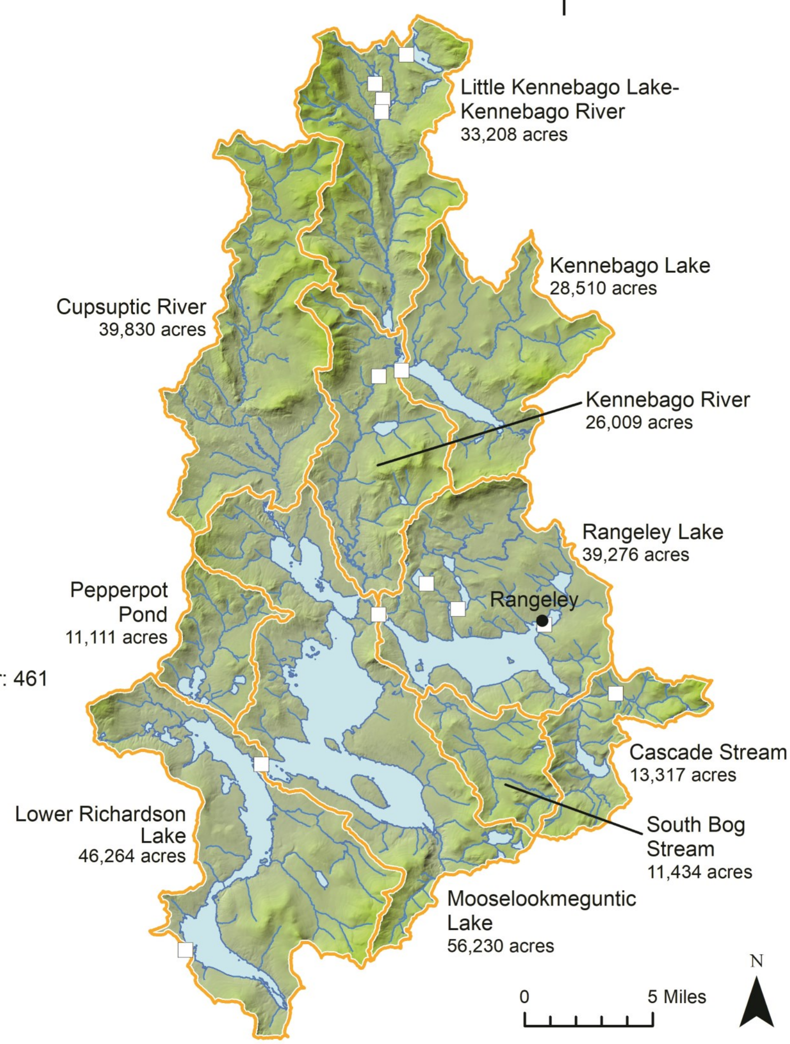
Number of USGS Subwatersheds: 6

Drainage area:
243 square miles (155,741 acres)
Total Androscoggin River miles: 0
Total stream miles 1st order & greater: 318
Lakes & Ponds 10 acres or larger
Number: 12
Total acres: 8,354

Elevation:
maximum: 3,652 feet
minimum: 1,253 feet

Dams □: 1





USGS watershed name:
Lower Richardson Lake

Hydrologic Unit Code:
0104000101

Number of USGS Subwatersheds: 10

Drainage area:
477 square miles (305,189 acres)
Total Androscoggin River miles: 0
Total stream miles 1st order & greater: 461
Lakes & Ponds 10 acres or larger
Number: 43
Total acres: 36,449

Elevation:
maximum: 4,097 feet
minimum: 1,439 feet

Dams □: 13

Map 16 (above) Aziscohos Lake watershed

Map 17 (below) Lower Richardson Lake watershed

— Geology —

The upper Androscoggin watershed is an old and geologically complex landscape. Though the rocks and mountains seem solid and unchanging, they are the result of dramatic events that took place hundreds of millions of years ago. The land we see today was shaped by the collision of continents, extensive volcanic activity, and the rise and subsequent erosion of two great mountain ranges, processes that are still ongoing. Figure 2 illustrates this rock cycle.

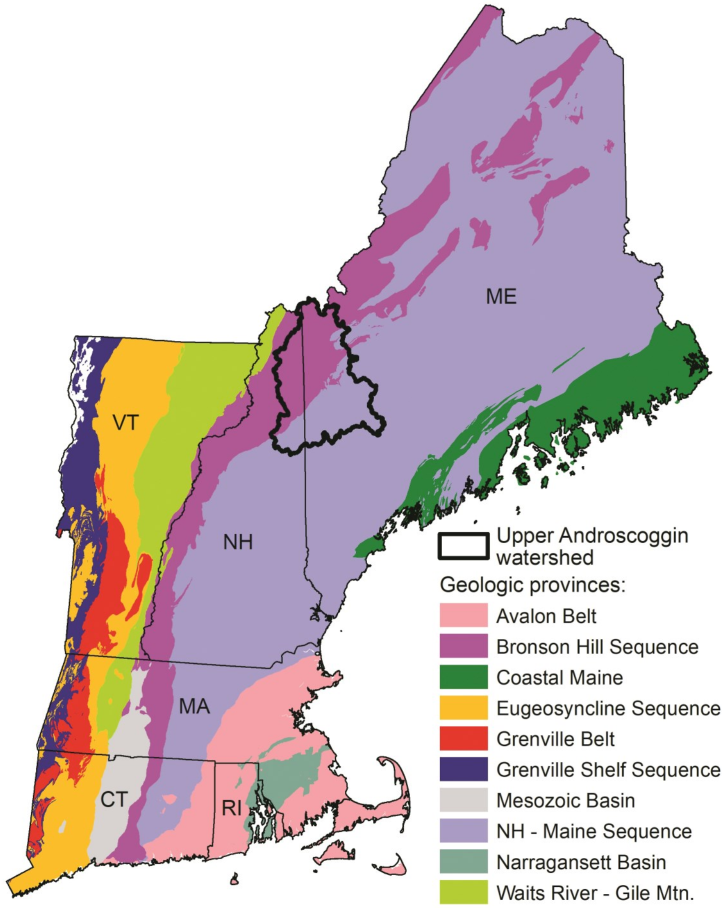
At the broadest level the watershed encompasses two geological provinces (Map 18). The *Bronson Hill Sequence* consists of metamorphosed rocks from a volcanic island arc overlain by metasedimentary rocks. The *New Hampshire-Maine Sequence* consists of metamorphosed ocean-floor sedimentary rocks interspersed with igneous plutonic rocks. At a more detailed level the watershed consists of multiple individual geologic formations with distinct composition and history (Map 19) as discussed below.

Precambrian history

More than 541 MYBP[1]

At the beginning of the Cambrian period (see Table 2) the coast of the ancestral North American continent lay to the west of its current location, near present day Quebec City and Albany, New York. The Adirondacks, formed during an earlier continental collision more than a billion years ago, were already an old range, worn down from hundreds of millions of years of erosion. New England lay under an ocean known as the "proto-Atlantic" or Iapetus (after the Greek god who was the father of Atlantis), which opened when the North American and European continental plates separated about 650 million years ago.

Precambrian rocks are rare in New England, present only in a few areas including parts of the Green and Berkshire mountains. In northwestern Maine lies such an area of ancient rock—the Chain Lakes massif. Consisting primarily of gneiss (very durable rock formed by extreme heat and pressure), the Chain Lakes massif extends from the upper Moose River into the northeastern corner of the Androscoggin watershed (the headwaters of the Kennebago River). These are the oldest rocks in Maine or New Hampshire —between 1 and 1.6 billion years old. The formation is often described as "mysterious" because its origins are not well understood. It is now thought to have been an isolated small piece of continental crust (a "microplate"), though it has even been suggested that it represents the site of an ancient meteor impact.



Map 18 — Geologic provinces of New England
(from Robinson and Kapo 2003)

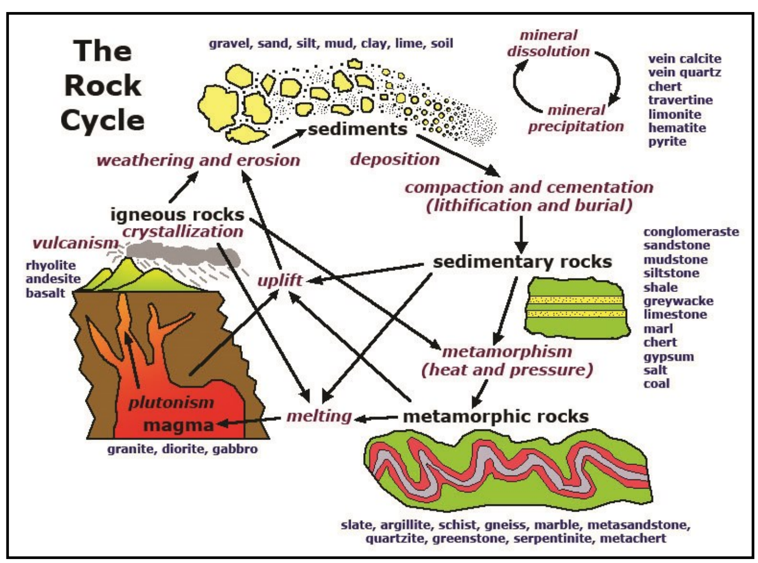
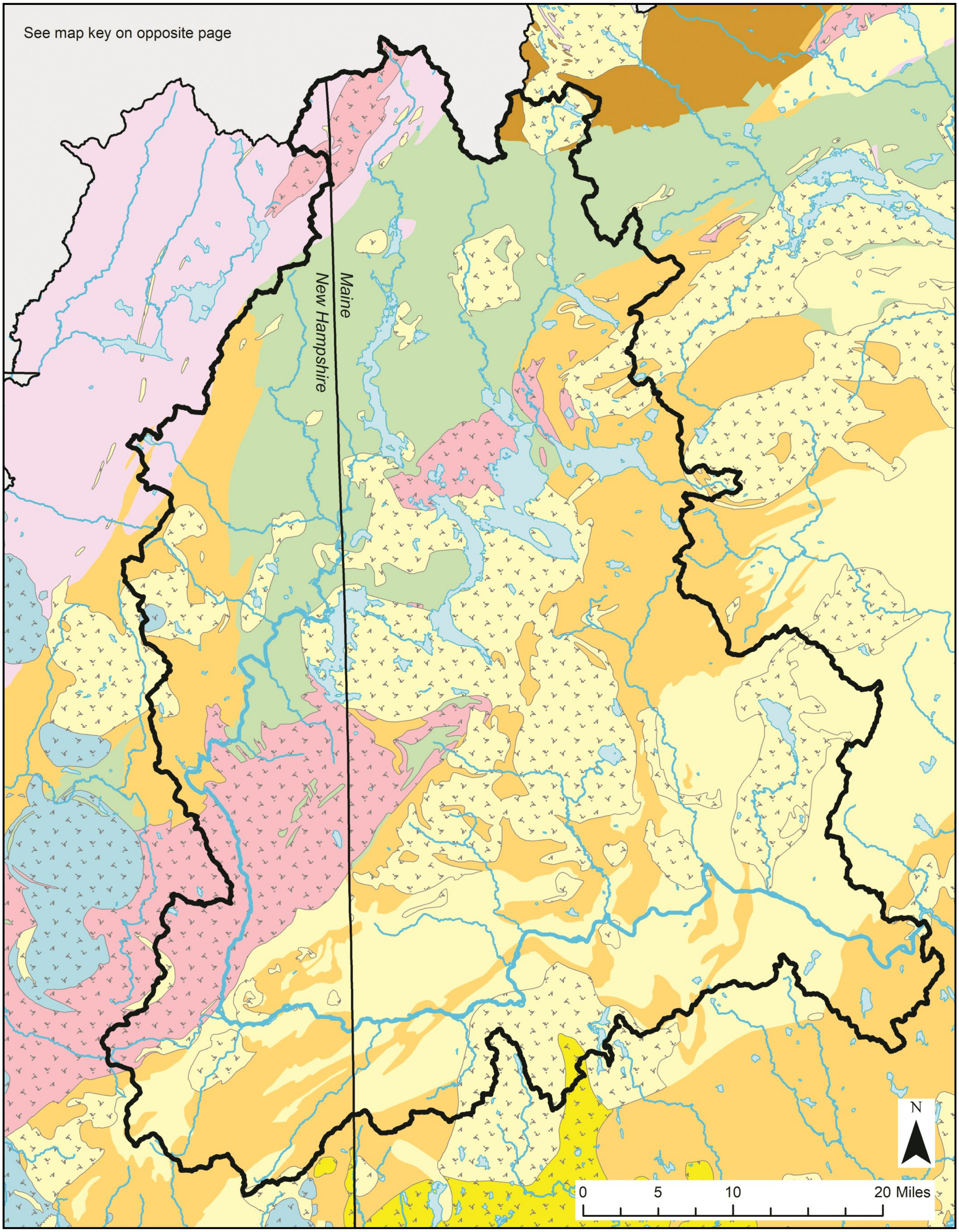


Figure 2 — The rock cycle (USGS)

[1]Million Years Before Present



Map 19 — Bedrock geology
Each group shown on this map is a consolidation of numerous geologic formations.

Table 2 — Geologic time scale (Million years before present)

Era	Period	Epoch	Time (MYBP)	Major events
Cenozoic	Quaternary	Holocene	.01 - present	Rise of human civilization
		Pleistocene	2.6 - .01	Continental glaciation, first modern humans
	Tertiary		66 – 2.6	Mammals become dominant
Mesozoic	Cretaceous		145 - 66	Extinction of dinosaurs; first modern flowering plants
	Jurassic		201 - 145	Dinosaurs dominant; first birds
	Triassic		252 - 201	First dinosaurs and mammals; breakup of Pangaea
Paleozoic	Permian		299 - 252	First coniferous trees
	Carboniferous		359 - 299	Alleghenian orogeny; first reptiles; lush forests
	Devonian		419 - 359	Acadian orogeny; first insects, amphibians and seed plants
	Silurian		444 - 419	First modern fish and vascular plants
	Ordovician		485 - 444	Taconic orogeny; first land plants and animals
	Cambrian		541 - 485	Major evolutionary diversification ("Cambrian explosion")
Precambrian time			4600 - 541	Origin of life; evolution of photosynthesis; algae and bacteria dominant; first multicellular organisms

Cambrian period
541 to 485 MYBP

At some point the movement of the continents changed and Iapetus began to close. In the middle of the ocean a "subduction zone" was created—a seam in the oceanic crust, where the western part of the ocean floor sunk underneath the eastern part. The tremendous heat and pressure created along this subduction zone led to a high level of volcanic activity, and an "island arc" was formed—a line of volcanic islands, similar to the present-day Aleutians. As Iapetus closed, this island arc was pushed toward the eastern edge of North America.

In the late Cambrian period, continued compression of the tectonic plate boundary along the eastern continental margin led to a period of folding and deformation known as the Penobscot orogeny. Deep ocean-floor rocks caught in the vice of this collision are present as a band stretching from the 13-Mile Woods section of the Androscoggin River, across Aziscohos Lake and the upper Magalloway River to the vicinity of Moosehead Lake.

Ordovician period
485 to 444 MYBP - the Taconic orogeny

About 450 million years ago the Bronson Hill complex collided with North America, in the first of two great mountain-building events that would shape the upper Androscoggin watershed. This event, known as the Taconic orogeny, pushed ocean floor sedimentary rocks westward across the eastern margin of the North American continent, creating the Taconic Mountains along the Vermont/New York border. The eroded core of the Bronson Hill complex remains as a line of metamorphosed volcanic rocks and granitic plutons along the western New Hampshire border, across the northern White Mountains, and through the Rangeley Lakes region to central and northeastern Maine (Map 20). At the end of the Ordovician period, this line marked the eastern shore of northern New England. The largest of these Ordovician plutons is the Jefferson Dome, extending from Bethlehem, New

- Upper Androscoggin watershed
- Precambrian gneiss of the Chain Lakes Massif
- Cambrian to early Ordovician metasedimentary and metavolcanic rocks
- Ordovician plutonic and volcanic rocks (Bronson Hill complex)
- Silurian-Devonian metasedimentary rocks (Connecticut Valley-Gaspe trough)
- Late Ordovician to Silurian metasedimentary rocks
- Devonian metasedimentary rocks (eastern source)
- Devonian plutonic rocks
- Carboniferous plutonic rocks (Sebago pluton)
- Mesozoic plutonic rocks

Hampshire across Jefferson, Randolph and Berlin to the Maine border north of the Mahoosucs. The large cliff on Mount Forest west of Berlin is an exposure of Jefferson Dome granite.

Silurian period
444 to 419 MYBP

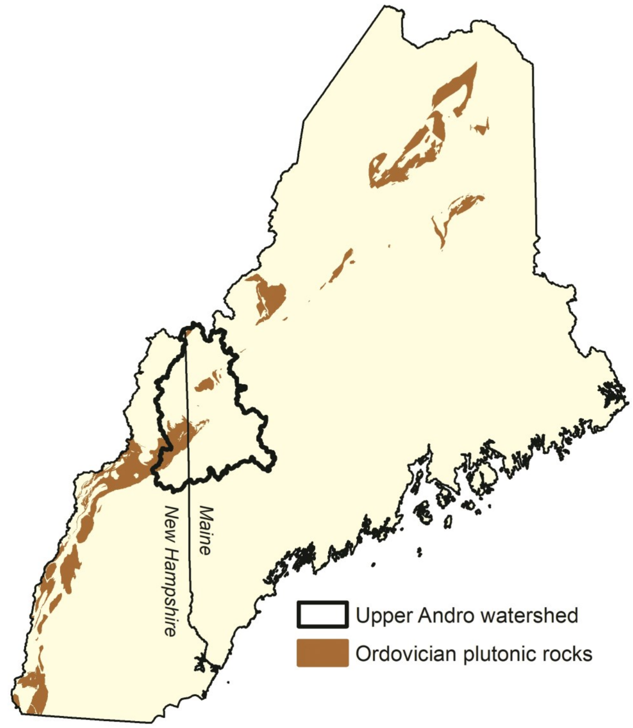
The Silurian period was relatively quiet, marked by the erosion of the mountains built by the Taconic orogeny. Iapetus continued to close, but the zone of subduction and volcanic activity shifted to the eastern side of the ocean. Sediments eroded from the Bronson Hill complex collected in deep layers in Iapetus, as well as in the Connecticut Valley–Gaspe trough to the west. There are few igneous rocks from this period, reflecting the lack of tectonic activity. By the end of the Silurian, the upper Androscoggin watershed had been reduced to a landscape of low relief, with much of it once again under water.

Devonian period
419 to 359 MYBP - the Acadian orogeny

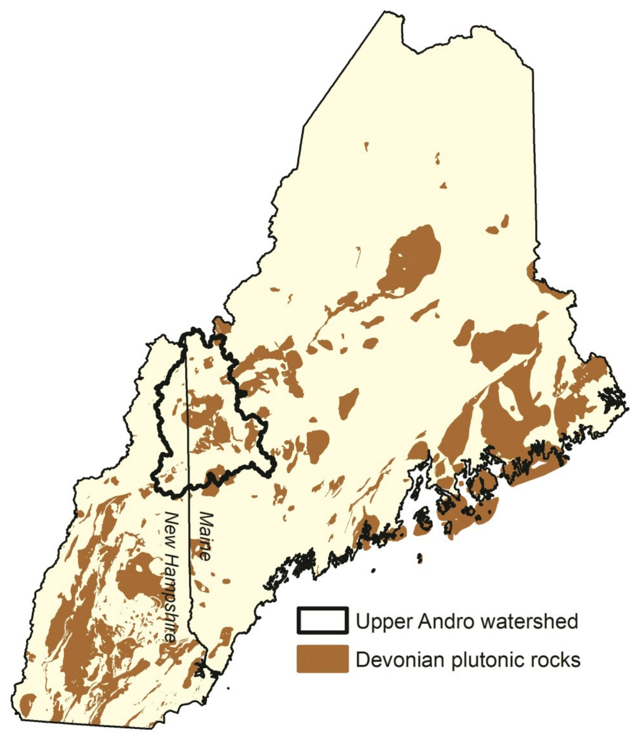
During the early Devonian period the ever-narrowing Iapetus continued to fill with sediment, but the source of these deposits shifted. Sediment was now coming from the east, from younger mountains along the edge of the approaching land mass on the other side of Iapetus. Rather than Europe proper, this land mass may have been a "microcontinent" known as Avalonia that lay between the larger North American and European continental plates.

Over the course of the Devonian period the North American and Avalonian/European continental plates came together in the second major event that shaped the region's landscape—the Acadian orogeny. Along with the somewhat later Alleghenian orogeny (marking the collision of Africa with North America south of New England), this collision resulted in the rise of the modern Appalachian Mountains. The rocks of the region were compressed, folded and thrust upward, with ridges following the northeast-southwest grain that marks the Appalachian landscape. The heat generated by the collision led to the intrusion of large bodies of magma deep underground. These Devonian-age plutons underlie much of New Hampshire and central and Downeast Maine (Map 21), including the center of the upper Androscoggin watershed from the Rangeley Lakes region south to the Mahoosucs and Ellis Pond.

At the end of the Devonian period most of the rocks of the present-day upper Androscoggin watershed were in place, though they lay many miles underground. The heat and pressure of the Acadian orogeny had caused tremendous deformation and metamorphism of the original rock forms. In the southwest portion of the watershed the heat and pressure were the greatest, and the sandstones and



Map 20 — Ordovician plutonic and volcanic rocks
These are the remnants of the Bronson Hill island arc complex, which collided with the eastern shore of North America during the Taconic orogeny about 450 million years ago.



Map 21 — Devonian plutonic rocks
These bodies of magma pushed up underground during the Acadian orogeny about 360 to 400 million years ago, when the European continental plate collided with North America.

mudstones that had collected on the floor of Iapetus were transformed into the highly resistant schists of the Presidential Range. Farther north metamorphism was less extreme, and "metasedimentary" rocks such as slate and phyllite were formed.

Late Paleozoic era to the Pleistocene epoch
359 to 2.6 MYBP

The New England region remained geologically active for another 250 million years, though much of this activity had limited effect on the upper Androscoggin watershed. The Alleghenian orogeny took place during the Carboniferous and Permian periods (360 to 248 MYBP). The intrusion of the extensive Sebago pluton (stretching from Bethel south to Lake Sebago) may have been related to this collision.

At the end of the Paleozoic era all the land masses of Earth were joined in a single supercontinent known as Pangea (Greek for "all lands"). Reptiles of the period could have walked from the Androscoggin watershed to what is now southern Morocco. About 50 million years later, during the early Mesozoic era (248 to 65 MYBP), North America began separating from Europe and Africa, leading to the formation of the modern Atlantic Ocean. The line of separation lay east of the earlier coastlines, as part of Avalonia was left joined to North America. During the middle Mesozoic era a new group of plutons intruded to the west and south of the Androscoggin. Though no plutons of this age lie within the upper watershed, today they make up the rocks of the Kilkenny region, much of the southern and western White Mountains, and the Ossipee Mountains. For the last 100 million years the New England region has been geologically stable.

The major process shaping the upper Androscoggin watershed for the last 360 million years has been erosion. Wind, ice, rain, and gravity have removed miles of overlying rock, reducing the great mountains formed during the Acadian orogeny to the mature ranges we see today. It was left to the glaciers of the Pleistocene epoch to put the finishing touches on the regional landscape.

Pleistocene epoch
2.6 million to 11,700 years ago - the "Ice Age"

During the Pleistocene epoch, large glaciers centered in eastern Canada expanded and retreated several times across much of northern North America. The last glacial episode, known as the Wisconsin glaciation, began about 25,000 years ago and reached its peak about 18,000 years ago. At that time a sheet of ice thousands of feet thick covered all of New England, extending south to Long Island and Cape Cod. Eventually the climate warmed and the glacier retreated, with the last of the ice disappearing from northern New England 10-12,000 years ago.

The glacier did not form in place but flowed from north to south. As it moved it acted like a giant sheet of sandpaper, pulverizing the rock underneath it and rounding off the rough edges of the landscape. The material carried along underneath, within and on top of the ice was spread across the landscape, often being deposited many miles from its bedrock source. Though the surficial deposits left behind by the glacier take many forms, they fall into two basic types:

Till is pulverized rock that was smeared across the surface of the landscape underneath the ice or dropped in place when the ice melted. It contains a heterogeneous mix of material from finely ground clay and silt to sand and rock fragments. Till covers most of the uplands of the region—thin or absent on mountaintops and ridgelines but deeper on lower or convex slopes.

Glaciofluvial deposits are materials that were moved and deposited by flowing water when the glacier melted. Because the flowing water carried away much of the finer material, these deposits tend to be coarser-textured sand and gravel. They are found primarily in valley bottoms and include alluvium (well-sorted sand, gravel and cobbles deposited along river beds, often to depths of hundreds of feet) and kamic deposits (less well-sorted material deposited by water flowing off the melting ice). The deeper glaciofluvial deposits and their soils (see Map 22 on page 21) create good aquifers.

The Holocene (and Anthropocene - "human") epoch
11,700 years ago to present

Have human beings permanently changed the planet? This simple question has pitted geologist and environmentalist over what to call the period we live in currently. The Holocene ("entirely recent") began 11,700 years ago after the last major ice age. Some scientists studying rock layers criticize the Anthropocene idea, saying clear-cut evidence for a new epoch isn't there. Others contend that by the 20th century, human-caused mass extinction of species, global-scale alteration of land cover, mountain top removal for coal, the damming (e.g. Lake Aziscohos) and replumbing of major river systems in the world (e.g. Hydro-Quebec in Quebec), and major chemical changes in the earth's atmosphere and accelerated climate change resulting from the release of greenhouse gases (CO_2) from the combustion of oil and coal—hydrocarbons that had been sequestered in the earth's geology for millions of years—warrants a new epoch, the Anthropocene.

— Soils —

Soils are one of the most basic features that determine the character of a natural landscape. They determine what plant communities will grow in an area (and by extension, what types of wildlife will be found there), as well as what uses humans can make of the land.

Soil Formation Factors

The types of soils found in any area are determined by six factors:

Time: Soils are dynamic systems that change over time under the influence of climate and vegetation. The soils in the Androscoggin region (and all of New England) are relatively young, dating back only 10,000 years to the end of the glacial period. (In contrast, soils outside of recently glaciated regions may be well over a million years old.)

Parent material: This refers to the original material in which the soils developed. Almost all soils in the region have glacial till or glaciofluvial deposits as parent material. In some local areas the parent material may be younger—for example, on landslide tracks or on river floodplains where sand and silt are regularly deposited. The type of parent material in which a soil develops is the primary factor governing its texture and fertility.

Climate: Climate determines the rate and type of chemical and physical processes that break down (weather) parent material. Minerals will dissolve faster in hot wet climates than in cold dry climates; freezing and thawing will physically break up rocks in the soil. In addition, climate determines what type of vegetation and microorganisms will grow in an area, which in turn affects soil development.

Topography: The shape of the land influences soil in many ways, including how the original parent material was deposited (thinner on ridgetops and upper slopes, deeper on lower slopes and in valley bottoms), whether the soil gains or loses material through erosion, and how water moves over and through the soil.

Living organisms: Soil influences what organisms can grow in an area, but these organisms in turn affect the nature and development of soil in many ways. Plants and microorganisms are the primary source for adding organic matter and nitrogen (a critical plant nutrient) to soil. Plant roots and fungi (and the chemicals they secrete) promote the physical and chemical breakdown of soil minerals. Earthworms, moles and other animals tunnel through the soil, mixing the various layers.

Human activity: In very recent geologic time human activity has strongly influenced soils. Land clearing, cultivation, drainage, construction, and forestry activity that alters species composition and scarifies the soils have had a lasting effect on soils in the region. The input of acid rain for well over a century, principally from the combustion of sulfur rich coal, has also had an impact on the chemistry of the region's soils. Acidic water dissolves the nutrients and helpful minerals in the soil and then washes them away before trees and other plants can use them to grow. At the same time, acid rain causes the release of substances that are toxic to trees and plants, such as aluminum, into the soil. The federal 1990 Clean Air Act Amendments to control sulfur dioxide (SO_2) and oxides of nitrogen (NO_X) emissions, and the decrease in coal usage to generate electricity has significantly reversed this detrimental trend.

These factors work together to create soils that vary in many important characteristics such as depth, drainage and moisture-holding capacity, texture (sandy, silty, clay, bouldery), and chemistry (acidity and the availability of nutrients critical to plant growth).

Soil Classifications

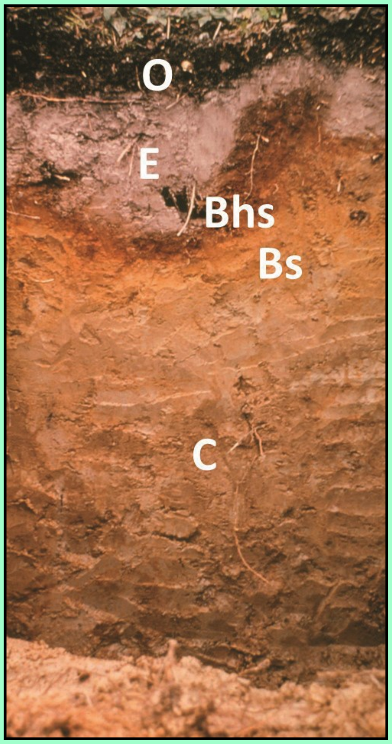
Soils are classified according to a hierarchical system in much the same way as plants and animals, with broad groups subdivided into increasingly detailed categories. At the highest level, all soils around the world are grouped in twelve *orders*. Of these, three are found in the upper Androscoggin watershed. The great majority of the region's soils are ***Spodosols*** (see page 21). These are the dominant soils of cool, humid forested regions. As a general rule they are coarse-textured, acidic, relatively infertile, and support primarily evergreen forests.

The region also includes smaller areas of two other orders. ***Inceptisols*** are soils that are less well developed, often because they are forming in younger parent material. Many of these may develop into Spodosols over time. ***Histosols*** are soils made up primarily of organic matter. They include bog soils, where deep accumulations of partially decayed plant matter (peat) have collected in ponds or poorly drained depressions. They also include thin soils of high mountain areas (sometimes called "duff" soils), where the glacier left behind only bare bedrock. Over thousands of years decaying plant matter (such as moss and evergreen needles) has built up in a thin fragile layer over the bedrock. The vegetation has created its own soil—an example of pulling oneself up by one's bootstraps.

Spodosols

Spodosols are found throughout the world's temperate forested regions. In the United States they are most prominent in cool or wet climates such as northern New England and New York, the upper Great Lakes, the Pacific Northwest and the southeastern coastal plain (Map 22).

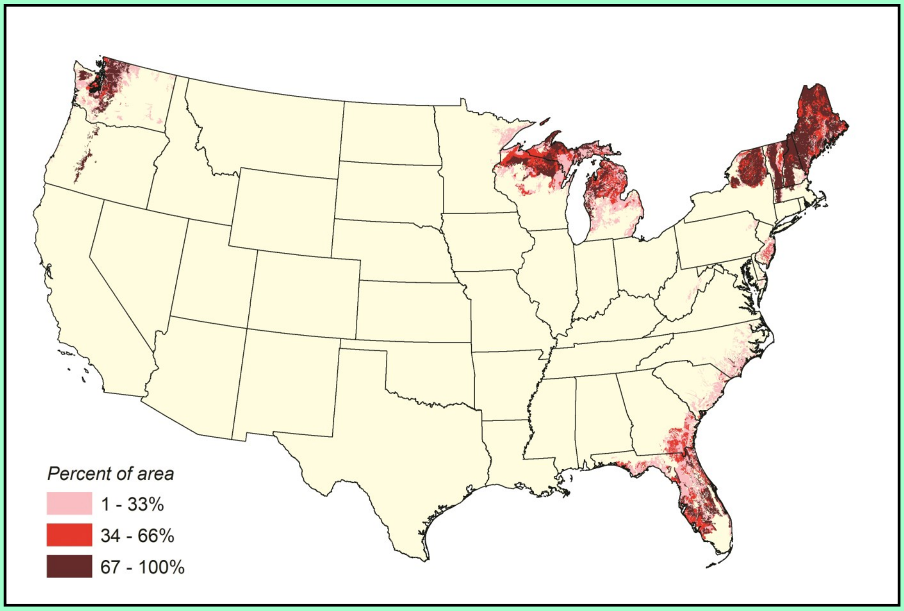
Spodosols develop through a process known as *podzolization*. The process begins with the buildup of dead plant material on the surface of the soil. Fine threads of fungi grow throughout this layer, breaking down this material and contributing to the pool of organic material. However, in the conditions that characterize these regions, this material does not fully decompose, but builds up as a layer (or *horizon*) of black, fine "greasy" *humus* on top of the mineral parent material (the **O** horizon, see photo).



Humus is very acidic, and as water moves downward through it, complex acidic organic compounds are dissolved and carried downward with the water. This acidic water draining through the soil dissolves the iron- and aluminum-based minerals (such as mica and feldspar) in the upper part of the parent material and carries them downward in the soil. However, quartz, which is more resistant to these acids, remains in place. This process creates a light gray quartz-rich horizon in the upper mineral soil (the **E** or *eluviation* horizon).

As the water drains farther into the soil, it reaches a point where the dissolved organic and iron- and aluminum-based molecules are no longer soluble. At this point they precipitate (come out of solution) and collect in a series of distinctly-colored horizons below the E horizon. The darker brown **Bhs** horizon is a layer where organic matter (*humus*) as well as iron and aluminum oxides (*sequioxides*) has accumulated, whereas the reddish/orange **Bs** horizon is a zone of primarily mineral accumulation. (The **C** horizon is unaltered parent material.)

The sequence of horizons created by podzolization gives well-developed Spodosols perhaps the most dramatic and photogenic profile of any soil type. Spodosols are most well-developed in coarse-textured parent material (especially granite) that has a high proportion of quartz and low amounts of calcium and magnesium (which help to neutralize the soil's acidity). While they can be found under any type of forest, they are most strongly developed in areas dominated by evergreen forest (pine, spruce and hemlock). The needles of evergreen trees are more resistant to decomposition than deciduous leaves, and their presence promotes the buildup of humus and increases soil acidity. Under some evergreen forests, the O horizon may be more than a foot thick, giving the ground in these areas its soft and spongy feel.



Map 22. Distribution of Spodosols in the United States

The cool humid climate and coarse-textured acidic parent materials of northern New England are ideal conditions for the development of Spodosols.

At the lowest level of classification is the *soil series*, equivalent to an individual plant or animal species. Soil series are usually named for the town or geographic area in which they were first described. Soils maps developed by the U.S. Department of Interior Natural Resource Conservation Service include nearly 100 different soil series in the upper Androscoggin watershed. These may be grouped into a few broad classes[1] (Map 23):

Coarse-textured soils developed from granite, gneiss and schist: These soils are found on hills, ridges and mountain slopes in the southern half of the watershed. They developed in deep deposits of till derived from granitic plutons and heavily metamorphosed rocks such as schist and gneiss. They are generally well-drained, sandy in texture, and contain many rocks. Because of the nature of the parent material they are very acidic and infertile. This group contains the most well-developed spodosols. The Skerry, Monadnock, Becket and Hermon series are the most common soils in this group[2].

Loamy soils developed from a combination of schist, phyllite, granite and gneiss: These soils are also found on hills and mountain slopes. They developed in glacial till derived from a mixture of rock types. In parent material, texture, drainage, acidity and fertility they are generally intermediate between the granitic soils of the previous group and the slaty soils of the next group. The Dixfield, Lyman, Colonel, Tunbridge and Marlow series are the most common soils in this group.

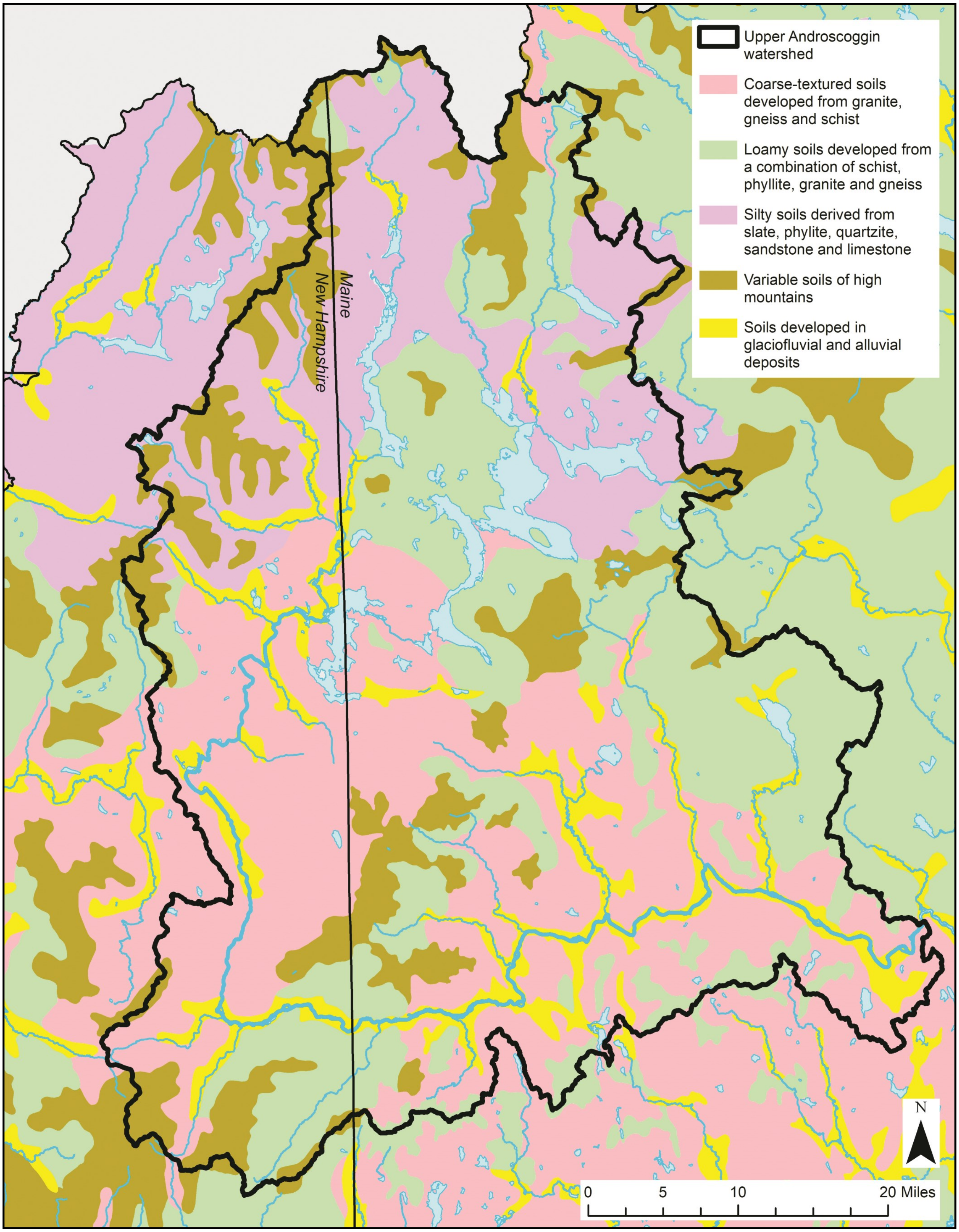
Silty soils derived from slate, phyllite, quartzite, sandstone and limestone: These soils are found on hills and plains in the northern part of the watershed. Because this area was located away from the main zone of plutonic and metamorphic activity of the Taconic and Acadian orogenies, the parent material was less heavily metamorphosed. These soils contain less coarse-textured acidic material (granite, schist and gneiss) and more fine-textured metasedimentary rocks such as slate and phyllite. The resulting soils are silty rather than sandy in texture with fewer large rocks. However, because of their finer texture and the presence of dense till layers that were compressed under the glacial ice, this group contains a higher proportion of poorly drained soils than the previous groups. The Monarda, Telos, Howland, Plaisted and Monson series are the most common soils in this group.

Variable soils of high mountains: These soils are found on mountain slopes and ridges, primarily above 2500 feet in elevation. Because of the complex mountain topography they vary greatly in depth, with deeper deposits on concave slopes and thinner deposits on ridgelines, though for the most part they are well drained. All are characterized by cold temperatures and support upper-elevation spruce-fir forests. The Saddleback, Enchanted, Surplus and Sisk series are the most common soils in this group. This group also contains the Ricker series—a thin organic soil lying directly on bedrock.

Soils developed in glaciofluvial and alluvial deposits: These soils are found in valley bottoms and developed in deep deposits of sand, gravel and silt deposited by glacial meltwater and more recent flooding. Because these soils are relatively flat and easily worked, they were the primary site for development and agriculture in the early settlement of this mountainous region. However, their low fertility and low moisture-holding capacity at the surface due to their porosity makes them poorly suited for growing crops. Where these soils developed as deeper deposits along water courses (Map 23), they can store large quantities of subsurface water making them good aquifers. This group also includes smaller areas of organic and wetland soils that developed in ponds and poorly drained areas.

[1]These groups hide much of the local variability found in the region. Soils in any group will differ in characteristics such as depth, texture and drainage. In addition, the areas as shown on the map include soils from the other groups. More detailed maps of the distribution of soil series can be found in the county-level soils surveys available from the Natural Resources Conservation Service.

[2]Detailed descriptions of these soil series can be found on the Natural Resources Conservation Service website at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/data/?cid=nrcs142p2_053587.



Map 23 — Major soils groups
The groups on this map show the dominant soils in different areas. However, each group is a consolidation of many individual soil types, including some that are more common in other groups.

— Climate —

"Weather" refers to the short-term condition of the atmosphere as reflected in things like temperature, precipitation and wind. In contrast, "climate" reflects the longer term averages of these conditions (typically over a 30-year period).

Current climate

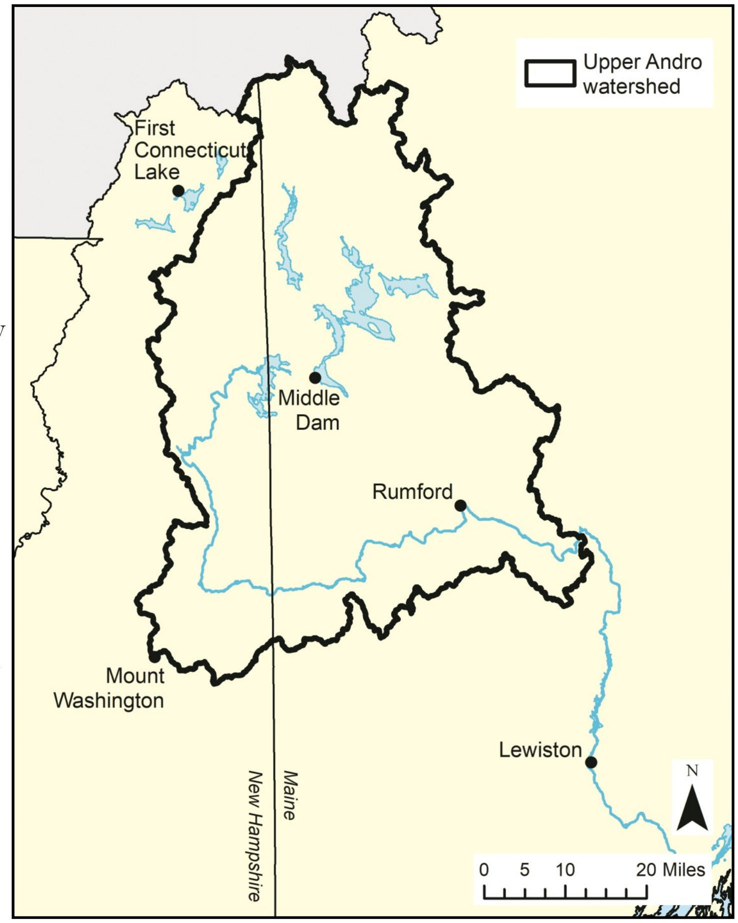
The upper Androscoggin watershed has a temperate continental climate, characterized by warm summers, cold winters, and a relatively even distribution of precipitation throughout the year (see inset, page 25). Both temperature and precipitation vary across the region in response to latitude, elevation, topography, and distance from the ocean.

As one moves farther north, average monthly temperatures decline, with First Connecticut Lake on average about 7° F colder than Lewiston (Map 24, Table 3). The difference is most pronounced in the winter—Lewiston is about 9° warmer than First Connecticut Lake in the winter but only about 6° warmer in the spring and fall (Figure 3). Record highs range from about 100° in the south to 95° in the north, and record lows from -35° to -45°.

Part of this pattern is due to the effects of elevation. On average, temperature drops about 3°F with every 1000-foot gain in elevation, and as one moves north in the watershed one is also gaining elevation. (First Connecticut Lake is nearly 1500 feet higher in elevation than Lewiston.) If all these stations were at the same elevation, the change as one moves north would still occur but would be less pronounced.

The effect of elevation can be seen in temperature data from the summit of Mount Washington, at 6288 feet the highest point in the northeastern United States and often described as having the world's worst weather. Average temperatures on the summit are about 20° lower than in the surrounding valleys in the summer and 10 to 15° lower in the winter. The all-time record high temperature on Mount Washington is only 72°.

Precipitation also varies across the watershed (Map 25) and is strongly influenced by elevation and topography. Much of the watershed receives about 40 to 45 inches of precipitation a year. However, the amount of precipitation increases with elevation. As moist air masses rise to pass over mountains they cool, reducing the amount of moisture the air can hold and leading to condensation of moisture as rain and snow.



Map 24 — Locations of climate data

Table 3 — Mean annual temperature and precipitation for selected weather stations

Station	Elevation (ft)	Temperature (°F)	Precipitation (in)
1st Connecticut Lk.	1650	37.9	46.11
Middle Dam	1460	40.0	39.33
Rumford	630	43.8	47.16
Lewiston	180	45.0	45.07
Mount Washington	6271	27.3	96.86

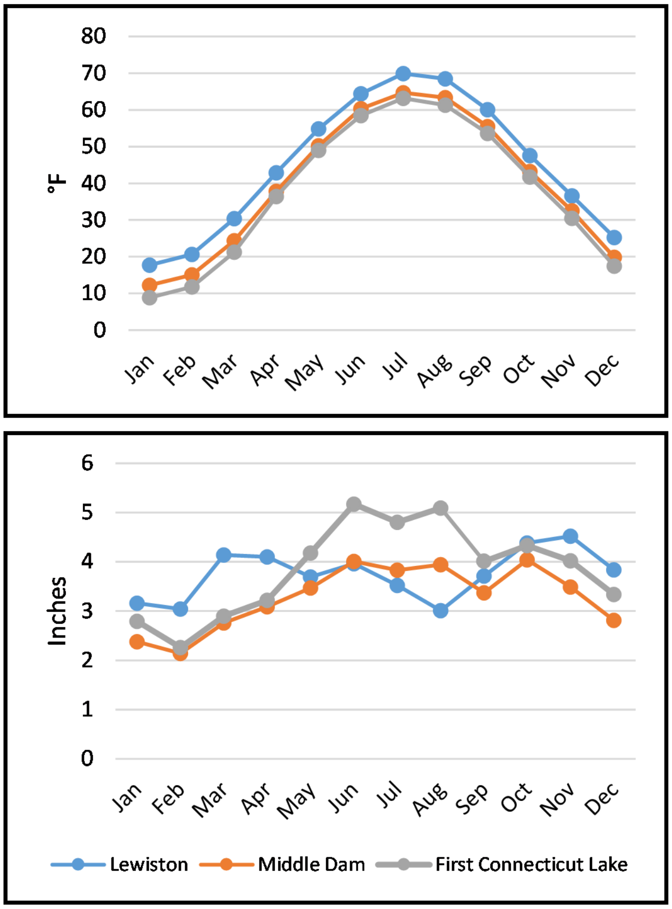


Figure 3 — Mean monthly temperature (top) and precipitation (bottom) for selected weather stations

The highest precipitation in the watershed is at the summit of Mount Washington (nearly 100 inches per year), while the driest is the Androscoggin Valley stretching from Berlin-Gorham, N.H. to the Pontook Reservoir and across the Rangeley Lakes region. This valley is surrounded on all sides by mountains, which create a "rain shadow" effect. Precipitation arriving from any direction falls heavily on the surrounding mountains, leaving less to fall on the valley behind the mountains.

The seasonal timing of precipitation also varies from south to north (Figure 3). Though there are no pronounced wet or dry seasons, closer to the ocean (Lewiston) precipitation is more evenly distributed throughout the year, with late fall the wettest part of the year. In contrast, in the north (First Connecticut Lake) there is a larger difference between wetter and dryer months, with the wettest months occurring in the summer.

Finally, the seasonal extremes in climate change from south to north. Differences between the warmest and coldest months, record high and low temperatures, and the proportion of precipitation falling in the wettest and driest months all increase as one moves north. The mountains stretching across the central part of the watershed act as a boundary between continental and maritime weather patterns, with a more continental climate to the north and a more maritime climate closer to the moderating influence of the ocean (see inset below).

Historical climate

During the height of the last glacial advance about 20,000 years ago (Years Before Present or YBP), global temperatures were about 7°F colder than the 1961-1990 average. As the glaciers retreated the global temperature increased, with the exception of a period of cooling about 11,000 YBP known as the Younger Dryas (thought to be caused by large amounts of cold glacial meltwater entering the northern Atlantic Ocean). Temperatures reached late 20th century levels around 9,000 YBP and continued to warm. The period from 9,000 to 5,000 YBP (known as the Hypsithermal Warm Period or Holocene Climate Optimum) was a period of stable climate with temperatures about 1° warmer than the late 20th century. Toward the end of this period the global climate entered a cooler and moister period that lasted for about 4,000 years. This long-term cooling culminated in the "Little Ice Age" from the 15th to the 19th century when temperatures were about 1° cooler. (The Little Ice Age was primarily confined to the Northern Hemisphere and is not evident in global temperature records.)

Continental and maritime climates

Continental climates are those influenced primarily by continental air masses, and are generally characterized by wide seasonal fluctuations in temperature and precipitation (hot summers, cold winters and pronounced wet and dry seasons). In contrast are maritime climates, which are influenced primarily by oceanic air masses and have less pronounced seasonal differences, with cooler summers and warmer winters due to the mitigating effect of the ocean. New England's climate is considered continental since on average its weather moves from west to east following the flow of the jet stream. However, the proximity of the Atlantic Ocean does influence the region's climate (especially precipitation patterns), and it should more properly be described as a "mixed continental-maritime" climate.

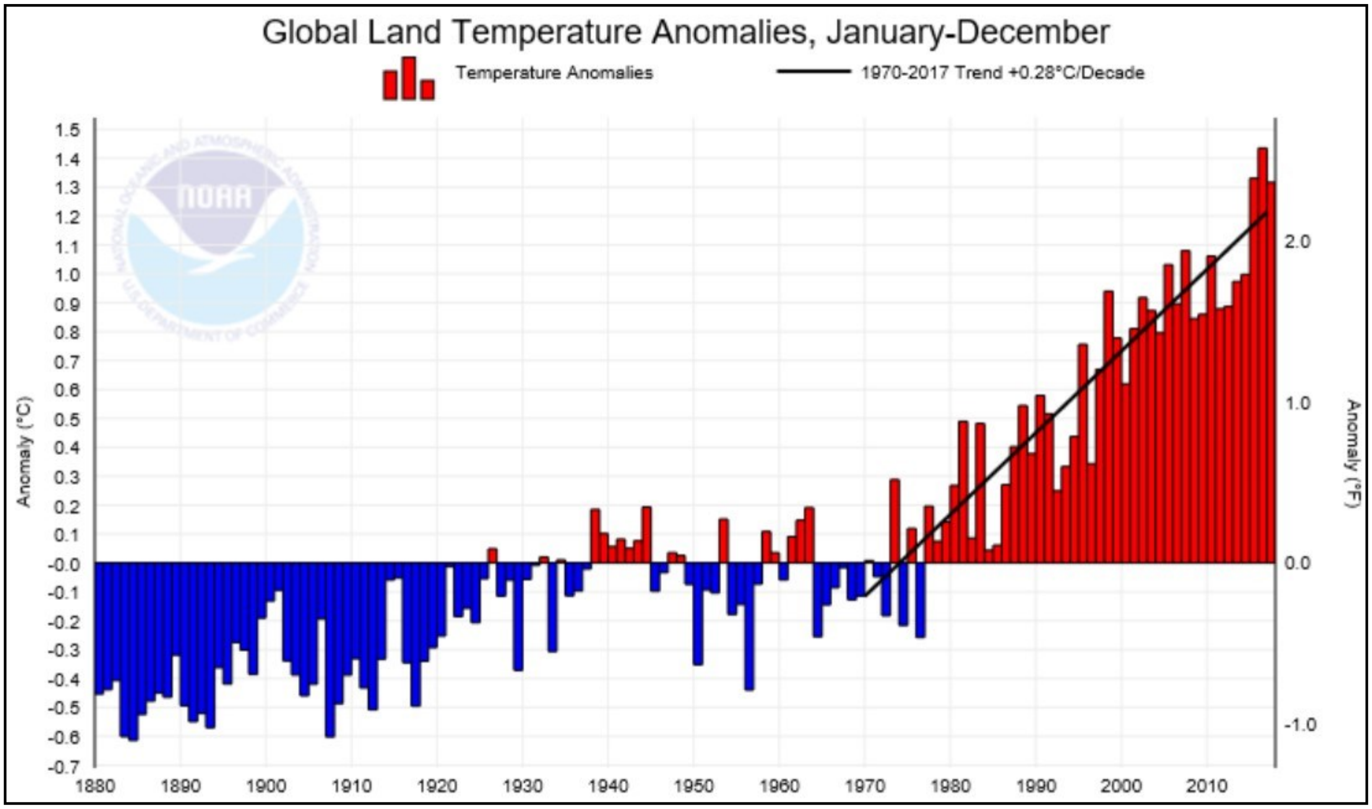


Figure 4 — Global land temperature anomaly (departure from 20th century average), 1880-2017

Since the late 1800s global and local temperatures have been rising, driven by human-caused increases in atmospheric greenhouse gases (primarily carbon dioxide) from the burning of fossil fuels and to a lesser extent from the clearing of forests. The increase in temperature has been particularly evident since 1970 (Fig. 4). Since 1900, global average land surface temperatures have increased by 0.2°F per decade, but the increase has been 0.3°F since 1940 and 0.5°F per decade since 1970. This pattern is present at all geographic scales down to individual weather stations. In the northeastern United States this trend has been driven primarily by warmer winter temperatures; in Coos County average January temperature has increased by 1.2°F per decade since 1970 but average July temperature has increased only 0.2°F per decade. The highest elevations have warmed at slower rates.

Since 1970 there has been little change in total annual precipitation across the United States, but there is considerable regional variation. The southeast, southwest and west coast regions have all become drier, while the northeast and upper midwest have become wetter. Northern New England has seen some of the greatest increases in the country, with New Hampshire's annual precipitation increasing about one inch per decade since the 1970s.

The warming climate is manifested in a variety of ways:

Longer warm seasons: The average warm season (i.e., average daily temperature above freezing) in Maine has increased by two weeks since the late 1800s.

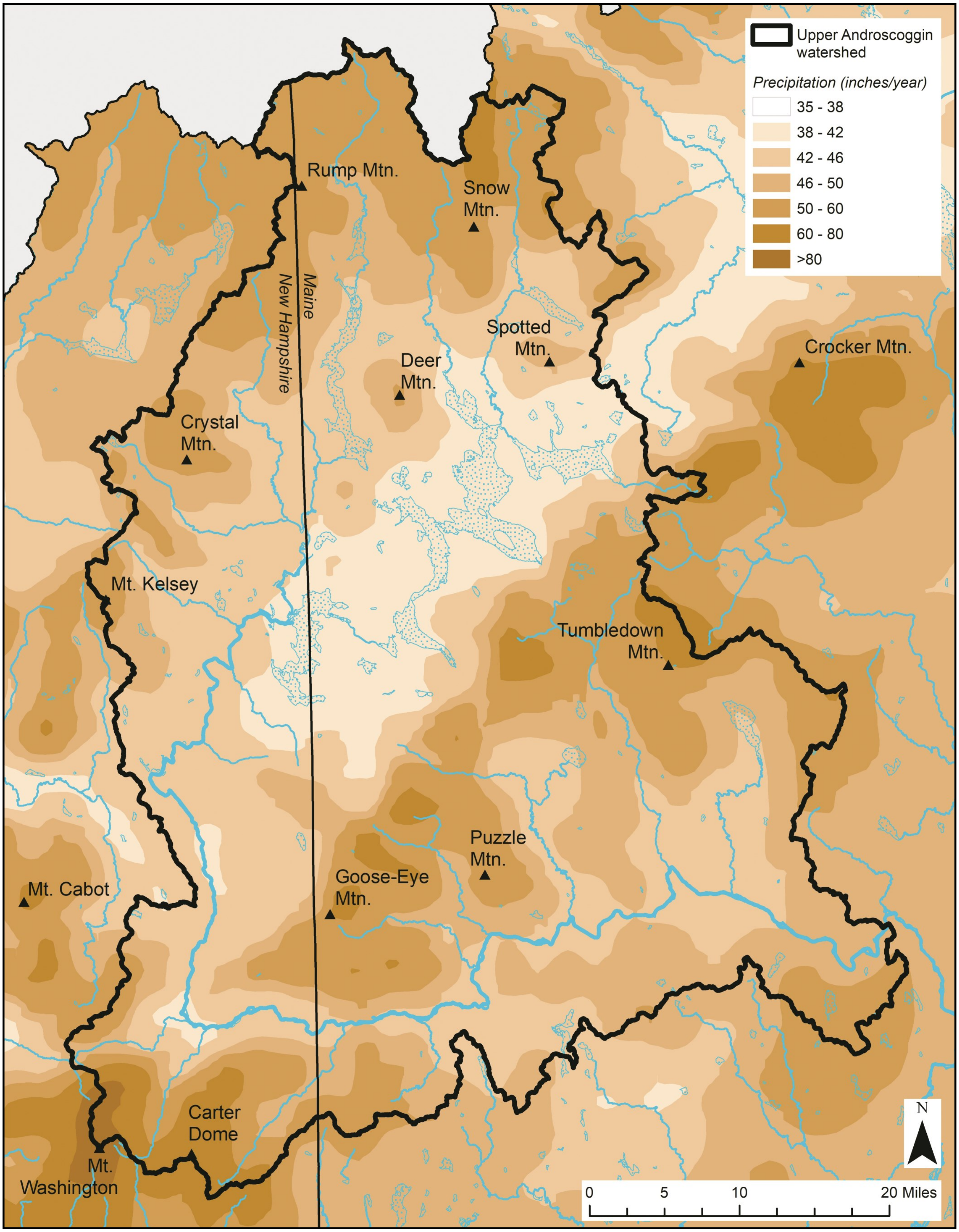
Earlier ice-out: Ice-out on Rangeley Lake has advanced 0.6 days per decade since 1880 but 2.1 days per decade since 1970.

Less snow: Average annual snowfall at Pinkham Notch, NH has declined by 56 inches (31%) since 1930 and the end of the snowpack is occurring 14 days earlier.

Future climate

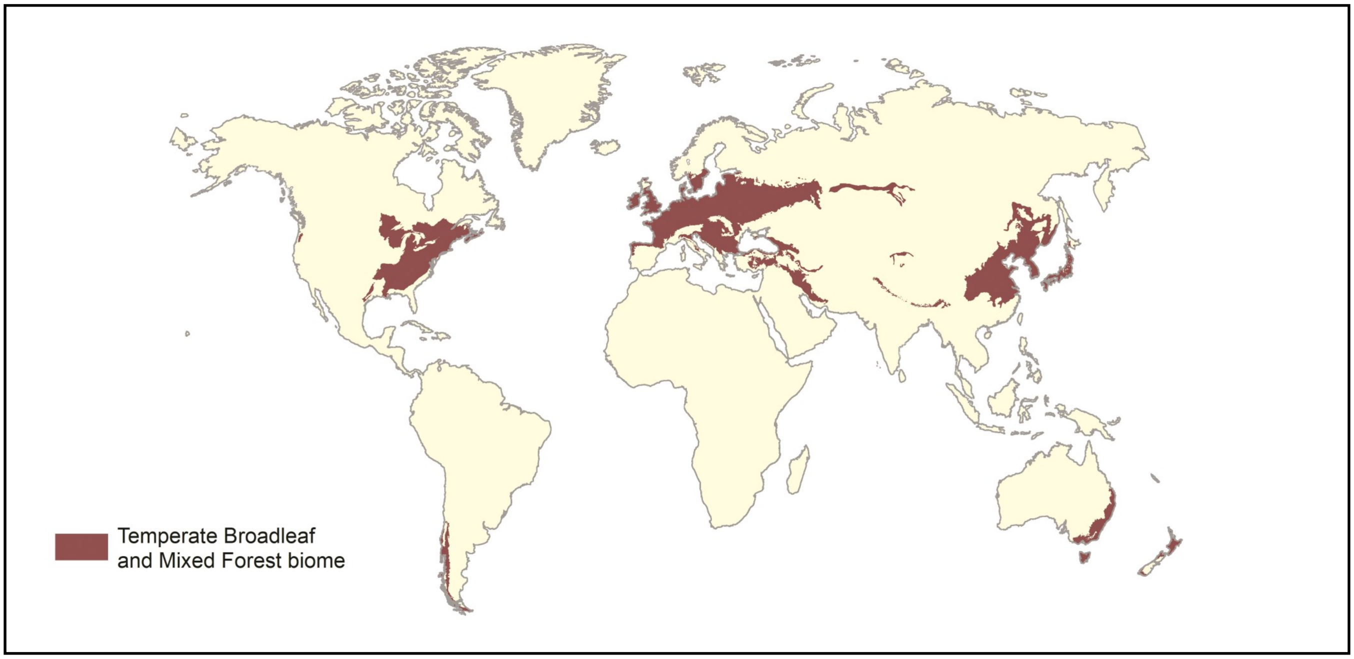
The climate change trends observed in recent decades are expected to continue and to accelerate through the 21st century. The intensity of these changes will depend on the degree to which future increases in atmospheric greenhouse gases are limited. Expected changes include:

- An increase in annual average temperature of 2 to 3 °F by 2050, with the greatest increase in winter.
- The warm season will increase by another two weeks.
- Longer and more intense heat waves.
- Increased precipitation, with more summer rain and less snow and more rain in the winter.
- Earlier spring run-off.
- More extreme storm events.



Map 25 — Modeled precipitation
This map does not show actual precipitation (which is recorded only at a few points in the watershed) but rather modeled data that uses elevation, topography and weather patterns to predict the precipitation at any point.

— Ecological Land Classification —



Map 26 — Temperate Broadleaf and Mixed Forest biome (Data courtesy of World Wildlife Fund)

"Ecological land classification" refers to the process of dividing landscapes into different regions based on similarities in dominant vegetation, climate, topography, geology, soils, and other factors. These systems are an important tool that allow ecologists and land managers to understand landscape patterns. They show what is unique about a particular region and what characteristics are shared with other areas. They help predict how different regions may respond to human management and natural disturbances as well as larger stresses such as climate change. They also allow us to understand whether networks of conservation lands include all the different types of landscapes in a particular region—an important step in ensuring that all aspects of biological diversity are conserved.

At the global level the landscape is often divided into "biomes"—areas of similar vegetation types ("physiognomy") determined by broad climatic patterns such as forest, grassland, desert, tundra, etc. In one such scheme, recently developed by the World Wildlife Fund, the upper Androscoggin River watershed is part of the *Temperate Broadleaf and Mixed Forest Biome* (Map 26). These are regions of deciduous and mixed deciduous/evergreen forests in the mid-latitudes of the northern and southern hemispheres characterized by abundant moisture throughout the year and pronounced seasonal variation of temperature but not precipitation (i.e. summer and winter but no true dry season).

Over the years many different systems have been developed for classifying landscapes at scales ranging from global to local. Many are based on dominant vegetation, though they differ in whether they reflect current vegetation (such as the Land Use/ Land Cover data discussed in the next chapter) or potential vegetation (what would exist in the absence of human disturbance). Some earlier systems and how they classified the upper Androscoggin region include:

E. Lucy Braun, *Deciduous Forests of Eastern North America* (1950): Hemlock-White Pine-Northern Hardwoods Forest.

A.W. Kuchler, *Potential natural vegetation of the conterminous United States* (1964): Northern Hardwoods, Northern Hardwoods/Spruce and Northeastern Spruce-Fir.

Society of American Foresters, *Forest Cover Types of the United States and Canada* (1980): Maple-Beech-Birch and Spruce-fir.

However, other systems, often described as the "ecoregion" approach, differ from purely vegetation-based classifications by integrating multiple characteristics of a landscape into the classification, rather than being focused on only one aspect such as soil or vegetation. This approach focuses more on the underlying physical characteristics of the landscape, using these to predict vegetation patterns, rather than having vegetation be the basis for the classification.

Ecoregions

Ecoregional systems are hierarchical classifications that divide landscapes into a nested series of classes. At the upper levels climate and vegetation form are the most important factors, while at lower levels differences in topography, geology, soils hydrology and other factors become more important.

One widely used scheme, used in the 2003 edition of this Atlas, was originally developed by Robert Bailey of the US Forest Service (and is sometimes referred to as "Bailey's ecoregions"). Originally developed in 1976 for the United States, it was extended in the 1980s to encompass North America and later the entire world. The upper Androscoggin River watershed is classified as follows in this system:

Domain: Humid Temperate Domain, encompassing the United States east of the 100th meridian.

Division: Warm Continental Mountains Division, encompassing northeastern mountains from the Catskills and Adirondacks to western Maine.

Province: Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province (same extent as Division level).

Section: White Mountains Section, extending from the White Mountains and northeastern Vermont to northwestern Maine.

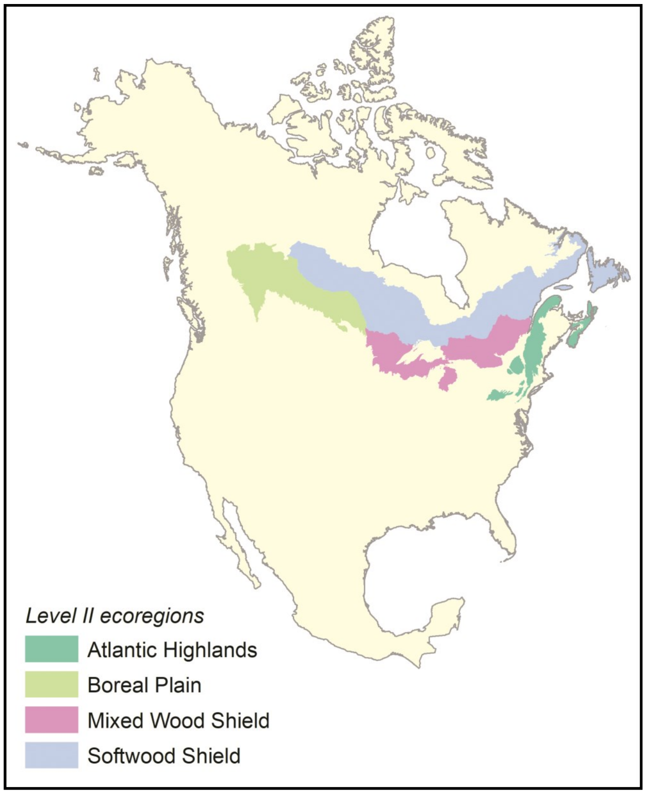
Subsections: White Mountains, Mahoosuc-Rangeley Lakes, Connecticut Lakes and Western Maine Foothills.

More recently the ecoregion approach has been refined by the US Environmental Protection Agency working with a coalition of agencies and organizations across North America. Their system is similar in many ways to the USFS system, but uses different criteria for classification at the various levels (including geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology), resulting in somewhat different spatial delineation of ecoregions.

This system, which is used here, has 4 levels:

Level I. At this level the upper Androscoggin watershed is part of the Northern Forest ecoregion, encompassing boreal forests of Canada west to Saskatchewan and extending east across central Canada and the Great Lakes to the Canadian Maritimes and the United States south to Pennsylvania (Map 27). It is one of 15 Level I ecoregions in North America.

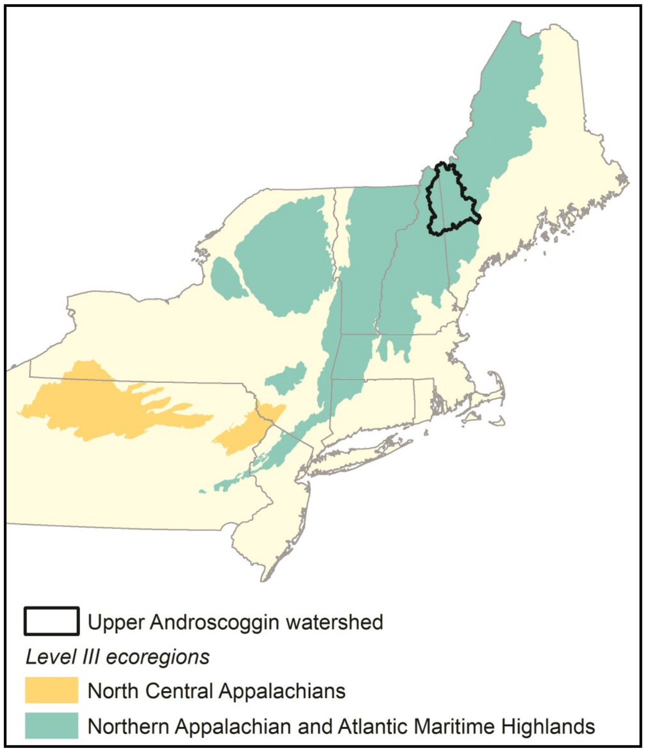
The area is characterized by a continental climate with long cold winters, short warm summers and sufficient precipitation to support forest vegetation. Soils are generally coarse-textured, acidic, nutrient-poor and derived from glacial deposits. Forests are dominated by northern species such as spruce, fir, pine, white birch and aspen. In the southern and eastern parts of the region these are mixed with northern hardwood species. Characteristic wildlife includes moose, white-tailed deer, marten, fisher, lynx, bobcat and snowshoe hare.



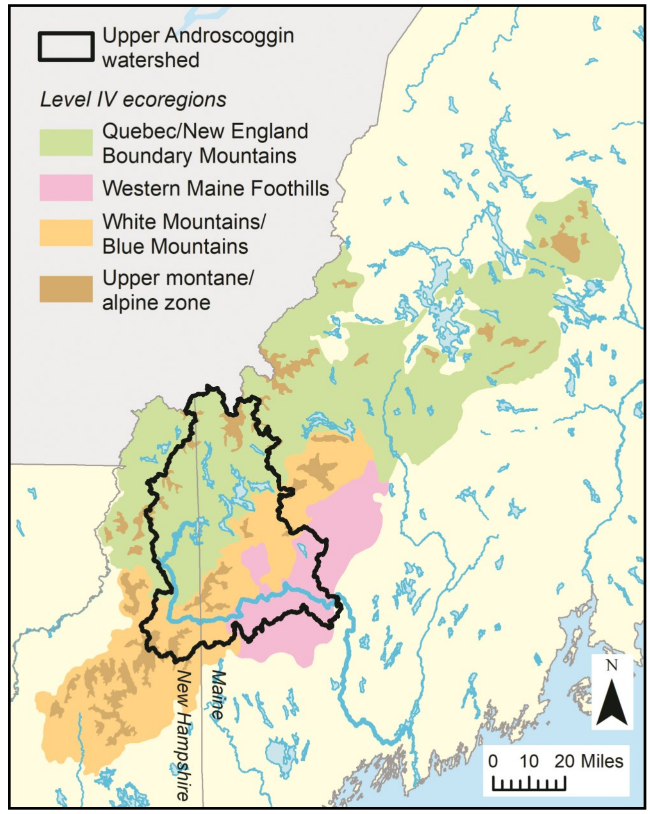
Map 27 — Level II ecoregions within the Level I Northern Forests ecoregion

Level II. Within the Northern Forests the upper Androscoggin watershed is part of the Level II Atlantic Highlands ecoregion (Map 27). This region extends from the Alleghany Plateau to the Gaspe Peninsula and Nova Scotia and includes the mountainous regions of the northeastern United States. In contrast to the broader Northern Forest region, the Atlantic Highlands have a more moderate climate due to the maritime influence (see box page 25). The forests of this region have a greater proportion of deciduous northern hardwoods such as red and sugar maple, yellow birch and beech.

Level III. The upper Androscoggin watershed lies within the Level III Northern Appalachian and Atlantic Maritime Highlands ecoregion (Map 28). This region encompasses the mountainous regions of New England, New York and maritime Canada. The climate is humid with snowy winters and precipitation well-distributed throughout the year. The terrain is rugged with old mountain ranges worn down by multiple glacial episodes. Forests are transitional between the evergreen boreal forests to the north and deciduous hardwood forests to the south. Northern swamps and bogs are common, as are numerous lakes and high-gradient perennial streams. Because of the rugged topography and generally poor soils, conversion of forests to agricultural use as well as the level of human settlement and development has been more limited than in surrounding regions.



Map 28 — Level III ecoregions within the Level II Atlantic Highlands ecoregion



Map 29 — Level IV ecoregions within the upper Androscoggin watershed

Level IV. The upper Androscoggin watershed encompasses parts of four Level IV ecoregions (Map 29):

Quebec/New England Boundary Mountains: Extending from Coos County to Mount Katahdin, this area has generally lower and mostly forested mountains, more lakes and swamps, more boreal vegetation, and better soils than the White Mountains region to the south.

White Mountains/Blue Mountains: Encompassing the White Mountains, Mahoosucs and the Saddleback/Sugarloaf/Bigelow region, it is one of the most rugged regions in eastern North America with generally higher elevations, steeper topography, more exposed bedrock, more acidic soils and more transitional (less boreal) vegetation than the Boundary Mountains.

Western Maine Foothills: This is a hilly region that is transitional between the mountains and gentler topography to the southeast.

Upper Montane/Alpine Zone: Generally including areas above 2500 feet in elevation, this is a zone of thin acidic soils and harsh climate supporting montane spruce-fir and subalpine fir forests as well as the only true alpine vegetation in the eastern United States. Deciduous species other than birch and mountain-ash are generally absent. It provides habitat for the endemic Bicknell's thrush—one of the rarest migratory songbirds in the country.

Finer-scale classifications

Other systems that show landscape distinctions at finer scales have also been developed to inform land management and conservation planning.

The US Forest Service's *National Hierarchical Framework of Ecological Units* utilizes Bailey's ecoregions at the higher level. Lower levels (scales from thousands down to tens of acres) are based primarily on soils, geology, topography and characteristic vegetation and include *land type association*, *land type*, and *land type phase*. These were developed primarily to assist with National Forest planning; within the upper Androscoggin watershed they have only been mapped on the White Mountain National Forest.

The Nature Conservancy's *Ecological Land Units* (ELUs) are a composite of several layers of abiotic information (elevation, bedrock geology, deep glacial sediments that mask bedrock's geochemical effects, moisture availability, and landform) mapped at a resolution of 30 meters (~0.22 acres). The ELU dataset describes the "ecological potential" of the landscape, not actual land use or land cover in a region where human alterations have almost everywhere affected the natural vegetation. ELUs can be considered nature's "stage", with vegetation and wildlife serving as the actors. The multiple factors create almost 600 possible combinations in the northern Appalachians, with more than half found in the Upper Androscoggin watershed. This dataset is a regional conservation planning tool to ensure that all parts of the physical landscape are represented in conservation lands. For example, in the Upper Androscoggin watershed some of the least common ELUs (such as calcium rich or ultramafic bedrock and lands above 4,000 feet) support numerous rare plants.

— Land Use / Land Cover —

"Land Use/Land Cover" refers to classifications that reflect the current condition of the landscape, including not only natural vegetation but also human uses such as agriculture and development. This is in contrast to the classifications described in the previous chapter, which reflect relatively unchanging characteristics of the landscape.

The most widely used land cover data is the National Land Cover Dataset (NLCD) developed by the US Geological Survey and other federal agencies. It is primarily derived from the classification of satellite imagery. Originally mapped in 1992, it was updated in 2001, 2006 and 2011 and will be updated every five years in the future. This periodic data not only provides a description of the current landscape but how it is changing over time.

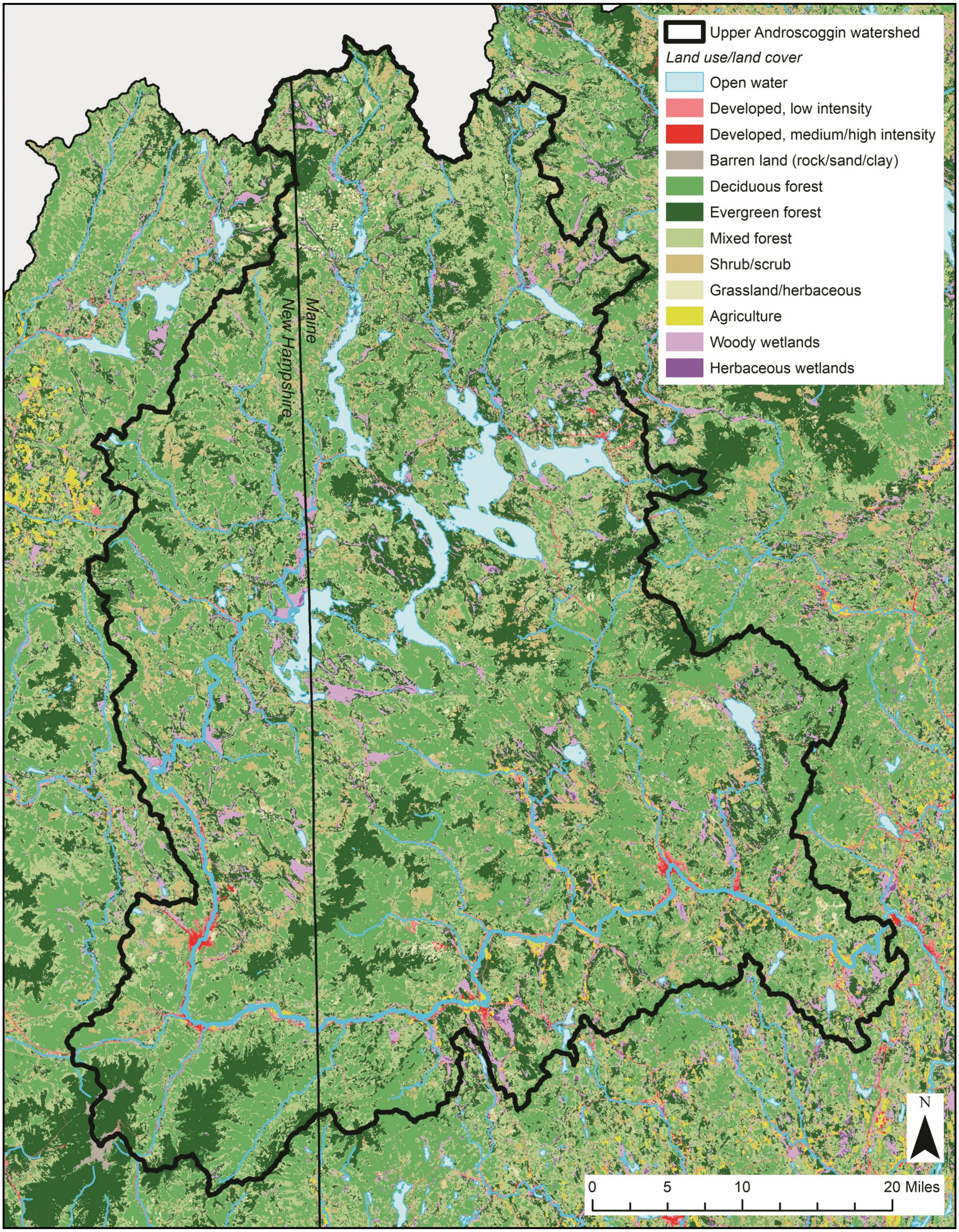
The 2011 data (Map 30, Table 4) shows that the upper Androscoggin River watershed is a dominantly forested area, with about 80% of the watershed classified as forest and only 2% classified as developed. (This underestimates forest cover, as much of the "Shrub/scrub" and "Grassland/Herbaceous" classes are recent heavy timber harvests that will regenerate to forest.) The distinction between northern and southern New England is evident, with significantly higher forest cover and lower levels of development in Maine, New Hampshire and Vermont. However, even within rural northern New England the upper Androscoggin watershed stands out for its low level of development (particularly more intensive development) and agriculture. Even compared to just Coos and Oxford counties the watershed has lower levels of agriculture and development. Significant development is limited to the Berlin/Gorham, Bethel and Rumford/Dixfield areas along the Androscoggin River. The largest town outside of the river corridor is Rangeley, Maine.

Between 2001 and 2011 the significant loss of forest and increase in developed area in southern New England is evident, with less pronounced changes in northern New England. However, the upper Androscoggin watershed saw very low levels of forest loss and development.

Table 4 — Distribution of National Land Cover Dataset land use/land cover classes (2011)

	Upper Andro	Coos/ Oxford	ME	NH	VT	MA	RI	CT
Forest								
Deciduous	30.6%	30.0%	17.0%	26.9%	37.7%	31.7%	37.2%	48.1%
Mixed	26.2%	29.2%	29.1%	27.0%	19.3%	7.8%	2.7%	3.4%
Evergreen	22.8%	20.4%	20.9%	20.5%	13.1%	10.5%	4.5%	3.1%
Total Forest	**79.6%**	**79.6%**	**66.9%**	**74.4%**	**70.1%**	**50.0%**	**44.4%**	**54.6%**
Other								
Shrub/Scrub	6.8%	5.4%	7.4%	3.2%	2.0%	1.3%	0.8%	1.3%
Grassland/Herbaceous	1.3%	1.0%	1.1%	0.6%	0.4%	0.9%	1.7%	0.5%
Barren Land	0.4%	0.4%	0.5%	0.4%	0.2%	0.9%	1.0%	0.3%
Wetlands	5.0%	5.7%	12.1%	6.4%	4.7%	12.1%	13.5%	9.0%
Open Water	4.0%	2.9%	4.8%	3.2%	3.9%	3.8%	4.2%	2.6%
Total Other	**17.6%**	**15.4%**	**25.8%**	**13.9%**	**11.1%**	**19.0%**	**21.2%**	**13.7%**
Agriculture	**0.7%**	**2.1%**	**3.7%**	**3.8%**	**13.3%**	**5.8%**	**4.9%**	**7.2%**
Developed								
Low Intensity	1.8%	2.6%	3.0%	6.3%	4.6%	16.2%	15.3%	18.2%
Medium/high Intensity	0.3%	0.3%	0.5%	1.6%	0.8%	8.9%	14.2%	6.2%
Total Developed	**2.0%**	**2.9%**	**3.5%**	**7.9%**	**5.5%**	**25.1%**	**29.5%**	**24.4%**
Percent change 2001 - 2011								
Forest*	-0.02%	-0.02%	-0.06%	-0.38%	-0.05%	-1.68%	-1.65%	-1.17%
Developed**	+0.01%	+0.02%	+0.06%	+0.41%	+0.07%	+1.49%	+1.21%	+1.07%

*Net change from Forest to Developed/Agriculture classes. **Net change in Developed classes.



Map 30 — Land use / land cover (2011)

— Forests —

Along with the mountainous topography, extensive forests are perhaps the most prominent characteristic of the upper Androscoggin landscape. These forests are the ecological, economic and cultural lifeblood of the region. Though timber harvesting has changed the structure and composition of these forests, areas converted to other uses (such as pastures and towns) occupy but a few percent of the area (see previous chapter).

The best source of information on the forests of the region is the US Forest Service's Forest Inventory and Analysis (FIA) program. Permanent plots across the nation are regularly remeasured, allowing an understanding of forest composition, volume, growth and harvest levels and how these change over time. Because this information is only available down to the county level, the information presented here is for the entirety of Coos County, N.H. and Oxford County, Maine.

At least 33 different species of trees occur in the upper Androscoggin watershed (Appendix B). However, FIA data show that just five species—red spruce, balsam fir, sugar and red maple, and yellow birch—comprise almost 60% of the timber volume in the two counties (Table 5). Four other species - white pine, hemlock, beech and paper birch – comprise another 28% of the volume. The many minor species, though making up a small part of the total volume, make an important contribution to the overall diversity of the region's forests.

Based on FIA data these two counties are about 90% forested, with northern hardwoods (beech-birch-maple) and spruce-fir types the most dominant (Table 6). Since the mid-1990s forest cover has declined by about 0.4% [1] and there has been a modest shift from softwood to hardwood types due to timber harvesting and natural succession.

These types differ from the more general NLCD classes described in the previous chapter, but together they present a picture of the forests of the upper Androscoggin watershed.

Northern hardwood (or beech-birch-maple) forests: Forests dominated by a combination of sugar maple, beech and yellow birch. Paper birch, red maple and ash are also common, and red oak may be present on warmer drier sites such as south-facing slopes. Softwoods (hemlock, white pine or red spruce, but less commonly balsam fir) may be present as a minor component. Northern hardwood forests are generally found on lower or middle slopes on better soils.

***Spruce-fir forests*:** Forests dominated by a combination of red spruce and balsam fir. They are found on sites that are too cold, dry, wet or infertile to support extensive growth of hardwood species. They are dominant on upper mountain slopes where they include yellow and heartleaf paper birch and mountain-ash. At middle elevations they are primarily found on rocky knobs and ridges with thin dry soils. In valley bottoms they are found on a variety of coarse-textured, nutrient-poor, acidic, cold or wet soils. Other softwoods (including white pine, hemlock, tamarack, northern whitecedar and white spruce) may be present depending on the site. Associated hardwood species include yellow and white birch and red maple, with sugar maple and beech being much less common.

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[1] This rate of loss is somewhat higher than given by NLCD data (Table 4 previous chapter) due to the longer time period and differences in methods.

Table 5 — Volume of live trees, Coos and Oxford counties

Species	Percent
Softwoods	
Red spruce	11%
Balsam fir	10%
White pine	9%
Hemlock	8%
White spruce	1%
Northern whitecedar	1%
Other softwoods	1%
Total softwoods	**41%**

Species	Percent
Hardwoods	
Sugar maple	15%
Yellow birch	12%
Red maple	11%
Paper birch	6%
Beech	5%
Red oak	4%
White ash	2%
Quaking aspen	2%
Bigtooth aspen	1%
Other hardwoods	1%
Total hardwoods	**59%**

Table 6 — Forest cover types, Coos and Oxford counties

FIA forest type	Current (%)	Mid-1990s (%)
Maple-beech-birch	63%	55%
Aspen-birch	9%	11%
Oak-pine	5%	4%
Other hardwoods	2%	1%
Spruce-fir	17%	21%
White/red pine	5%	8%

Northern hardwood forest

Montane spruce-fir forest

Early successional birch-aspen forest

Mixed hardwood-softwood forests: [2] This is a very broad type and includes various combinations of species depending on the site. Common combinations are spruce-fir forest with a significant amount of yellow birch or red maple and northern hardwood forests mixed with spruce, fir, hemlock or white pine. They are generally found on middle and lower slopes on soils that are intermediate between the better hardwood-dominated soils and the poorer softwood-dominated soils.

Oak-pine forests are a dominant mixed type south of the upper Androscoggin watershed but are less common within it. They are found primarily on sandy alluvial soils along larger rivers.

Aspen-birch: This early successional type is inherently temporary (see Disturbance, succession and old growth below). Any of the three broad groups above may become dominated by white birch or aspen following a large disturbance such as a clear-cut or severe fire. However, these species are shade-intolerant and relatively short-lived, and they will eventually be replaced by the longer-lived and more shade-tolerant species characteristic of a particular site.

The current composition of the region's forests is strongly influenced by natural factors such as climate, soils and topography. However, almost every acre of the watershed's forests has been affected by multiple cycles of timber harvesting over the past 150 years (See Timber Harvesting, page 65). For much of this period harvesting has selectively favored the removal of softwood trees, especially spruce and pine. This history, combined with the natural patterns of succession following disturbance, has converted many softwood stands to mixed stands and many mixed stands to hardwood stands. It is likely that early settlers encountered a forest with more spruce, pine and hemlock, and less maple, beech and aspen, than is found in today's forests. Today one can find many stands where the mature overstory is primarily hardwood trees, but spruce and fir are plentiful in the regenerating understory. In the absence of human manipulation, natural succession will increase the amount of softwood in the region's forests, though climate change may alter the previous natural successional pathways.

Disturbance, succession and old growth

The forests of our region are dynamic. While the broad patterns are determined by topography, soil and climate, the composition and structure of any

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[2] The NLCD (Map 30) considers "mixed forest" to be any forest where neither hardwoods nor softwoods have more than 75% canopy cover, whereas FIA splits these forests based on whether hardwoods or soft-woods are dominant.

Maine Spruce Budworm Task Force

Spruce budworm mortality

individual area is constantly changing in response to natural and human disturbance and forest growth.

Disturbance is any impact on a forest that kills or damages trees and opens up growing space for other trees. The primary human disturbance in the upper Androscoggin watershed has been timber harvesting. Agricultural clearing and abandonment, while the major human disturbance farther south, has been limited to major river valleys in the upper Androscoggin watershed. The primary natural disturbance is weather—wind, ice and snow. Insects and disease also play a role, sometimes (as with spruce budworm) a significant one. Introduced insects and diseases (including emerald ash borer, Asian long-horned beetle, hemlock woolly adelgid and beech bark disease) have the potential to introduce novel species-specific disturbances. Though human-caused fires have had a major impact in some areas, large natural fires are very rare.

In general, the more severe a disturbance is, the less frequent it is. Storms that topple trees individually or in small groups are very common. Larger events, such as severe windstorms, ice storms (such as the one in January 1998) or insect epidemics, that create openings of many acres or result in partial canopy mortality across large areas, occur on average every few decades to a century or more. Very severe events that result in nearly complete mortality across large areas ("stand-replacing disturbances") such as hurricanes or large fires are very infrequent, occurring only every few centuries. In contrast, timber harvesting has followed a different pattern, creating disturbances that are much more frequent than natural disturbances of similar scale and intensity.

While the effects of disturbance are immediate and obvious, the growth of the forest leads to slower changes. However, anyone who observes a patch of forest for more than a few years can see the changes that are taking place. Existing trees get bigger, and new trees grow up in the spaces created by disturbance. The process of forest development over time is known as *succession*. While the process can be complex, one of the most important factors governing succession is the tolerance of different tree species to shade. While every species will grow best in full sunlight, they differ greatly in their ability to survive in the shade of other trees.

Some species, primarily white birch and aspen, are very *shade-intolerant*. They require full sunlight to grow and do not survive in shade. They are fast-growing, short-lived and produce large quantities of seeds that need to find newly-disturbed areas to become established. These are known as *early-successional* species, since they will dominate the early stages of forest development following a major disturbance. (They are sometimes called "fugitive" species.) Pin (or fire) cherry is an early-successional species with a different strategy—it drops large numbers of long-lived seeds that remain in the soil until a new large disturbance creates conditions favorable to germination. It is a fugitive in time rather than space.

At the other end of the scale are shade-tolerant species such as sugar maple, beech, red spruce and hemlock. They tend to be slower-growing but long-lived. These species can reproduce under dense canopies of mature trees and survive for long periods as understory trees. Balsam fir is also shade-tolerant (but less so than the other species), though it is short-lived. Red maple, oak and yellow birch are intermediate in shade tolerance. White pine is somewhat unique—relatively shade-intolerant but long-lived.

The development of forests will also be influenced by the type of disturbances that affect them, as well as the different ways trees reproduce. Disturbances that create small openings, or remove only parts of the overstory, will favor the regeneration of more shade-tolerant species, whereas disturbances

Small gap created by blowdown

that create large openings will promote regeneration of shade-intolerant species. Some species (such as white and yellow birch, white pine and aspen), need bare mineral soil to be exposed for their seeds to germinate. Red maple can sprout from live stumps and may grow vigorously following a timber harvest. Shade-tolerant species may establish dense understories of seedlings; if these seedlings survive the disturbance they may have enough of a head start to compete with faster-growing shade-intolerant species even in areas of full sunlight.

In the absence of major disturbance, succession will lead to the gradual replacement of less shade-tolerant and shorter-lived trees by more shade-tolerant, longer-lived species. Over a period of several centuries, a *late-successional* or old-growth forest will develop. In our region these forests are dominated by sugar maple, beech, yellow birch, hemlock, spruce and white pine, which can reach ages of 300-400 years and diameters of 3 to 5 feet. Less shade-tolerant species will be present in lesser quantities, growing in small openings created by small-scale disturbance or the death of older trees. These forests will tend to have complex multi-aged structures with trees of all sizes, as well as large accumulations of dead wood. Though detailed information on the pre-European settlement forest is scarce, it is likely that half or more of the region's forests would have been in this late-successional condition at the time of settlement.

Unlike earlier years, when old-growth forests were considered "biological deserts", they are now recognized as rich and vibrant ecosystems—perhaps the most biologically diverse part of the successional sequence. However, these forests have been almost totally eliminated from the eastern United States. Within the upper Androscoggin watershed, only a small number of remnant patches are known, most no more than a few tens of acres in size. Larger areas of high-elevation forest in the White Mountains may have escaped harvesting, but trees in these subalpine forests do not reach the age or size usually associated with old growth.

Restoring a component of old-growth forest to the region's landscape is one of the major goals of ecologists, and is a primary reason for establishing ecological reserves and other natural areas. While an early-successional forest can be created in a matter of days, restoring old-growth takes a couple of centuries.

Climate change

The expected future changes in the climate (see Climate, page 24) are likely to alter the composition, structure and successional pathways of the region's forests in significant ways. The projected increase in the frequency and intensity of severe storms may shift the forest towards a younger, more early-successional condition. However, the biggest change may be in which species are present in the region.

The US Forest Service's Climate Change Atlas models the projected changes in forest types and individual species by the end of the 21st century under two future greenhouse gas emission scenarios. The "low emissions" scenario envisions a significant reduction in future CO_2 emissions, while the "high emissions" scenario envisions little reduction in future emissions. Forest types and species distributions are correlated with current climate conditions and adjusted to match future conditions projected by three widely-used climate change models.[3]

The Climate Change Atlas shows that the upper Androscoggin watershed currently supports a mixture of northern hardwood and spruce-fir types. Under the low emissions scenario northern New England remains as northern hardwood forest, but spruce-fir forest has disappeared. Under the high emissions scenario northern Maine, New Hampshire and Vermont remains as northern hardwood but the southern parts of these states (up to the southern part of the upper Androscoggin watershed) would be more suitable to oak-hickory forest.

Table 7 — Projected changes in major species within the upper Androscoggin watershed

Species	Low emissions	High emissions
Red spruce	-	- -
Balsam fir	-	- -
White pine	+	++
Hemlock	+	+
White spruce	0	0
No. whitecedar	-	-
Sugar maple	0	0
Red maple	+	+
Beech	++	+
Paper birch	-	- -
Yellow birch	-	- -
White ash	+	++
Quaking aspen	-	+
Red oak	+	++

[3] It is important to recognize that the Climate Change Atlas does not project the actual future composition of the region's forests, but rather what forest types and species are most suited to the projected future climate. There will be a significant time lag in how forests adjust to climate change based on the ability of existing forests to maintain themselves in a changing climate and the time it takes individual species to adjust their ranges.

The Climate Change Atlas is a coarse-scale model that does not reflect local conditions at a finer scale. Though it projects the complete disappearance of conditions suitable for spruce-fir forest, it is possible that the higher elevations of northern New England will remain as refugia for this type. Paleoecological research in the White Mountains has shown that high-elevation coniferous forest remained stable during post-glacial climate fluctuations, even as the vegetation at lower elevations changed dramatically.

The Climate Change Atlas also projects major changes in the climate suitability for individual species (Table 7). As would be expected, species associated with more northerly forests (red spruce, balsam fir, northern whitecedar and paper and yellow birch) are projected to decline, while species associated with more southerly forests (white pine, hemlock and red oak) are projected to increase.

Conditions could also become suitable for other southerly species that are currently uncommon or absent within the watershed. Under the low emissions scenario these include black cherry, sweet (black) birch, and white and black oak. Under the high emissions scenario these also include scarlet and chestnut oak, eastern redcedar, yellow-poplar and several species of hickories. If greenhouse gasses continue to be emitted at their current rate, the forests of the upper Androscoggin watershed in the 22nd century may more closely resemble those of the central and southern Appalachian than the northern forest that has sustained the region for centuries.

Why are some trees evergreen?

One obvious feature of the region's forests is the mixture of evergreen trees (such as spruce, fir, pine and hemlock) and deciduous trees (such as maple, beech, birch and oak), often in the same small area. If an engineer were to design a "biological solar energy collector" (that is, a leaf), they would design something that looked like a maple leaf - thin and flat. They certainly wouldn't design something like a spruce needle. What is the value of evergreen needles, which seem so poorly designed for their major function of collecting sunlight?

These two growth forms represent different strategies that trees have evolved to deal with their environment. Deciduous leaves are more efficient at collecting solar energy - they have higher rates of photosynthesis per unit weight than evergreen needles. However, because they only live for a few months there is little reason for a tree to put energy or nutrients into making them tough. Thus they have a higher risk of being lost to late frosts, insects or drought. They are in essence a "junk bond" strategy - high returns when times are good, but with a high risk of poor return or total loss when times are bad.

Evergreen needles are more expensive for a tree to construct, since energy and nutrients have to go into features such as thick coatings, "antifreeze" chemicals to survive winters, and complex chemicals to ward off damage from insects or fungi. (It is these chemicals that give many evergreen needles their pungent smell.). However, these features, as well as their more compact shape, make them better able to withstand environmental stresses and ensure their survival for several years. They are a "savings bond" strategy - not flashy, with but more assurance of a steady return in both good and bad times.

Among the stresses that evergreen needles are able to deal with are:

Short growing seasons: Above a certain elevation (about 2700' in our area) or where cold air collects in valley bottoms, summer is too short for most deciduous trees to complete their annual cycle, and late frost presents a high risk of killing newly-emerging leaves. Evergreen needles are able to start photosynthesizing as soon as temperatures are warm enough and continue as late as conditions remain favorable.

Drought: The thick waxy surface of evergreen needles reduces the loss of moisture through the leaf surface. In addition, their compact and closely bunched shape maintains a layer of still air around leaf surfaces, thus reducing the drying effect of wind. This allows them to survive dry periods that would damage or kill deciduous leaves and resume photosynthesis when conditions improve.

Nutrient-poor soils: In more fertile soils, deciduous trees are able to absorb sufficient nutrients (such as nitrogen and calcium) to grow a new crop of leaves each year. However, if nutrients are scarce (as is the case in many of the acidic granitic soils of the region), a tree can maximize its growth by retaining foliage (and the nutrients used to grow it) for several years. This is analogous to the difference between a rich society (where resources are plentiful and possessions are thrown out and replaced on a regular basis) and a poor society (where resources are scarce and possessions are held onto and used for as long as possible because they are difficult to replace).

In combination, these factors lead to the dominance of deciduous trees on better sites - warmer lower slopes with moist fertile soils. While softwood species would also thrive on these sites, the greater productivity of deciduous trees allows them to outcompete the evergreen species. On poorer sites, evergreen species are able to survive conditions which deciduous species cannot, and they can take advantage of a longer growing season in colder areas. However, in many areas of temperate climate such as northern New England conditions are such that there is no distinct advantage for either evergreen or deciduous trees and the forest contains a mixture of both types.

— Natural Communities —

The New Hampshire Natural Heritage Bureau (NHNHB, the state agency responsible for maintaining information on the state's biodiversity) defines natural communities as "recurring assemblages of species found in particular physical environments." The equivalent agency in Maine, the Natural Areas Program (MNAP), defines them as "an assemblage of interacting plants and animals and their common environment, in which the effects of recent human intervention are minimal." Natural communities can range from common types that cover the majority of the landscape ("matrix" communities) to rare communities associated with uncommon conditions of topography, hydrology, bedrock or soil.

The classification of vegetation into "natural communities" is particularly relevant for the understanding and conservation of biological diversity. Understanding the nature and distribution of natural communities allows ecologists and land managers to communicate effectively and to make better decisions regarding the management of natural landscapes. It allows them to better understand what parts of a landscape are less common (and thus more important for conservation), and how different areas will respond to management actions. In addition, many rare plants or animals are associated with particular natural communities, allowing field surveys and conservation actions to be focused more efficiently.

The classification of natural communities differs from forest types in several important ways. It is more detailed and better captures the full variability of the natural environment. It includes consideration of the full range of vegetation and the associated physical environment, not just the most obvious characteristics of the dominant vegetation. Finally, it is not based on the current condition of the vegetation, but on the mature vegetation that would exist in an area in the absence of human manipulation. Classification of natural communities is based primarily on examination of areas that have remained relatively unaffected by human activity (such as remnant fragments of old-growth forest)—one reason the identification and protection of such areas is a high priority for ecologists.

Both NHNHB and MNAP have classified the natural communities in their states. The two systems are somewhat different; while many communities are described and classified similarly, the correspondence is not exact. Classifying natural communities involves dividing the complex patterns of the natural landscape into groups. Some communities are distinct and easily recognized, while others grade continuously into one another. Deciding where to draw the lines requires both extensive field work and human judgment, and there is no one right way to do it.

Maidenhair fern

Cove Forests

Cove forests (officially Maple-Basswood-Ash Forest in Maine and Rich Mesic Forests in New Hampshire) occur in the most fertile parts of the landscape. These forests are dominated by sugar maple with white ash a common associate. (Basswood is also characteristic of this community but is uncommon in the northern forest.) They are found in small concave pockets of lower slopes, draws and ravines where downslope movement of soil organic matter forms deep, fine-textured, moist, nutrient-rich, less acidic soils. They are most common where parent material contains higher levels of calcium but may even be found in areas of acidic granite.

Sugar maple and ash are found across the landscape, and if one looks only at the trees this community can easily be overlooked. What sets it apart is the understory vegetation. The moist fertile soils support many enriched site indicator and even rare plants, including maidenhair fern, Dutchman's breeches, red and white baneberry, blue cohosh, squirrel corn, ginseng, large yellow lady's-slipper and Goldie's fern (our largest fern, reaching a height of up to four feet).

While many uncommon forest communities are too dry, rocky or wet to support regular timber management, cove forests are very productive and well-suited to the growth of high quality timber. Very few examples of this community have been left untouched by harvesting. Because of its potential to support rare plants, both the Maine Natural Areas Program and the New Hampshire Natural Heritage Bureau have been working to educate forest landowners and managers about its importance. They will then be better able to identify cove forests and either reserve them from harvesting or manage them with a light touch that maintains mature tree cover and protects understory vegetation.

Maine's system recognizes 104 different natural communities (59 upland types and 45 wetland types). New Hampshire's system recognizes 197 communities (72 upland and 125 wetland). The larger number of communities in New Hampshire does not reflect a higher level of diversity in that state, but rather a different approach to classification. The same area that the Maine system may classify as a single broad community may be made up of several more narrowly-defined communities under the New Hampshire system.

The states also recognize natural community "systems", which are groups of communities that repeatedly occur together in the landscape. Maine recognizes 24 such systems and New Hampshire 45.

Communities (as well as plant and animal species) are assigned an "S-rank" indicating their rarity in the state (Appendix E). These range from 1 (critically imperiled) to 5 (demonstrably secure). Individual occurrences also receive an "element occurrence" (EO) rank that rates the quality of the occurrence based on size, condition and landscape context; these range from A (exemplary) to D (poor).

Mapping of natural communities across broad areas is rarely undertaken, both because of the large amount of fieldwork required, and because human alteration of many areas has made identification of the underlying natural community difficult if not impossible. Ecologists undertaking field surveys will generally focus on identifying and mapping only those communities that are rare or exemplary. The Natural Heritage programs maintain databases of documented better quality occurrences of rare communities (S1 through S3) and exemplary occurrences of more common communities (S4 and S5).

Of the 104 natural communities recognized by MNAP nearly two-thirds are known from or are likely to occur in northwestern Maine (Appendix C). Of NHNHB's 197 communities about half may be found in northern New Hampshire. Not all of these communities have been documented in Natural Heritage databases, either because of lack of surveys or because better quality occurrences do not exist.

Landowners and managers can make an important contribution to the conservation of biodiversity by learning to identify natural communities that may be present on their lands, reporting suspected good quality occurrences to the state Natural Heritage programs, and protecting any areas of unusual vegetation from significant disturbance.

Kettlehole bog systems

Kettlehole bogs are a classic type of acidic peatland found in cold northern climates. These bogs form in small depressions created when glacial sediments collected around detached blocks of melting glacial ice. These ponds are usually isolated without a connection to flowing water. The resulting bogs are saturated, extremely acidic and very nutrient poor ("oligotrophic"), with vegetation limited to species capable of surviving these challenging conditions.

Maine Natural Areas Program

Bog Moss Lawn

Over thousands of years these ponds have undergone a successional process that converts the pond into a peatland. In the early stages, a floating mat of vegetation, composed primarily of sphagnum, sedge, cotton-grass, low evergreen shrubs (bog rosemary and small cranberry) and carnivorous plants (pitcher plant and sundew), advances out over the edges of the pond. As this "floating bog" advances, decomposing organic matter (peat) collects in the pond, and dwarf evergreen shrubs (leatherleaf, sheep laurel, Labrador tea, rhodora and sweetgale) advance out on to the thicker parts of the mat. While in some cases open water may remain in the center of the bog, eventually the mat closes over the open water and the basin completely fills with peat. The peat may build up to the point where the vegetation growing on the surface is isolated from groundwater, with the primary source of nutrients coming from precipitation and the very slow decomposition of the peat (a "raised bog"). In the final stages the peatland will succeed to a forested bog with scattered stunted black spruce and larch.

Both Maine and New Hampshire classify kettlehole bogs as ecological systems. They are not a single community but a combination of several distinct communities in different parts of the bog. These may include (under the Maine classification) Bog Moss Lawn, Sheep Laurel Dwarf Shrub Bog, Leatherleaf Boggy Fen, Sweetgale Mixed Shrub Fen and Spruce – Larch Wooded Bog.

— Rare Plants —

Both Maine and New Hampshire contain about 1500 species of native vascular plants (trees, shrubs, herbs, grasses, ferns and clubmosses). Numbers are not exact; new species are occasionally found and changes in plant classification can combine or separate species. Because the two states have similar soils and climate most species will be found in both states. In addition, both states have hundreds of species that have been introduced to the region from other places, most of which occur in heavily disturbed areas but some of which have become naturalized in native habitats.

About one-quarter of the native plant species in each state are considered rare. The New Hampshire Natural Heritage Bureau (NHNHB) currently tracks 411 rare species, and the Maine Natural Areas Program (MNAP) 352. Three species in each state are also listed as federally threatened or endangered. Four species in New Hampshire but 22 in Maine are classified as potentially extirpated.

Species may be rare for a number of reasons. Some are naturally rare. They may be common in other areas but be at the edge of their geographical range in northern New England, or occupy extreme or limited habitats. Some species are rare because they occupy a geographically limited area (such as alpine zones), but within that area they may be relatively abundant. Others may be at risk because their essential habitat has been altered, reduced or degraded by human activities (such as those found along the banks and floodplains of large rivers, many of which have been dammed or developed). Others have been reduced through commercial or scientific collecting (such as ginseng and some orchids).

Both NHNHB and MNAP maintain databases of known locations of rare plants. A total of 129 plant species considered rare in either Maine or New Hampshire have been recorded from the upper Androscoggin watershed, 84 in New Hampshire and 63 in Maine (Appendix D), representing about 20% of the rare species in each state. About two-thirds of the species in New Hampshire and more than half in Maine have been confirmed to be present within the last 20 years. In contrast, 10 species in New Hampshire and 16 in Maine have not been confirmed since the 1940s.

The most species-rich habitat for rare plants in the upper Androscoggin watershed is alpine areas. More than one-third of the rare species in the watershed are alpine species; nearly all are found in the Presidential Range with a smaller number in the Mahoosucs. Enriched (calcareous) habitats (ranging from rich forests to cliffs and ledges to fens and marshes) are the next most common habitats, followed by a variety of wetlands and shorelines and dry ledges, cliffs and woodlands. Very few rare plants are found in common matrix forests habitats.


Maine Natural Areas Program

American ginseng (*Panax quinquefolius*), cove forest


Maine Natural Areas Program

Alpine blueberry (*Vaccinium boreale*), alpine zone

Knowledge of the distribution of rare plants is very incomplete. Some areas (such as alpine zones) have been extensively surveyed; the presence of the Presidential Range alpine zone is entirely responsible for the larger number of rare species in the New Hampshire portion of the watershed. Much more information is available for public lands than for private lands. However, large areas have never been thoroughly searched. Additional surveys may find additional rare plant occurrences but also indicate that some species are more common than previously believed.

Though state laws create no obligations on private landowners or managers to identify or protect rare plants, their willing cooperation has been and will continue to be a very important factor in understanding and maintaining the region's botanical diversity.

— Subalpine and Alpine Ecosystems —

Spruce-fir and subalpine forest ecosystems. Found at elevations above 2700 feet are high-elevation spruce-fir forests (red spruce and balsam fir), which transition to subalpine forests (balsam fir – heart-leaved paper birch), and yet higher in more exposed habitats to "krummholz"—horizontally growing thickets primarily of balsam fir and black spruce less than 8 feet in height. Krummholz forms the ecotone boundary with and can be found as islands within alpine ecosystems.

These forest ecosystems are a limited yet critical component of the northeastern landscape, recognized in Maine and New Hampshire's state and regional wildlife conservation plans. They represent some of the most natural and least impacted parts of the northeast where a long history of human use has occurred. They occupy only 4 percent of the area in New Hampshire and 0.7 percent in Maine. Most of these "forests in the clouds" are disjunct and less than 500 acres in size. On a mountain, similar to a cone, as the elevation increases the surface area above that elevation decreases. The larger units in the upper Androscoggin River watershed include a portion of the Presidential Range; the Mahoosucs; Old Blue, Elephant and Bemis mountains; and ridges in the upper Cupsuptic and Kennebago watershed extending north from Burnt to White Cap Mountain and East Kennabago to Snow Mountain. Smaller, more isolated pockets of these forests above 2700 feet elevation occur in the Swift and Dead Diamond rivers watersheds (Crystal Mountain), and in the upper Magalloway watershed (including Deer, Azisochos, Bosebuck, Magalloway and Rump mountains).

These "forests in the clouds" provide the primary habitat for Bicknell's thrush, the northeast's rarest migratory songbird and a species of highest conservation concern, as well as numerous other species of conservation concern like blackpoll warbler, spruce grouse, boreal chickadee, white-winged crossbill, three-toed woodpecker, purple finch, olive-sided flycatcher, bay-breasted warbler, northern bog lemming, American (pine) marten and Canada lynx.

Paleobotainical studies using plant parts found in lake sediment layers going back to the last glacial period show that the ecotones between the subalpine spruce-fir and fir forest, and the fir forest and alpine zone, have not changed altitude much over the last 10,000 years, including during the Hypsithermal Warming Period five to nine thousand years ago. During the Hypsithermal Warming period, today's commercially important low elevation spruce-fir forest mostly disappeared, surviving in refugia in the cooler, wetter higher elevations, and along the eastern coast of Maine. As the climate cooled some two thousand years ago, the spruce-fir-forest advanced back into the lower elevations. The lowland forest changes in response to past climatic events had minimal impact on the region's high elevation spruce-fir and subalpine forest and alpine zone. With ongoing rapid climate warming the mountains' role as refugia for spruce-fir forest may be needed again, a reason they should be protected.

Regionally, the overall level of conservation of forests above 2700 feet elevation from development is very high. However timber harvesting above 2700 feet elevation is legal in Maine and New Hampshire, including on conservation easement lands, and occurs on private forest lands in the upper Androscoggin River watershed. Because of the strong wind resources in the high elevation forests, the push for renewable energy, and recent technological advances, industrial scale wind farms are now being prospected or developed in some of these mountain forests, e.g. Mount Kelsey and Dixville Peak west of Errol, N.H. Wind farm access roads and turbine pads permanently remove and fragment these high elevation forests and impact their special biota.

An interesting phenomenon found only on a handful of mountains in New England, Newfoundland, and Japan known as "fir waves" occurs in this watershed's subalpine forest. Balsam fir dominate the upper elevation subalpine forest, but unlike red spruce, it is a relatively shorter lived species—typically in the century range. Fir waves have a distinct mortality-regeneration pattern—dead trees occur in a network of undulating rows, separated by patches of living trees which have predictable variations in age and height. Wind is behind this dynamic process. When a tree falls, it no longer protects its downwind neighbors from damaging winds. These newly exposed balsam fir now bear the brunt of the weather and quickly succumb, exposing yet another cohort of trees to damage. This mortality wave advances through the forest about 3-6 feet per year depending on prevailing wind forces, follows the direction of the prevailing winds, and is trailed by a wave of understory regeneration of new balsam fir.

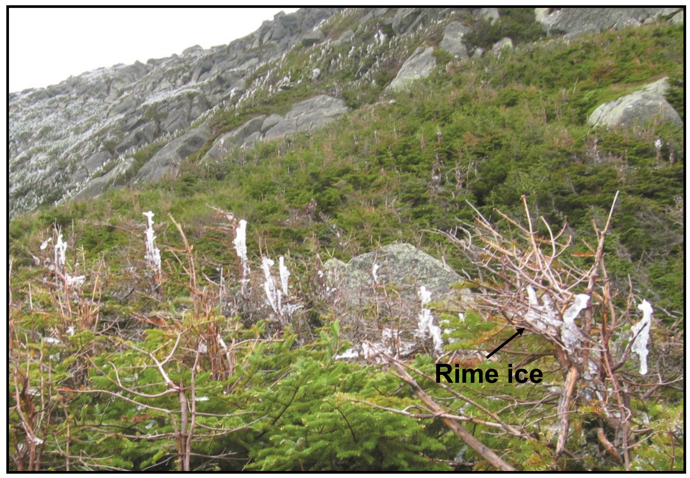
Alpine ecosystems. The upper Androscoggin watershed contains one of the rarest and most unique ecosystems in the eastern United States—the alpine zone. Found at the upper elevations of the region's highest mountains (generally above 4000 ft), alpine plants are adapted to the challenges of shorter growing seasons, thin soils, and frequent winter exposure to freezing clouds, heavy icing, and the sandpapering effect of blowing snow. The zone harbors a number of plant species common in arctic areas a thousand miles north. Today northeastern alpine ecosystems are biogeographic islands in a sea of forest. This remnant arctic-tundra vegetation once blanketed the region after the last glacier receded 10-12,000 years ago.

Today about 13 square miles of true alpine area remains in the entire eastern United States. The largest units (about 4.5 square miles) exist in the Presidential Range, New Hampshire, with another 2.9 square miles on Mount Katahdin, Maine. Forty percent of the Presidential Range alpine is in the Androscoggin River watershed. Small pockets and narrow linear bands of alpine exist on other high peaks from northern Maine to the Adirondacks.

The Mahoosuc Range in the upper Androscoggin watershed, though most barely above 3500 feet elevation and well below climatic treeline, is dominated by a distinctive heath community that contrasts with other northeastern subalpine/alpine ridge ericaceous (heath family) shrub communities dominated by bog Labrador tea (*Rhododendron groenlandicum*) and blueberries (*Vaccinium spp*.). Instead the 'flat' subalpine ridgeline found in the Mahoouscs hosts extensive concave and poorly drained areas dominated by sheep laurel (*Kalmia angustifolia*) shrublands and *Sphagnum*-heath bogs which are compositionally similar to lowland raised bogs in Quebec and eastern Maine. The peat that accumulates in these nutrient poor depressions can remain frozen well into the summer.

Northeastern alpine communities are characterized by low-growing, long-lived perennial plants that have evolved adaptations to harsh conditions. The alpine habitat is a mix of very exposed areas and microhabitats protected from the frequent strong winds. These different microhabitats host plants specialized best to survive in them. Locations behind the shelter of boulders or in small depressions favor shrubby species. More exposed ridges, where the snow blows off and frequent freeze thaw cycles churn the soil, favor low mats of cushion-tussock communities. Many alpine plants have small tough leaves and compact growth forms that allow them to withstand the affects of high winds, blowing snow and low winter temperatures in the absence of insulating deep snow cover. Other alpine plants (e.g. black spruce, Labrador tea, sheep laurel and rhodora) are also found in acidic bogs at low elevations—similar cold and nutrient poor environments.

Species of lower elevations can potentially migrate north or upslope as the climate warms. However, the region's alpine zones reside at atypically low elevations for their latitude and lack available higher elevation habitat. In fact low temperatures and shorter growing seasons are not the primary factors in determining the region's treeline and alpine zone; small balsam fir trees grow on the summit of Mount Washington in very protected microhabitats. If temperature were the only factor, the alpine zone would be overtaken by subalpine forest. Originally thought to be particularly sensitive to the effects of a warming climate, these alpine areas survived the postglacial, Hypsithermal Warming Period (see Climate chapter, page 24). More important are the frequent incidences of clouds, high winds and rime icing events, and the abrasive affect of blowing snow that can kill any parts of trees extending above the protective winter snow cover or protective microtopography.



The predicted rate and magnitude of ongoing climate change exceeds the warm temperatures that these alpine plant communities survived thousands of years ago, making future predictions on the fate of the alpine zone challenging. If a warming climate leads to wetter winters and greater icing frequency, the timber (forest) line could recede downslope, but possibly with further loss of the remnant arctic-tundra origin flora in the alpine zone (Appendix D).

To establish baseline information on the current distribution of alpine communities the Appalachian Mountain Club has mapped the major alpine communities in New Hampshire and Maine. These data allow future ecologists to monitor changes in forest line and distribution of alpine plant communities. The mapping distinguishes seven alpine plant communities in the Presidential Range (Map 31) that generally correspond to rare natural plant communities delineated by the Maine Natural Areas Program and New Hampshire Natural Heritage Inventory (Appendices C and D). The dominant plant community is shown, though patches of different plant assemblages determined by microtopography and too small to map at this scale exist within them.

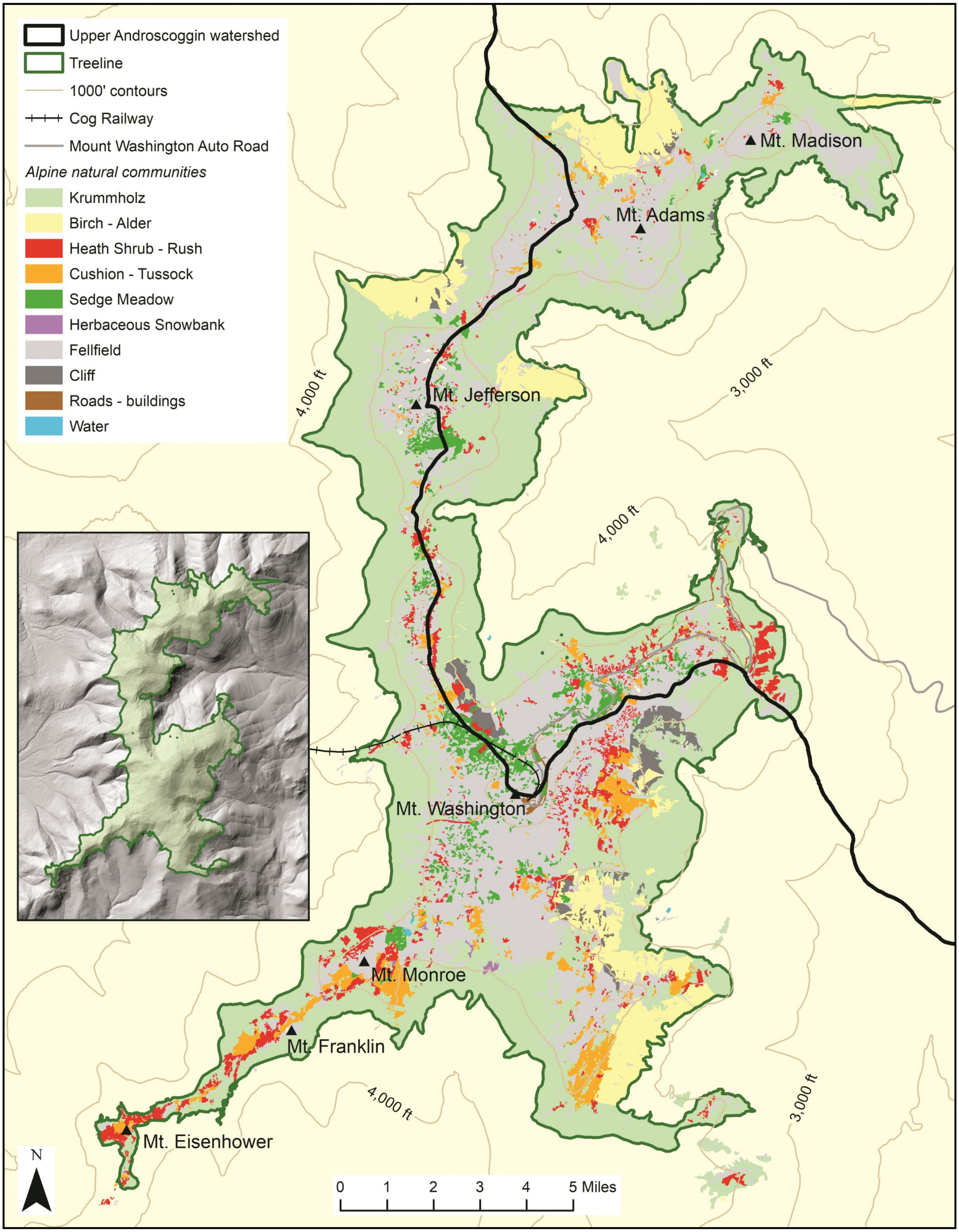
The Significance of 2700 feet

Ecologists commonly use an elevation of 2700 feet as a rough delineation of high-elevation ecosystems. It represents the approximate lower limit of average cloud cover. Above this elevation, forests encounter a harsher climate, with colder temperatures, shorter growing seasons, a greater exposure to damage from wind, snow and ice, as well as thinner, rockier, more acidic soils. As a result of these conditions, the northern hardwood-spruce-fir forests that are common at lower and middle elevations give way to a true boreal forest composed of red spruce, balsam fir, white birch and mountain-ash. At even higher elevations (above about 4000 feet), conditions become even more severe, and the boreal forest gives way to true alpine communities. Because of the sensitivity of these higher elevation ecosystems, an elevation of 2700 feet is used by both the Coos County Planning Board and Maine's Land Use Planning Commission to delineate high elevation protection zones, where greater limitations on land use and development apply.

Table 8— Peaks over 3500 feet elevation

Peak name	Elevation (ft.)	Peak name	Elevation (ft.)
Mount Washington*	6288	Shelburne Moriah	3735
Mount Adams*	5798	West Kennebago	3705
Mount Jefferson*	5717	North Peak	3680
Mount Madison	5363	Rump*	3647
Carter Dome*	4832	Kennebago Divide (south peak)	3645
Middle Carter	4610	Cow Ridge*	3645
Wildcat*	4422	Kennebago Divide (north peak)	3640
Old Speck	4180	East Kennebago (west peak)	3640
Mount Moriah	4049	Stub Hill	3607
Snow* (Alder Stream Twp.)	3960	Old Blue	3600
Goose-Eye	3870	Bemis	3592
Unnamed (Oxbow Twp.)*	3855	North Baldface*	3591
East Kennebago (east peak)*	3825	Mount Success	3590
White Cap	3815	Boil*	3580
Baldpate	3811	Twin Mountains	3580
Elephant	3774	Carlo	3562
Snow (Upper Cupsuptic Twp.)	3756	Jackson*	3535
Stock Farm	3735		

*These peaks are on the watershed divide.



Map 31 — Natural communities of the Presidential Range alpine zone

The 4.5 square miles above treeline is the largest alpine zone in the United States east of the Rocky Mountains.

— Fish and Wildlife —

The fish and wildlife resources of the upper Androscoggin watershed are some of its most distinguishing and valuable components—both economically and ecologically. The native eastern brook trout, loon and moose are prime examples of the North Woods iconic species, and part of the region's identity. Once severely degraded, depleted or exptirpated from colonial times into the 1900s, many elements of this watershed's fish and wildlife resources have rebounded due to low human density, road fragmentation and urbanization, reintroductions, and the passage of environmental laws and regulations.

Each species has its own "niche" or set of habitat conditions that it needs to survive. Many common fish and wildlife species are "generalists" that use a wide range of habitats. Others are more habitat-specific, requiring particular forest types or age classes, particular features such as large trees with cavities, certain types of wetlands, the presence of cold or fast flowing water, stream riffles and runs, or the presence of particular food sources.

Like the forests in the region, the fish and wildlife biota have changed with the climate since the glaciers retreated. Following deglaciation, American mastodons, wooly mammoths and caribou grazed the tundra vegetation, followed by early humans who hunted them. By pre-colonial settlement times the distribution of species remained to a large degree mostly under the control of natural forces, though native people did affect habitat in some areas.

Over the last two centuries human activities replaced natural disturbances as the primary force shaping fish and wildlife habitat. The clearing of the river valleys for agriculture favored increases in species using grasslands and shrubby habitats, and landscape scale clear cutting by timber barons using wood-fired steam locomotives facilitated intense forest fires and subsequent soil erosion as occurred in 1903 in the Wild River drainage. Unregulated meat hunting and trapping greatly reduced the numbers of deer, moose, bear, beaver, marten and other species. Key predators like the wolf, wolverine, and cougar were purposefully eliminated by the beginning of the 1900s and moose became a novelty. From 1806 until 1973 in New Hampshire and 1897 to 1976 in Maine, there was a bounty on bobcat. Other species took advantage of these open niches and migrated into the region, including more generalist species such as the coyote in the mid-1900s to fill the mammalian predator void. Genetic studies show that the eastern coyote interbred with wolves in Canada before entering the region. Such interbreeding likely contributed to the eastern coyote being significantly larger than its western counterpart.


skeeze

Moose populations in the region, almost driven to extinction by the early 1900s, rebounded dramatically following hunting protection, the elimination of its natural predator, the wolf, and spruce budworm epidemics that resulted in heavy forest harvesting and creation of abundant lower story hardwood browse. The moose population grew unchecked by predators, peaked in the 1990s, and has since declined dramatically. High moose densities combined with climate warming that enhanced an outbreak of moose winter ticks (averaging more than 40,000 ticks/animal), has resulted in low calf production and reduced winter survival due to anemia.

Road salting also contributes to moose-car collisions and mortality. Moose require sodium as part of their diet, more so in the spring and early summer. Due to the regional geology naturally available salt is scarce. Road salt is very soluble and drains quickly into roadside marshes. In addition many aquatic plants can concentrate salts to much greater levels than terrestrial plants. Moose are attracted to and remember these roadside salt-rich environments and food locations—conditions contributing to a greater probability of moose-car collisions as well as roadside moose tours having a greater chance of sighting at these areas.

The region's river and lake ecosystems suffered similar impacts. Overfishing by logging and sporting camps, the introduction of non-native species, scouring of streambeds by log drives, damming and regulating of river flows to move logs to downstream mills starting in the 1850s (later these dams were expanded), and severe water pollution from the pulp and paper mills in Berlin, Gorham, Rumford and Jay resulted in a much modified aquatic biota today. Now absent are strong swimming anadromous fish species that live in the ocean and spawn in freshwater like the Atlantic salmon, and catadromous species that spawn in the ocean, like the American eel, which historically occupied the Androscoggin watershed up to the impassable falls in Rumford, Maine.

Today about 287 species of terrestrial vertebrates (mammals, birds, reptiles and amphibians) are found in Maine or New Hampshire. Of these, about 232 may potentially be found in the upper Androscoggin watershed (Appendix F)—16 amphibians, 10 reptiles, 51 mammals, and 155 birds. About three-quarters of these are relatively common. However, nearly 60 are at least somewhat rare—either listed as Threatened or Endangered by state or federal wildlife agencies, or ranked as S1, S2 or S3 (Appendix E), or tracked as a species of special concern by state natural heritage programs (Appendix D). A few (such as lynx and golden eagle) are rarely seen in the area. One of the most limited is the American pipit, a species common in arctic regions but found breeding in the eastern U.S. only on the uppermost slopes of Mount Washington, N.H. (and further northeast on Mount Katahdin in Maine).

In general, forest practices today are at much more sustainable levels. Paralleled by other positive factors in the past half century, including reintroductions, sustainable hunting and trapping regulations, and elimination of environmental pollutants, a number of pre-colonial species have rebounded in the watershed again to self-supporting levels including the bald eagle, osprey, loon, turkey, beaver, American martin, fisher, bobcat and moose. The upper Androscoggin watershed and other large, relatively undeveloped forest areas are especially important to the broader region's wildlife. Many areas to the south have been so heavily developed that wildlife is limited to species that can co-exist with humans in a fragmented landscape. The extensive forests of northern New England are among the few remaining places in the eastern United States where large, intact landscapes can be managed in a way that again hosts many of its once prosperous native species at self-supporting population levels. And the establishment of wilderness and ecological reserves over time can restore old growth forest habitat that was favored by many species in pre- and early colonial days.

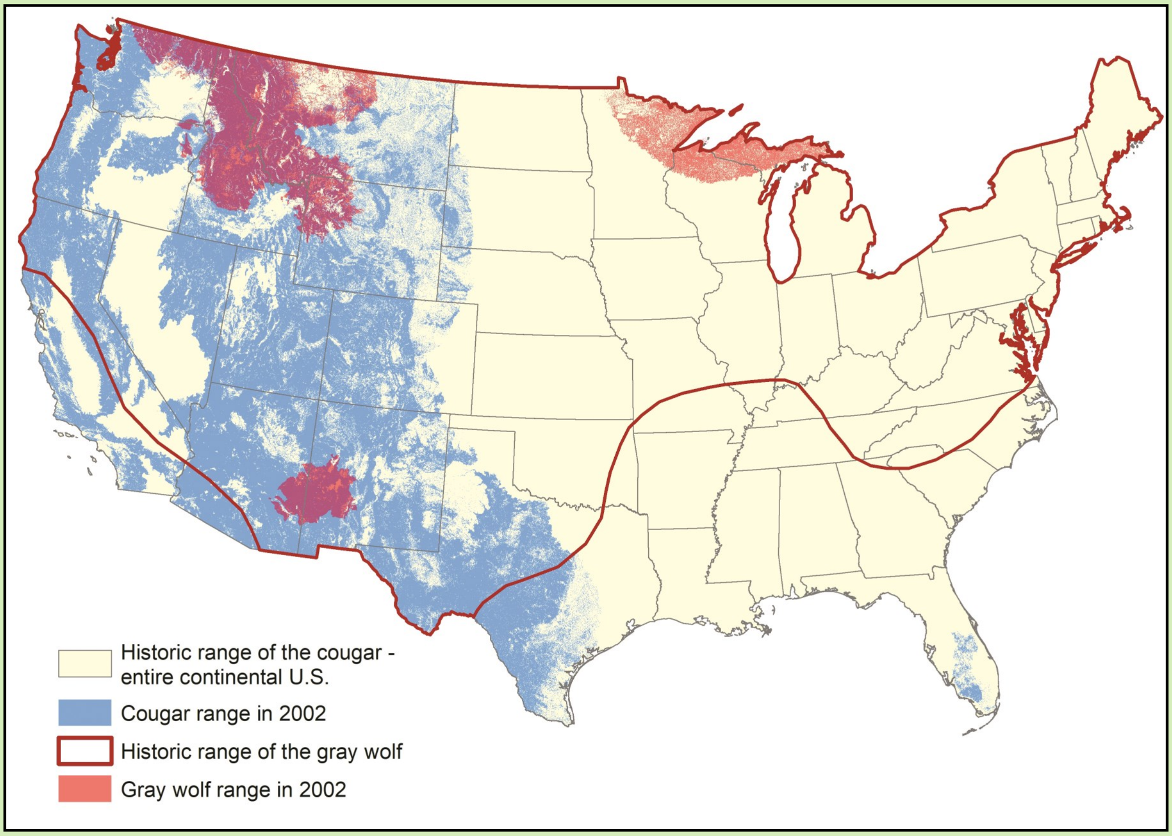
Fish have always been an important part of the Androscoggin landscape—the native name "Androscoggin" referred to fish abundance in the river. Fish formed an important part of the diet of native people and early settlers, and were one of the early attractions bringing tourists to the area. Fish species composition has since changed, and the fishery has declined dramatically from its historical abundance when it was common for fisherman to catch dozens of brook and blueback trout a day, some exceeding 10 pounds. Blueback trout were declared extinct from the Rangeley Lakes in 1905, the victim of overfishing and competition from introduced species. Such takings soon proved to be unsustainable since the region's waters geologically are nutrient-poor, resulting in low biological productivity rates. In addition, fluctuating lake and river levels caused by dam operations altered aquatic habitat


Robert Michelson

The upper Androscoggin River watershed today still contains some of the best native eastern brook trout waters in the United States. Today an emphasis has been put on preserving this iconic resource, including identifying and removing barrier culverts, scaling back stocking with genetically inferior hatchery trout, and trying to prevent further competition from introduced and non-native smallmouth bass.

and blocked passage to tributary streams used for spawning by brook trout. Landlocked salmon were introduced to the Rangeley Lakes in 1875 and were the primary game species by the early 1900s. Rainbow and brown trout, smallmouth bass, and rainbow smelt are species that are not native to northern Maine and New Hampshire but which have been introduced to the region's waters. Lake trout, yellow perch and alewife are native to other parts of both states but have been introduced into the Rangeley Lakes. Today, of the 30 or so species of fish found in the upper Androscoggin watershed, more than one-quarter are exotic species, including many of the most important game species. As with many other aspects of the region's ecological systems, fish populations are now governed as much by human decisions as by natural processes.

Many resident fish species, once considered to require only limited river reaches to fulfill their life cycle, actually move considerable distances on an annual basis—be it to spawn or to seek colder, higher oxygenated refugia waters during the warm, low water summer period. Brook trout caught and radio tagged in the Dead and Swift Diamond rivers show that some individuals will naturally move over 20 miles in a year. Fish surveys in the early 2000s from the mouth of the Androscoggin River to Errol, N.H. recorded that fish species diversity in impounded riverine reaches is lower than in more extended, undammed riverine reaches with greater access to more tributaries. Unlike the region's loons that simply fly over to the Gulf of Maine to spend the winter, fish movement is frequently blocked by human barriers. Connectivity impediments like dams and road culverts, lake drawdowns, and logging road sediment runoff still hinder full recovery of the region's fishery, though today much greater focus and resources are being employed to reduce these human barriers.



Map 32 — Historic and recent range of the gray wolf and the cougar

Ghosts of the past

Three large mammal species that were once widespread across northern New England have been extirpated from the region.

The eastern timber wolf (a subspecies of the gray wolf) was considered a threat by early settlers and active persecution eliminated it from New England by the mid-1800s. Though they remain established in the upper Great Lakes states, the closest population to the upper Androscoggin watershed lies north of the St. Lawrence River in Quebec. The U.S. Fish and Wildlife Service has identified large areas of Maine (extending into northern New Hampshire) as suitable habitat, and wolves could become re-established here, though the St. Lawrence River valley presents a considerable obstacle to their migration. Whether wolves should be actively re-introduced has been a subject of considerable (and often contentious) public debate.

The eastern cougar (also known as the catamount or mountain lion) was also eliminated by hunting and trapping by the late 1800s. Though the range of the cougar originally encompassed the entire continental U.S., its current status in the east is unknown. Occasional sightings occur in this region, possibly random wild individuals that are known to be able to migrate thousands of miles seeking new territory and mates, but there is no evidence in recent times of a breeding population.

Woodland caribou once ranged across the northern United States and were an important part of the diet of native people of the region. Over-hunting eliminated them from the region by the early 1900s. Today the closest population is in Quebec's Gaspé peninsula. An attempt to reintroduce the species to central Maine in the 1980s was unsuccessful.

Wolves and cougar played a critical ecological role in the region. Their function as large carnivores has only partially been filled by black bear, bobcat, lynx and coyote, all of which feed primarily on smaller animals. As long as large areas of northern New England remain as relatively remote, contiguous, undeveloped forest, their return to the area (through either natural recolonization or active re-introduction) will remain a possibility. The limiting factor is not the condition of the habitat, but the increasing human presence in the region, and our willingness to share the land with these magnificent creatures.

— Lakes and Rivers —

Lakes and rivers join with the mountains and forests to shape the ecological, economic and cultural landscape of the upper Androscoggin watershed. Few areas in the eastern United States possess this region's combination of large lakes, rivers and high mountains.

For thousands of years these waters have supported the lives of the people who lived here. For native people they served as the primary transportation routes, as well as supplying much of their food. For early settlers they also provided food and travel routes, as well as water power for early mills. As the towns grew, the lakes and rivers provided a means to transport logs and generate electricity, as well as an attraction for the growing tourist industry. For much of human history they also provided the primary source of drinking water. In addition, lakes and rivers are ecologically critical to the survival of many species. Unfortunately, over time they also came to serve as the primary means of disposing of industrial and human wastes. With the gradual success of pollution control efforts following passage of the Clean Water Act in 1972, the region's waters have once again become an invaluable source of scenic beauty, recreational opportunity and wildlife habitat.

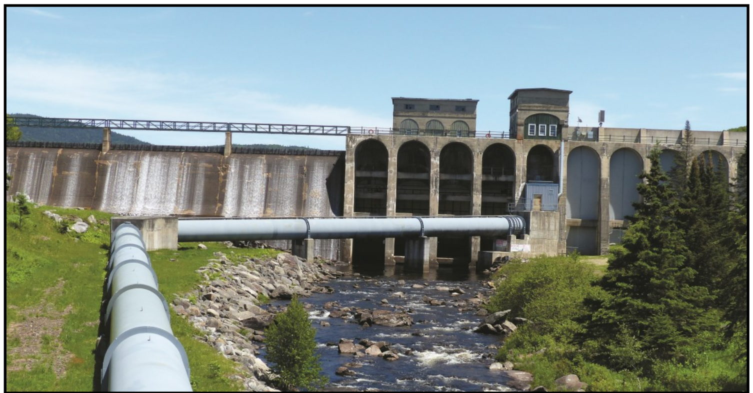
The most obvious aquatic features of the region are the Androscoggin River itself and the large lakes of the Rangeley Lakes chain. However, within the upper Androscoggin watershed lie 125 "great ponds" (lakes $\geq$ 10 acres, which are legally defined as publicly owned waters), and more than 3,700 miles of 1st order or higher streams and rivers (see Watersheds, page 8). Forty-five lakes exceed 100 acres in size (Table 9). With two exceptions, Aziscohos Lake and the Pontook Reservoir, lakes of the region are natural features though many have been significantly expanded by damming. Rivers range from the Androscoggin, which flows 107 miles from Lake Umbagog to Riley, Maine (more than half its total length of 177 miles), to the Rangeley River, extending barely one mile between Rangeley and Mooselookmeguntic lakes.

During the 1980s the states conducted assessments of their lakes and rivers to better understand their important resource values and to guide state planning agencies in making decisions about the use and management of the region's waters. Maine evaluated both lakes and rivers; New Hampshire assessed rivers but not lakes. The evaluations used similar but not identical approaches, rating the significance of lakes and rivers in a range of resource categories—areas such as fisheries, scenic quality, wildlife habitat, historic and cultural values, and recreational opportunities. The individual category rankings were then combined into a single overall rating showing the composite value of each river and lake.

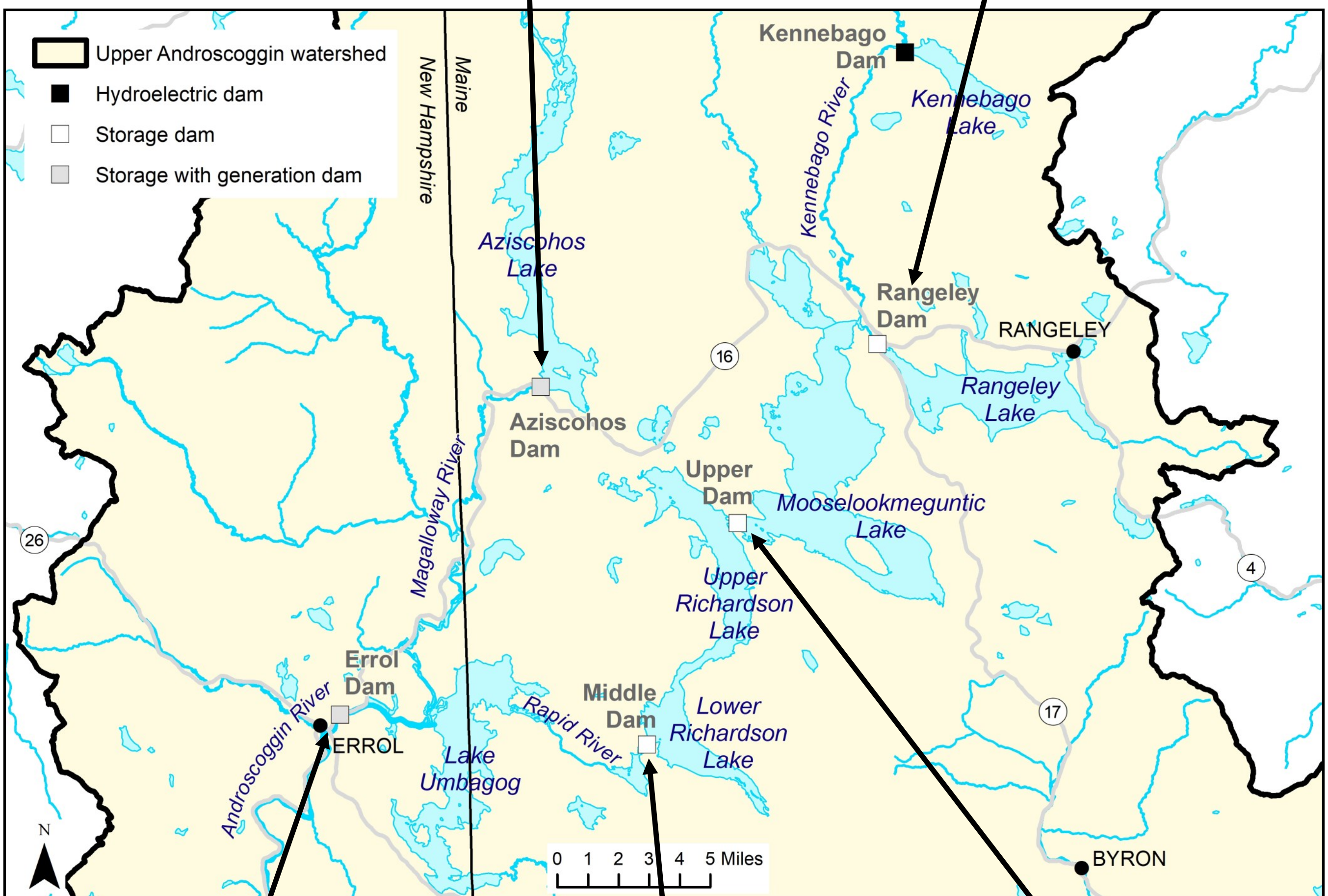
Class A rivers and Class 1A lakes are the "gems" of the landscape, with high value for many resources. Only 5% of Maine's river and stream miles and only 7% of its lakes received this rating. With the exception of Lake Umbagog, the large lakes of the Rangeley Lakes chain were all rated Class 1A. Umbagog was rated 1B only because many of the most important features (such as extensive wetlands) lie on the New Hampshire side of the lake and were not considered in the Maine lakes study; if it lay entirely in Maine it certainly would have been rated 1A.

Table 9 — Lakes in the upper Androscoggin watershed larger in size than 100 acres

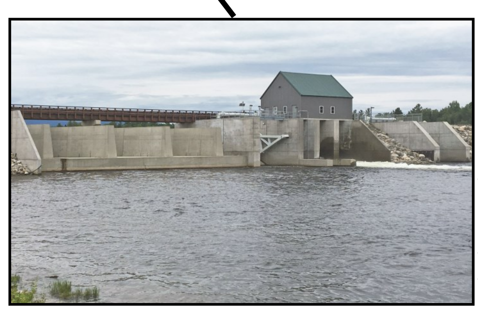
Mooselookmeguntic Lake	13,653	Sturtevant Pond	528	Gull Pond	283	Little Kennebago Lake	165
Umbagog Lake	7,902	Beaver Mtn. Pond	499	Success Pond	282	Millsfield Pond	165
Aziscohos Lake	6,916	Pond in the River	469	Akers Pond	276	Haley Pond	164
Rangeley Lake	6,302	Richardson Pond	465	Long Pond	271	Quimby Pond	157
Upper Richardson Lake	4,647	South Pond	463	Johns Pond	252	Round Pond	134
Lower Richardson Lake	3,105	Worthley Pond	375	Greenough Pond	234	Howard Pond	128
Cupsuptic Lake	2,706	B Pond	357	Dodge Pond	214	Jericho Lake	127
Webb (Weld) Lake	2,194	Big Island Pond	340	Pontook Reservoir	203	Metallak Pond	116
Kennebago Lake	1,908	Lincoln Pond	327	Beaver Pond	191	Dummer Ponds	114
Ellis (Roxbury) Pond	919	North Pond	307	Diamond Pond	181	Cranberry Pond	105
Parmachenee Lake	913	Little Ellis Pond	293	C Pond	180	Concord Pond	105
Lake Anasagunticook	598						



Maine Trail Finder



Lakewood Camps



Kyle Murphy

(Middle Dam to undergo reconstruction)

Map 33 — Upper Androscoggin River headwater storage reservoir system

The Swift Diamond, Dead Diamond, Androscoggin and Magalloway rivers in New Hampshire, and the Kennebago River in Maine were all rated Class A or B. The Wild, Dead Diamond and Swift Diamond rivers lie in almost totally undeveloped watersheds, some of the most natural river systems in the state. Because more of New Hampshire's rivers have been affected by human activity, the wilder rivers of the north country are especially valuable to that state.

Logs floated without dams to control flows took up to four years to get to downstream mills, and many never made it. By the 1850s dams to facilitate logs drives were constructed. And the Industrial Revolution gave rise to paper and manufacturing mills downstream fostering the Union Water Power Company (UWP) which was incorporated in 1878 to raise and store the waters of the Rangeley Lakes. By 1885 UWP had bought and rebuilt the existing dams, and purchased flowage rights. These dams raised water levels and annual fluctuations of the Rangeley Lakes from 4 to 18 feet, joining the previously separate Upper and Lower Richardson lakes and Mooselookmeguntic and Cupsuptic lakes, and expanding the size of Lake Umbagog nearly fivefold. Following the drought of 1903-04, the Androscoggin Reservoir Company (ARCO) was formed in 1909 by the downstream paper companies to construct Aziscohos Dam in 1911. The narrow Magalloway River valley became Aziscohos Lake with the largest storage capacity and annual water level fluctuations in the watershed. The shallow Pontook Reservoir was created by a dam in 1909 to hold logs at that site.

Typical natural flow patterns have up to 50% of the total annual runoff occurring during snowmelt freshet. Very low seasonal flows occur during the winter, and from mid-summer to leaf-off in the autumn due to evapotranspiration (where moisture is naturally returned to the atmosphere). The upper Androscoggin storage dams (Map 33) are managed for highly regulated and unnatural flows, impacting downstream river ecology. They have large annual water level fluctuations (Figs. 5-9) negatively impacting their littoral zone (shallow water) ecosystems. The natural lakes usually fluctuate but several feet per year.

The ARCO operating agreement of 1909, modified in 1983, has since largely governed flows artificially downstream of the Errol Dam to provide: a regulated flow year round of not less than 1,550 cubic feet per second (cfs) at Berlin (with drought exceptions); the seasonal draw of one third from Aziscohos and two thirds from the other reservoirs combined; and the companies proportionally paying for the maintenance, repair and operations of these storage dams. Now operated for hydroelectric generation, but with different owners, these dams require Federal Energy Regulatory Commission (FERC) relicensing every 30-50 years, since they use publicly owned, navigable waters. The relicensing of Upper and Middle Dams resulted in a major collaborative Settlement Agreement in 1998 involving twenty environmental groups, state and federal agencies, municipalities, camp owners and the Rangeley Lakes Heritage Trust. Highlights of this landmark settlement include:

- increased minimum flows in the Magalloway and Rapid rivers to benefit fish, and on alternating, summer weekends scheduled white water releases for individual and commercial boating interests;
- more stable reservoir water levels, except for Azisochos Lake whose relicensing is in 2025, to protect loons and summer recreational interests;
- riparian land protection; and
- the storage dams providing consistent flows for hydroelectric generation, industrial use, wastewater treatment, and flood protection.

Figure 5 — Rangeley Lake Dam (flows to Cupsuptic/Mooselookmeguntic Lakes)

Date Built: 1836 (rebuilt 1983)
Full pond: 6302 acres
Days Water Supply[1] (%storage) =10 days (36%)
Storage billion ft^3 : 1.3 bcf
Maximum depth (ft): 149 ft
Depth available for storage (ft): 4 ft

Maximum level full pond (asl[2]): 1519.5 ft
Rated full pond elevation (asl): 1518.0 ft
Average spring fill (asl): 1518.0 ft
Average ice out: May 9
Annual drawdown restrictions: No
Hydroelectric generation: No

[1] 1 days supply = 1,550 cubic feet per seconds (cfs) in Berlin, NH
[2] above sea level

Lake gauge long term average (feet above sea level)

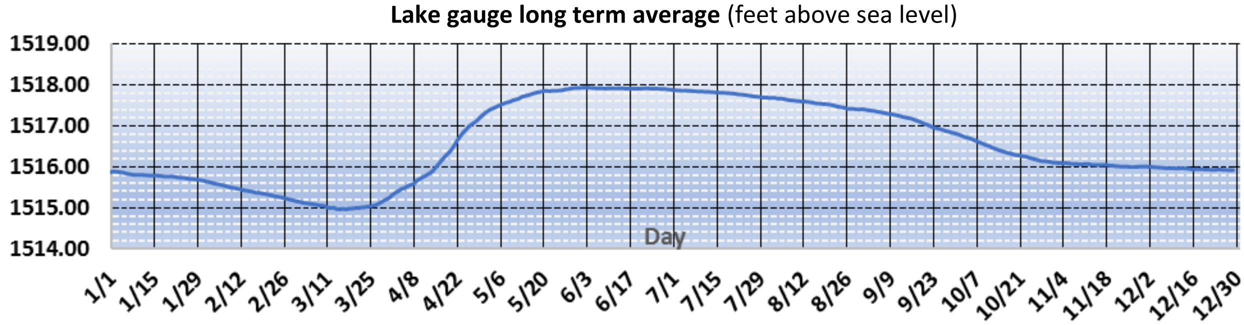


Figure 6 — Upper Dam – Mooselookmeguntic/Cupsuptic Lakes (flows to Richardson Lake)

Date Built: 1853/ reconstructed 2016
Full pond: 16,359 acres
Days Water Supply[1] (% storage): 62.5 days (31%)
Storage billion ft³: 8.1 bcf
Maximum depth (ft): 139 ft
Depth available for storage (ft): 12.2

[1] 1 days supply = 1,550 cubic feet per seconds (cfs) in Berlin, NH

Maximum level full pond (asl): 1468.7 ft
Rated full pond elevation (asl): 1468.0 ft
Average spring fill (asl): 1467.8 ft
Average ice out: May 6
Annual drawdown restrictions: Yes
Hydroelectric generation: No

[2] above sea level

Lake gauge long term average for Upper Dam (feet above sea level)

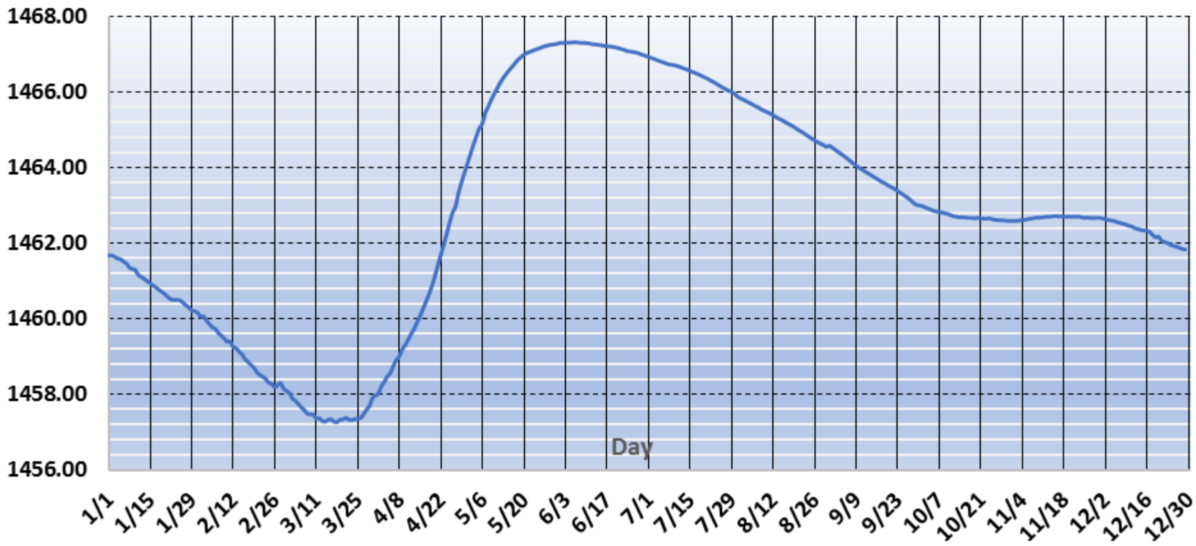


Figure 7 — Middle Dam – Upper/Lower Richardson Lakes (flows to Lake Umbagog)

Date Built: 1853
Full pond: 7,752 acres
Days Water Supply[1] (% storage): 42.5 days (21%)
Storage billion ft³ : 5.7 bcf
Maximum depth (ft): 108 ft
Depth available for storage (ft): 17.5 ft

[1] 1 days supply = 1,550 cubic feet per seconds (cfs) in Berlin, NH

Maximum level full pond (asl): 1450.5 ft
Rated full pond elevation (asl): 1450.0 ft
Average spring fill (asl): 1449.2 ft
Average ice out: May 7
Annual drawdown restrictions: Yes
Hydroelectric generation: No

[2] above sea level

Lake Gauge long term average for Middle Dam (feet above sea level)

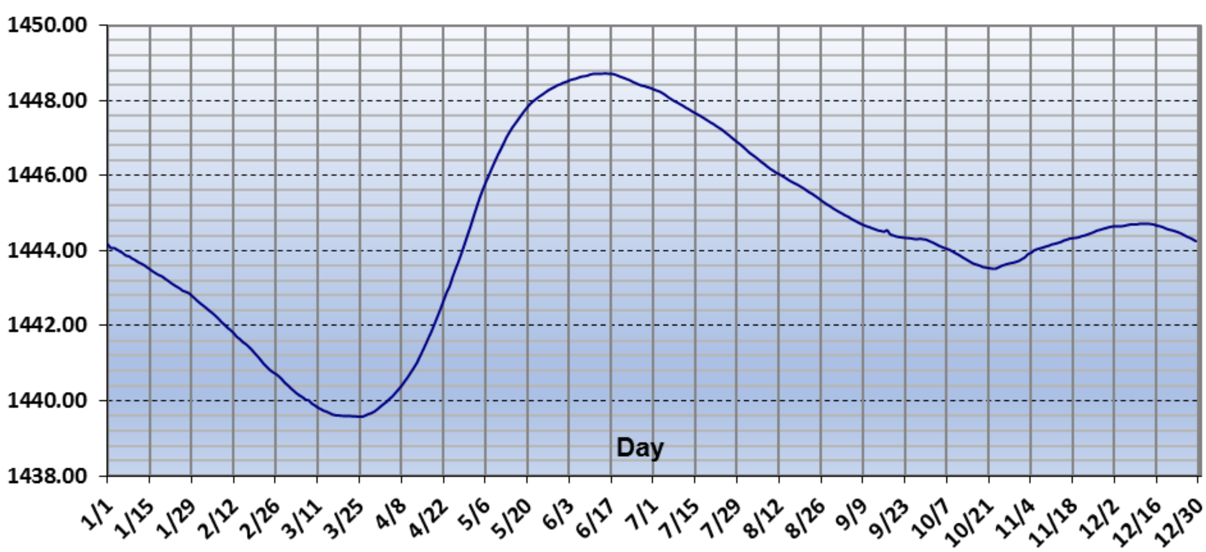


Figure 8 — Aziscohos Lake (flows to Lake Umbagog)

Date Built: 1911
Full pond: 6,916 acres
Days Water Supply[1] (%storage): 72 days (36%)
Storage billion ft^3 : 9.6 bcf
Maximum depth (ft): 60 ft
Depth available for storage (ft): 45 ft

[1] 1 days supply = 1,550 cubic feet per seconds (cfs) in Berlin, NH

Maximum level full pond (asl[2]): 1522.453 ft
Rated full pond elevation (asl): 1520.3 ft
Average spring fill (asl): 1519.7 ft
Average ice out: May 9
Annual drawdown restrictions: None
Hydroelectric generation: Yes (6.7 MW)

[2]above sea level

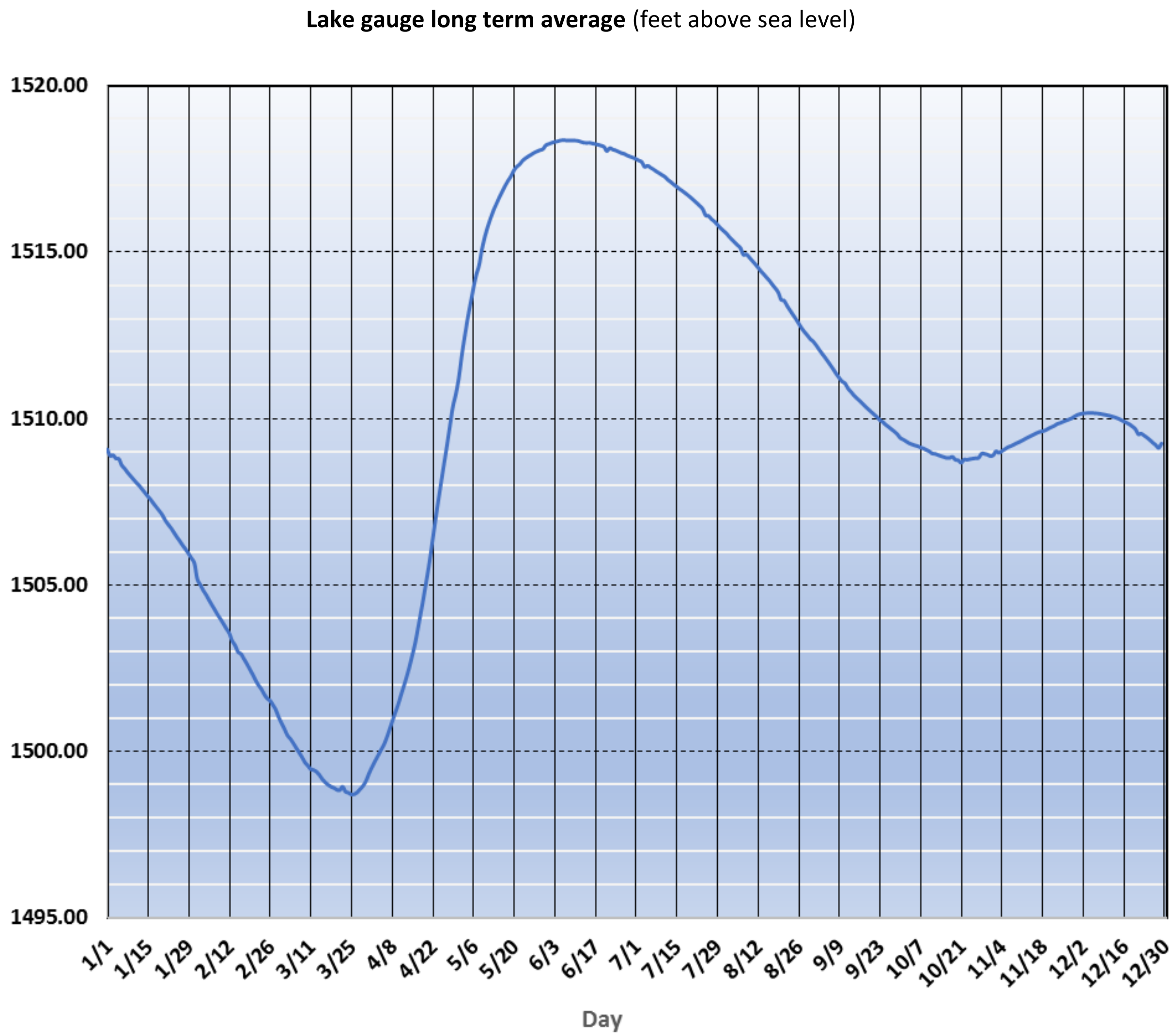


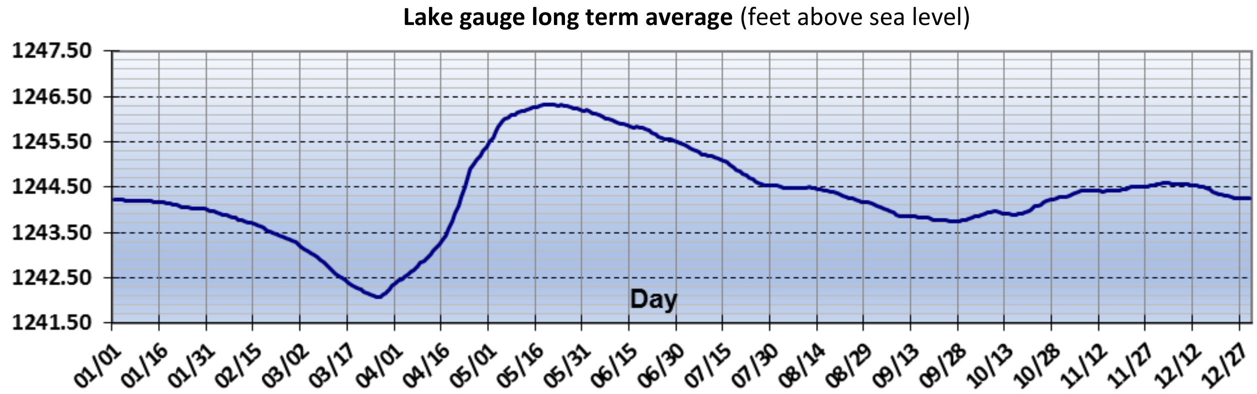
Figure 9 — Errol Dam – Umbagog Lake (start of Androscoggin River)

Date Built: 1853
Full pond: 7,641 acres
Days Water Supply[1] (% total storage): 23 (12%)
Storage billion ft^3 : 3.1 bcf
Maximum depth (ft): 48 ft
Depth available for storage (ft): 9.5 ft

[1] 1 days supply = 1,550 feet per seconds in Berlin, NH

Maximum level full pond (asl[2]): 1250.7 ft
Rated full pond elevation (asl); 1247.0 ft
Average spring fill (asl): 1247.0 ft
Average ice out: May 2
Annual drawdown restrictions: Yes
Hydroelectric generation: Yes

[2] above sea level



The controversial reconstruction of the Pontook Dam with a 2-mile diversion canal for hydroelectric generation resulted in a 1984 settlement with guaranteed fishery, scenic and scheduled whitewater releases, and river access land protection. Prior to this in the 1960s a huge and controversial 7,000-acre reservoir and peak power generation dam was proposed at the Pontook Dam site by the US Army Corps of Engineers and then Public Service of New Hampshire. Similarly a proposed tunnel in the 1980s to divert the Rapid River at Middle Dam for hydroelectric generation also succumbed to public pressure.

Riparian areas are the transitional zones along the shores of streams, rivers and lakes—places that influence, and are influenced by, the presence of open water. They are an especially important part of the landscape, used by more than 90% of the region's wildlife species. In addition to serving as travel corridors they are the primary habitat for species such as belted kingfisher, mink and otter. They protect aquatic habitats by stabilizing banks, filtering sediment and pollutants from upslope areas, and shading streams. Leaves and insects falling from over-hanging vegetation are an important part of the food chain of small streams and rivers, and larger fallen logs create pools and ripples. Large trees are the primary nesting sites for bald eagles, osprey, heron, wood ducks and mergansers. Many rare plants are associated with streamside wetlands and forests. In addition, riparian habitats are critical scenic areas—the places aesthetically most obvious to fishermen, canoers, and other recreational users of lakes and rivers.

Riparian areas range from narrow bands of alder brush a few feet wide to extensive floodplain forest and wetland complexes. Along smaller streams there may be no distinctive riparian vegetation outside of the stream channel itself. A single tree height may be all that is needed to shade a stream, and water quality can be protected by buffers 50 to 100 feet wide, but wildlife habitat associated with larger lakes and rivers can extend hundreds of yards into adjacent upland forests. Riparian areas have recovered from the damage caused by the pounding of millions of logs during the days of the river drives, which ended in 1964. Today shoreland development regulations in both states provide moderate protection from development and tree cutting in the riparian zone for lakes and ponds, larger streams and rivers.

Pontook Dam and Reservoir on the Androscoggin River

— Wetlands —

Marsh, Kennebago River

Harper's Meadow, Umbagog NWR

Wetlands are places where saturation with water for at least part of the year is the dominant factor controlling soil development and the nature of plant and animal communities. They are transitional habitats between drier upland forests and lakes, rivers and streams. Most wetlands are found in flat valley-bottom areas where the water table lies near the surface or soils are subject to seasonal flooding. However, they may also be found in upland areas along the margins of streams and ponds, in shallow basins, in areas where groundwater emerges at the surface (seeps), where dense soil horizons restrict drainage, or where beaver dams have created temporary ponds.

Wetlands are among the most ecologically important components of a landscape. They maintain water quality by filtering sediment and pollutants from upslope areas. They regulate streamflow by acting as sponges, absorbing water at periods of high flow and slowly releasing it throughout the year. They provide important habitat for a wide range of wildlife species, and contain a disproportionate number of rare plants and unusual natural communities. In the heavily forested landscape of the upper Androscoggin watershed, even small wetlands of a few acres make a significant contribution to maintaining the diversity of plants and animals.

There are many different types of wetlands and many different ways to define them based on hydrology, soil characteristics, or vegetation. Detailed classification of wetland types can be very complex, and the following is only a very general description. Wetlands may be grouped into a few broad types:

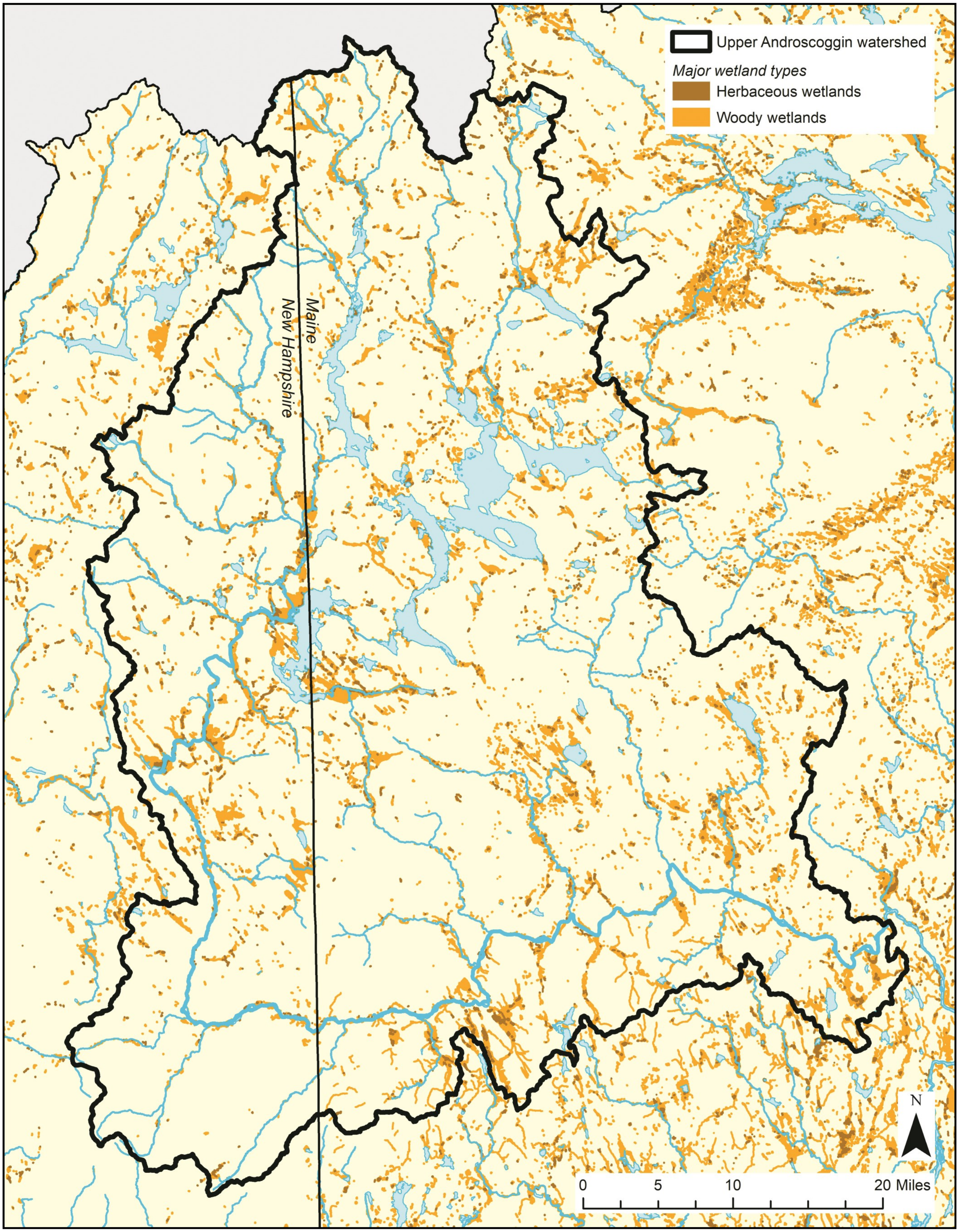
Peatlands

Peatlands are wetlands where vegetation is rooted in deep deposits of partially decomposed organic matter (peat). They usually form in ponds and wet basins such as kettlehole ponds (see page 39). Bogs are very acidic (pH <4.0) peatlands dominated by sphagnum mosses and generally isolated from streamflow or groundwater. Fens are less acidic peatlands containing a mixture of sphagnum mosses and sedges. They have a higher level of available plant nutrients due to greater contact with groundwater. The distinction between bogs and fens is fuzzy; there are few true bogs in our region and most areas that people might call bogs are more properly considered acidic fens. In addition to sphagnum and sedge, acidic peatlands commonly contain evergreen shrubs and trees including black spruce, tamarack, leatherleaf, sheep laurel and Labrador tea, as well as unique plants such as pitcher plant and sundew that obtain nutrients by catching and dissolving insects in their leaves. Less acidic fens may contain a wider variety of herbaceous and woody species, while the least acidic, most nutrient-rich fens (called calcareous or circumneutral fens) may contain northern white cedar, as well as being prime sites for rare plants.

Swamps and Marshes

Swamps and marshes are wetlands in which plants are rooted in mineral soil, though some swamps accumulate a thick layer of woody peat and can be considered peatlands. They may be found in basins, on poorly drained flats or river floodplains, or around the edges of ponds and streams. Swamps are dominated by woody vegetation, and may be broken into forested swamps and shrub swamps. Evergreen forested swamps are dominated by black and red spruce, balsam fir and tamarack, with northern white cedar common in less acidic swamps. The dominant species of northern deciduous forested swamps is red maple, with white and yellow birch, elm, and black ash common associates. On low river terraces subject to frequent flooding silver maple is an important species. Deciduous shrub swamps commonly contain speckled alder, sweet gale and meadowsweet.

Marshes are dominated by grasses and sedges, usually growing in mineral soil or muck (a fine-textured mixture of mineral and organic soil) that remains saturated for most of the year. Cattail



Map 34 — Wetlands

The most extensive wetlands are found along larger rivers, though small wetlands can be found along most streams in the watershed.

marshes are a well-known example, though these are relatively uncommon in the upper Androscoggin watershed. Areas of shallow water containing emerging or floating plants such as arrowhead, pickerelweed and pond lily (known as aquatic beds) are another type of marsh.

Wetland Mapping

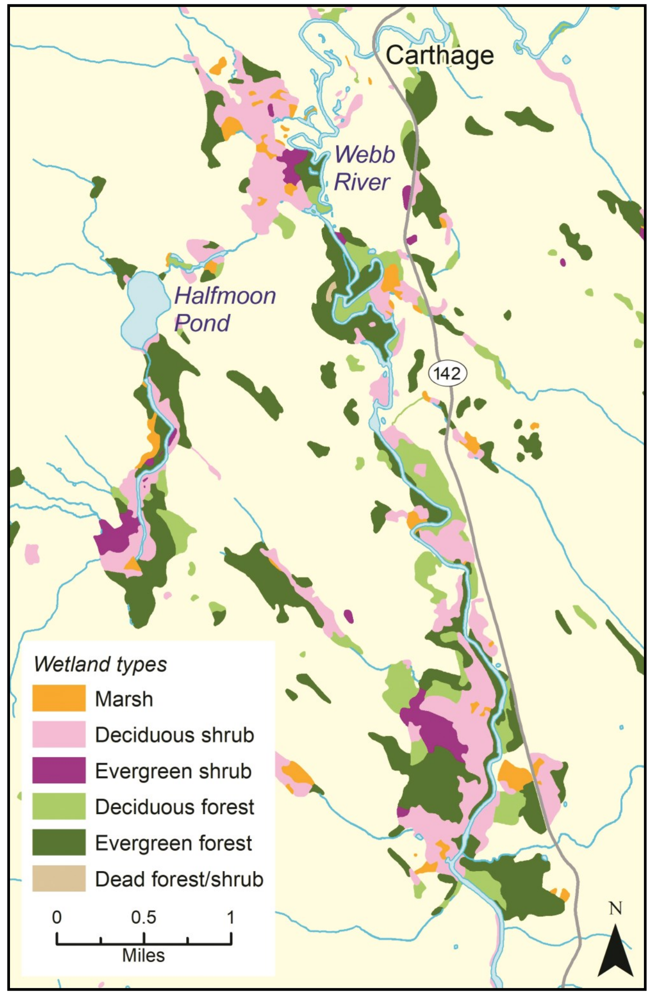
The most comprehensive mapping of wetlands has been done by the U.S. Fish and Wildlife Service as part of the National Wetlands Inventory (NWI) program. This system classifies wetlands according to broad types without reference to species composition, and it does not specifically identify peatlands. The NWI has mapped about 57,842 acres of wetlands in the upper Androscoggin watershed, or about 3.7% of the area (Map 34, Table 10). By comparison, the entire state of New Hampshire is about 3.1% wetland, whereas Maine is about 9.7% wetland.

The most common wetland types are evergreen forested swamps (primarily spruce-fir swamps, though also including northern whitecedar swamps and black spruce-tamarack bogs) and deciduous shrub swamps (usually dominated by alder, sweet gale and/or meadowsweet), which together make up nearly three-quarters of the wetland acreage. Deciduous forested swamps (primarily red maple swamps), evergreen shrub swamps (acidic bogs and fens) and marshes (primarily sedge meadows) are present in lesser amounts. Marshes are of particular interest, as they provide open grassy habitat that is critical for many wildlife species (including pied-billed grebe, American bittern, northern harrier, sedge and marsh wrens, muskrat, mink and moose).

Table 10 — Area of major wetland types within the upper Androscoggin watershed

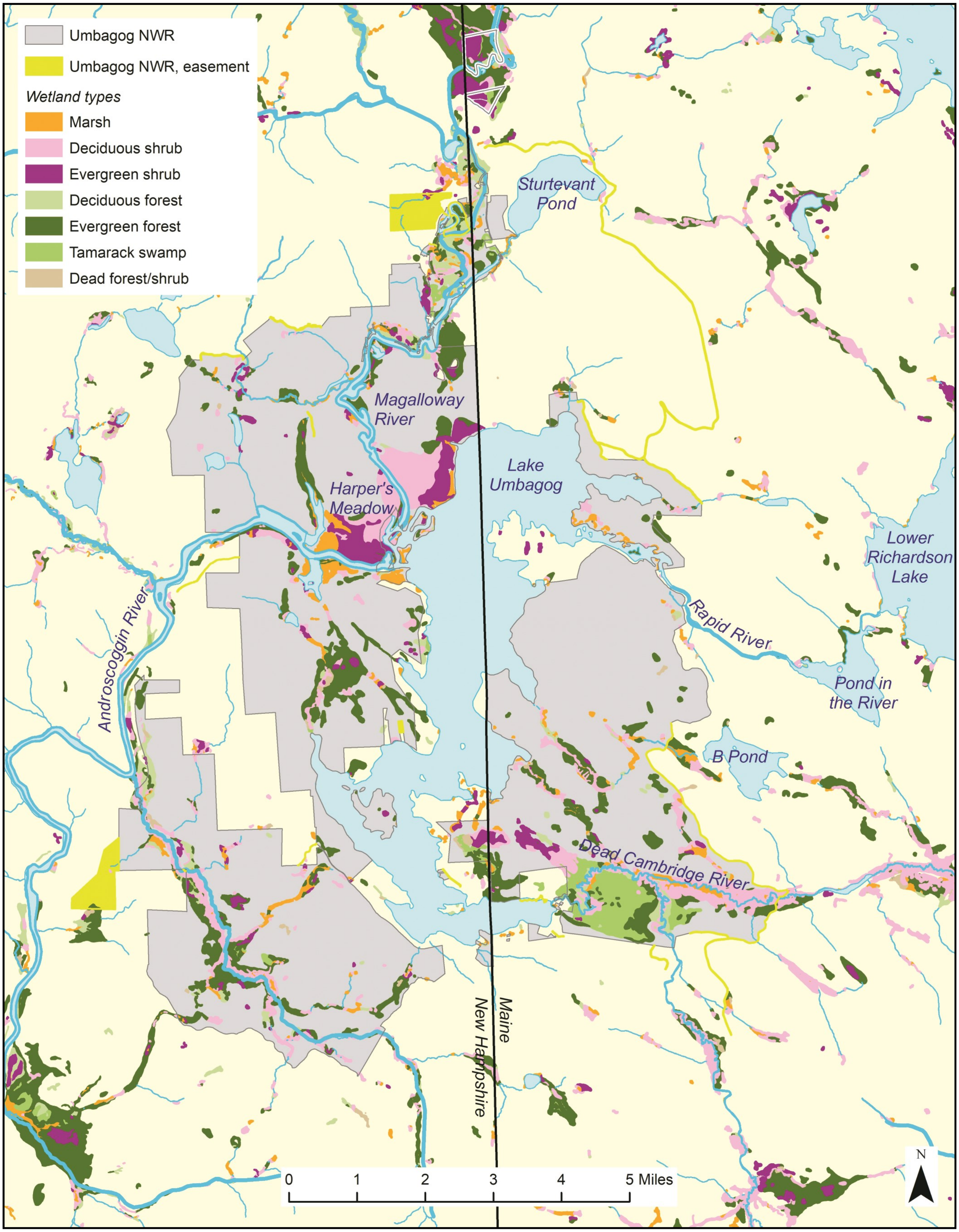
Wetland type	Area (acres)	Percent of wetland area	Percent of watershed area[1]
Marsh	5,028	8.7%	0.3%
Swamps			
Deciduous shrub	16,056	27.8%	1.0%
Evergreen shrub	2,694	4.7%	0.2%
Deciduous forest	7,838	13.6%	0.5%
Evergreen forest	22,899	39.6%	1.5%
Tamarack swamp	902	1.6%	0.1%
Dead forest/shrub	248	0.4%	0.02%
Unconsolidated[2]	2,176	3.8%	0.1%
Total wetland	57,842		3.7%

[1]Upper Androscoggin Watershed 1,564,833 acres
[2] Loose deposits of silt, sand and gravel in riverbeds and along lakeshores without well-developed vegetation.



Map 35 — Wetland complex along the lower Webb River

Except for the steep slopes of the White Mountains and other high peaks, wetlands are scattered throughout the watershed. The great majority of wetlands are small patches of less than five acres, mostly spruce-fir swamps and deciduous shrub swamp/meadows (often created by beaver activity). Nearly every major stream in the watershed has these small wetlands along parts of its length. Larger wetland "complexes" (mixtures of several different types) may be found along slow-moving, meandering rivers with wide low floodplains, including the lower Magalloway, Cupsuptic, Kennebago, Ellis and Webb rivers (Map 35). The most extensive and diverse wetlands lie around Lake Umbagog—the primary reason the area was designated a National Wildlife Refuge in 1992 (Map 36). Nearly 10% of the wetlands in the upper Androscoggin watershed lie within the refuge boundary. On the western side of Umbagog Lake is a large peatland complex encompassing four areas: Leonard Marsh, Sweat Meadow, Harper's Meadow, and Chewonki Marsh. Harper's Meadow, an extensive area of peatland and floating bog with peat in places up to 30 feet deep includes 860 acres known as "Floating Island Bog", which was designated a National Natural Landmark in 1972.



Map 36 — Wetlands in the Umbagog National Wildlife Refuge
Nearly 10% of the wetlands within the upper Androscoggin watershed are found within the refuge boundary. The extensive wetlands around the confluence of the Androscoggin and Magalloway rivers (Harper's Meadow) are among the most critical wildlife habitat areas in the region.

— Historical Use of the Landscape —

Native People (11,000 BP to 1600 AD)

Humans have been living on and using the land in the upper Androscoggin valley for thousands of years. Evidence of human activity in the region dates back at least 11,000 years, shortly after the most recent glaciers receded. Paleo-Indian artifacts collected from an encampment on the shore of present day Lake Aziscohos are the oldest human relics found in all of New England. Various stone knives and projectile points from the site indicate that these prehistoric humans hunted migrating caribou from this location. Other archaeological sites dot the region dating from around 10,000 years ago to the more recent past.

These paleo-Indians were the ancestors of the various Abenaki tribes of northern New England, including the Anasagunticooks, who inhabited the Androscoggin Valley. Prior to the arrival of European settlers, each tribe occupied a different river valley. Although there is evidence of some trade as well as hostilities between tribes, commerce was limited and warfare rare, as each tribe made use of the abundant resources of their valley. This was especially true for the Anasagunticooks, who were more isolated than most by the mountainous terrain bordering much of the Androscoggin watershed.

One of the most important resources to these people was the Androscoggin River itself. In addition to providing abundant fish and other food supplies, traveling the river by birch-bark canoe was the preferred mode of transportation. The river acted as a highway between the ocean, which provided a consistent food supply and mild winter climate, and upstream locations, which provided hunting and fishing opportunities as well as furs and hides for clothing and shelter. Although the Anasagunticook generally led a seasonally nomadic lifestyle, there were permanent village locations along the river (including Rumford Falls and near Bethel Hill) that were centers of fishing, agriculture, and commerce. Every summer, many Anasagunticooks migrated to Canton Point. This was reportedly the largest native village in New England and was the center of the Anasagunticook tribe. Although estimates are based on limited information, prior to 1600 the population of the regional Abenaki nation was somewhere around 10,000, and the Anasagunticooks within the Androscoggin valley numbered a few thousand.

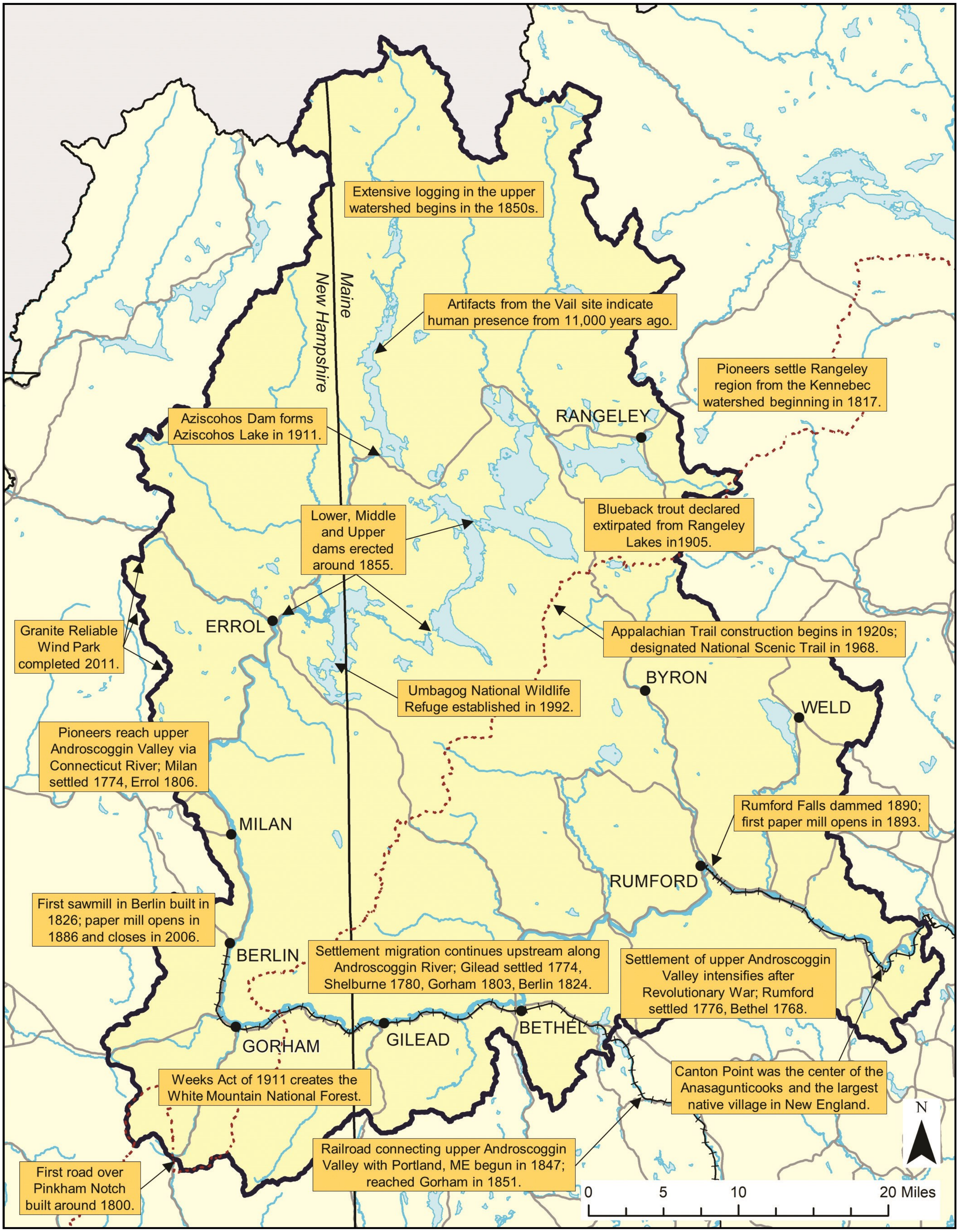
Exploration (1600 to 1800)

While exploring the Maine coast in 1605 the French explorer Samuel de Champlain first mentioned the Androscoggin when he wrote of two rivers (the Kennebec and the yet unnamed Androscoggin) converging in Merrymeeting Bay. Shortly thereafter, English pioneers began to settle coastal regions and lower sections of the Androscoggin River. When a plague struck the Anasagunticooks in 1615, they began to move up river, abandoning their southern settlements and "selling" the land to the English. Although English settlement was slow and conflicts rare along the Androscoggin River, there were strong tensions between the native people and English throughout New England that erupted into a regional war in 1675 (King Philip's War). The alternating cycle of peace and war over the next 50 years (collectively known as the Abenaki Wars) resulted in large losses on all sides. In the end, the Anasagunticooks and other Abenaki tribes moved to the upper reaches of the Androscoggin, before finally retreating to the St. Francis settlement in Canada.

English exploration and settlement of the Androscoggin region continued throughout this period. Although settlement of the lower reaches of the Androscoggin was well under way by 1750, exploration of the upper Androscoggin began much later. In addition to the steep mountains and unnavigable rapids and falls of the main channel, which made access difficult, the rough terrain made the area less desirable for farming. Unlike the nearby Connecticut and Kennebec rivers, which were largely settled by the 1760s, settlement activity in the upper Androscoggin watershed did not build until the 1780s. In search of raw materials, safe trade routes, and suitable settlement areas, these early explorers and pioneers traveled by navigating the main channel and larger tributaries of the Androscoggin and using marked trails established by the Anasagunticooks. By 1795, a map that included the northern headwaters of the Androscoggin valley was created.

Settlement (1760 to 1825)

Settlement and ownership of these lands was often a complicated process. Initially, townships in the wild lands were granted by the Crown (or later a Governor) to an often-absentee landlord who was responsible for improving and developing the granted area. Rather than do this task himself, the landowner would usually organize a colony or divide the grant into lots and sell or give the land to individuals or families. These pioneers were then obligated to work the land as a condition of ownership. Land speculation played an important role, as landowners made large amounts of land available inexpensively or free, with the hope that their remaining land would increase in value as the region was settled.



Map 37 — Historic development in the upper Androscoggin River watershed

Northern Forest Heritage Park

Early loggers at work

Early settlers were motivated to live in this wilderness by this promise of land ownership and new beginnings. Increasing growth along the coastline and lower Androscoggin shorelines led settlers to explore the interior region. At the end of the Revolutionary War, settlement of the Rumford-Bethel-Gilead area increased dramatically, as veterans of the Patriot army were granted land as payment for their service.

These pioneers cleared the forests along valley bottoms to make room for agricultural fields and to produce building materials for their homes. Although farming was difficult and limited, it played an important role in the early settlement of Bethel, Gilead, and Shelburne. In addition to producing crops for personal use and for trade or sale, early settlers hunted and trapped for food and furs, raised sheep for wool, and cleared more forest to produce wood and potash.

As these towns were established, the early pioneers or their heirs continued to move upstream. Settlement of Gorham began in 1803. Berlin was one of the last areas in New Hampshire to be settled, and a permanent settlement was not established there until 1824.

Although most towns along the river were settled by pioneers migrating upstream, many of the towns further north along the Androscoggin had already been settled. Pioneers arriving from the Connecticut River valley to the west settled Milan in 1774 and Errol in 1806. The early settlers that arrived in the Rangeley region beginning in 1817 arrived from the Kennebec River to the east.

Emerging Economies and Populations (1800 – 1850)

Initially, the settlements throughout the upper Androscoggin valley were self-sufficient and all activity was geared towards producing locally needed goods. The pioneer family had to be skilled in lumbering, carpentry, farming, weaving, and canning, among other tasks. The occasional peddler would travel through with items that were not available locally for sale or trade, but the few primitive roads made travel to or from outside markets difficult. This isolation limited local industry, although in Berlin (then known as Maynesborough Plantation), a small potash camp and a lead mine sprang up as the town was first settled.

The settlers quickly began to use the river's power more directly to settle the land. The first grist and saw mills were constructed in Bethel in 1774; in Berlin a sawmill was in place by 1826 and a grist mill by 1835. Unfortunately, the mills were subject to the strong freshets that arrived with the snowmelt each spring. Between flood and fire, a mill usually lasted only a few years before it had to be rebuilt. Despite these hardships, the settlements flourished: Rumford was incorporated in 1800 with a population of 252 and Gorham in 1836 with 135 townspeople. Shelburne had grown to 400 by 1830, and Berlin had a population of 72 when it incorporated in 1829.

In part, this growth was driven by a strong market for the tall straight white pines that grew along the valley bottoms of the Androscoggin River and its tributaries. Whenever the local mill owners had a surplus of logs, they were laboriously hauled to Portland. Soon, loggers and river drivers were recruited to the area from the Kennebec and Penobscot regions to help meet the increasing demand for timber. Although their numbers were usually not reflected in official censuses, towns would periodically swell with these migratory workers, and populations began to shift from the settled pioneer family to the independent transient woodsman.

Getting the logs downstream to market was slow, difficult, and dangerous work. Trees located near the Androscoggin were cut during the winter and skidded by ox to a nearby frozen lake or river to await spring. The river drivers would ride downstream along with the log rafts, making sure that the booms did not become stuck on the shoreline or form logjams. Although the river currents were swift and plentiful in the spring, water levels dropped rapidly in the summer and often stranded the driver's payload. Oftentimes, it took from two to four years to float logs to their final destination. To counter this problem, a dam was built at the outlet of Rangeley Lake in 1836 to moderate the flow of water and extend the river drive further into the summer.

Early Industrial Growth (1850 – 1880)

Despite the creation of the Rangeley Lake log driving dam, the journey to market was still a drawn-out and expensive process. However, businessmen in Portland, Boston, and Bangor recognized the increasing market for lumber and the potential resources available in the upper Androscoggin watershed. They purchased forestlands, secured water rights, and developed access to the area by extending the Atlantic and St. Lawrence Railway from Portland to Montreal. The arrival of the railroad to Gorham in 1851, and Berlin two years later, created rapid and dramatic changes throughout the upper valley.

With quick and efficient transport available, a series of new log driving dams were quickly erected to bring the logs from the Rangeley Lakes region to Berlin. Dams were constructed on the Rapid River (no longer exists), at Lower Richardson Lake (Middle Dam), Mooselookmeguntic Lake (Upper Dam), and below Lake Umbagog (near the present day Errol Dam). These larger dams markedly altered the flow of the Androscoggin and raised the water levels of Mooselookmeguntic and the Richardson lakes by more than 5 feet.

A dam of a different type was built downstream at Berlin Falls. Like the settlers who had set up mills at this location previously, the Winslow Company recognized the power that could be harnessed where the Androscoggin narrowed right above the mighty falls. They bought the land along the shoreline, and immediately built a new dam and modern sawmill at Berlin Falls to collect, process, and ship the logs harvested from the vast region upstream.

With all this activity surrounding the construction, operation, and maintenance of the railroad, dams, and mills, Berlin became a boomtown practically overnight. With the infrastructure in place, logging along the Rangeley Lakes and the Magalloway and Dead/Swift Diamond rivers increased dramatically. Although its permanent population reached a moderate 400 residents by 1860, part-time residents doubled the actual number of people in town.

However, these events had a very different effect on other towns along the Androscoggin. The railway from Portland had come up the Little Androscoggin River, bypassing the towns of Shelburne, Gilead, Bethel and Rumford. In addition, the completion of the Berlin Falls mill nearly eliminated downriver log drives and the small mill enterprises along the way. As people were tempted to abandon their marginal farms by the lure of wage employment in Berlin, the populations of these once growing towns dropped quickly. As a result, some of these towns retain their rural character today.

Late Industrial Growth (1875 - 1900)

If it were not for developments in paper manufacturing, the logging boom in the region might have been short lived. The narrow band of white pines along the river corridors was being exhausted quickly. But shortly after the Civil War, an increasing national appetite for reading newspapers, now made from pulpwood rather than rags, created a new resource for the region. Spruce and fir trees needed for this new market were so abundant in the region that the first Maine Forest Commissioner's report in 1896 recognized the Androscoggin drainage as the most valuable spruce land in the Northeast.

Northern Forest Heritage Park

Aerial view of Milan, circa 1940. Note the log boom piers used to separate logs going to different mills.

Berlin was poised to take advantage of this new resource. A businessman named William Wentworth Brown added to the lumber operation at Berlin Mills by building or buying a number of pulp and paper mills beginning in the 1880s. The first paper was produced in 1886. By the turn of the century several major paper companies were in operation, and Berlin was home to three of the largest pulp and paper mills in the world. The Berlin Mills Company (which was not renamed the Brown Company until 1917) controlled three million acres of timberland in New England and Quebec. Berlin was incorporated as a city in 1897, and its population grew from 1,150 in 1880 to 9,000 by the turn of the century.

Around the same time, ownership and control of the Rangeley Lakes dams were consolidated under the Union Water Power Company. The Middle and Upper Dams were soon reconstructed, raising the water level further and flooding out the "Narrows" that had been a middle lake between Upper and Lower Richardson lakes. Although the restructured dams increased headwater storage, water discharge was now primarily managed to augment low summer flows for the textile industry in Lewiston, rather than to float logs.

Berlin was not the only area along the Androscoggin to take advantage of the growing paper industry. Although Rumford had missed the logging boom of the 1850s when the railroad bypassed the area, the pulpwood resources in the region could no longer be ignored. Hugh Chisholm (who had already brought the paper industry to Livermore downstream) capitalized on the potential power at Rumford Falls and the largely unlogged watersheds of the Bear, Ellis, and Swift Rivers. He purchased forestlands, brought rail service to the region, and dammed the powerful falls to form the Oxford Paper Company. With this rapid development, the population of the town skyrocketed to more than 5,000.

Growth in Tourism (1850 - present)

Although the logging and paper industry emerged as the dominant industry, it was not the only one to flourish in the region. Tourism and recreation began around the same time as the budding timber industry and continues to expand today. Even prior to the arrival of the railroad, a stage road from Andover to Lower Richardson Lake provided access to the extraordinary fishing and hunting opportunities throughout the Androscoggin Lakes region. Brook trout weighing 5 pounds and more were not uncommon and drew wealthy businessmen (known as "sports") from as far away as Boston, New York, and Philadelphia. Although not as prized by the vacationing angler, blueback trout were also abundant and an important local source of food and income. They were caught in large quantities by net and marketed to Boston and New York.

The arrival of the railroad eased access to the Rangeley Lakes and led to the establishment of many sporting camps along the shorelines. Although timber and other freight were the initial intended revenue source, the railroad companies quickly recognized the benefits of hauling passengers as well. They actively promoted the region as a tourist destination and helped to finance hotels, steamboats and activities in the region. Sports and their families would arrive by train and spend a week or a month at the lavish hotels or more remote camps.

As a hub and maintenance center for many of the early rail lines, Gorham experienced a burst of growth during this period as well. In addition to its proximity to booming Berlin, it became a tourist destination as the gateway to the White Mountains. A number of restaurants and hotels sprung up in and around Gorham, including the Glen House in the shadow of the Presidential Range. From the Glen House, tourists could take the Carriage Road all the way to the summit of Mt. Washington, the tallest peak in New England. Even at the summit, travelers could find shelter from the harsh alpine environment at the Tip Top House, which was built in 1853. Bethel also experienced a tourism-related boom at this time; its 1860 population of 2,523 was larger than any other time in the town's history.

Though the days of the grand hotels are long since past, the region has remained a major tourist destination, and hiking, skiing, hunting, fishing, snowmobiling, and wildlife viewing are an increasingly important part of the regional economy.


Northern Forest Heritage Park

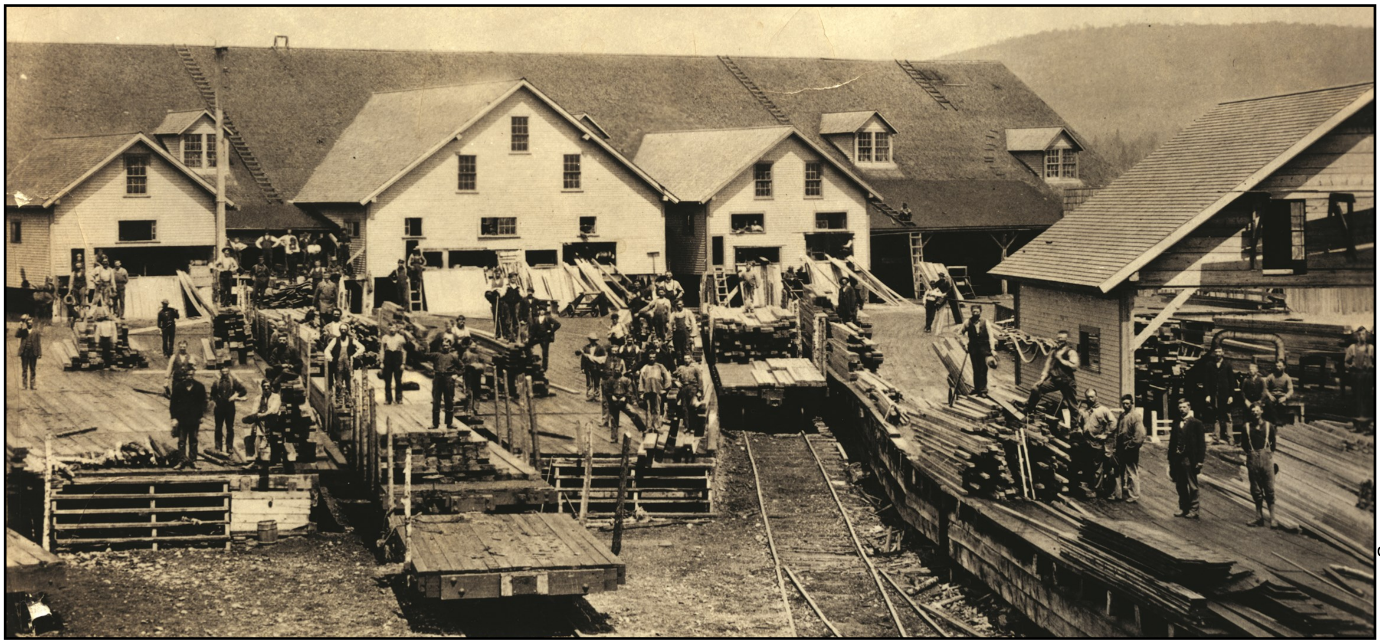
Driving logs in Hell's Gate on the Dead Diamond River

Overutilization (1875 – ?)

All of this recreational and industrial activity took its toll on the land and local economies. Declines in fish populations were one of the first areas where these effects were noticed. By 1880, the combination of dams and river contamination from timber, textile, and municipal waste had put an end to salmon migrations along the lower Androscoggin. But the previously pristine and productive waters of the upper Rangeley Lakes were soon experiencing similar problems. Increased sedimentation and water temperatures from timber harvesting along spawning streams, along with unregulated overfishing and non-native salmon introductions, caused crashes in the once abundant brook trout populations. Despite protections beginning in 1880, even the ubiquitous blueback trout was declared extinct in the region by 1905. The loss of these fisheries, along with major changes in the public's vacationing habits (such as the introduction of the automobile), led to the demise of many of the luxury hotels and a drop in tourism in the region that lasted through the Depression.

Downstream at Berlin and Rumford the growing paper industry introduced a new stress to the river ecosystem. In addition to waste generated from logging, sawmills, and municipal sewer systems, developments in pulpwood processing now added sulfur to the list of effluents being dumped directly into the Androscoggin River. The amount and toxicity of waste was increasing and would soon test the limits of the Androscoggin.

The growth and development of the paper industry also had a direct effect on the surrounding land. As demand increased, timber extraction continued to expand. Whereas the initial round of harvesting had focused on large trees (primarily pine and spruce) suitable for sawing into lumber, smaller trees could be utilized for pulpwood. Eventually hardwood as well as softwood pulp was used for papermaking, increasing the demands on the region's forests.



Northern Forest Heritage Park

The Wilson Saw Mills in 1887

The White Mountains were particularly hard hit during this time. As the last area in the region to be logged, it contained large tracts of virgin spruce after the supply on surrounding lands had been exhausted. Timber interests had acquired the lands from the state of New Hampshire and began to intensively log them in the 1870s. A comprehensive railroad system was put in place, which gave access to the remotest mountainsides. Within the Androscoggin watershed, the peak period of logging railroad activity was from 1890 to 1910, with lines built up the Wild River valley and from Berlin to Success Pond (allowing access to the north slope of the Mahoosuc Range). Trees were logged wherever they could be reached and vast areas were clearcut. Around the turn of the century devastating fires burned many cutover areas, leading to skies darkened by smoke and rivers choked with erosion from the barren slopes. Public concern that arose in the wake of these fires created the first conservation movement in the region.

Over time the fact that the forest was not limitless became clear. The massive clearing of large areas is a thing of the past. Social pressure, education and scientific advances have led to significant improvements in how forestlands are managed. However, the globalization of the timber industry and the exposure of the region's forests to an increasingly competitive marketplace are putting new pressures on both landowners and the forests they manage. The quality of timber management across the region is highly variable, and inappropriate practices such as overharvesting, high-grading (harvesting only the best quality trees) and liquidation harvesting (stripping a tract of all merchantable timber without concern for future management) remain a concern. Whether we have truly left behind the era of overutilization and entered a new era of sustainable forest management remains an issue of intense public debate.

Conservation (1900 – present)

In the first decade of the 20th century, the heavy logging and devastating fires in the White Mountains led to criticism from the tourist industry, conservation groups (including the Appalachian Mountain Club and the newly-formed Society for the Protection of New Hampshire Forests) and even the textile industry (due to concern about less reliable water flow). These groups advocated that the state buy back the high slopes and other special areas, and that the private sector practice responsible forestry. Unfortunately, because of political and economic considerations, the state was unable to act, and the private timber interests had no incentive to stop logging at this unsustainable rate. The need for federal action became evident during a discussion regarding a tract of land in the northern Presidential Range. Upon purchase of the land, the Berlin Mills Company publicly expressed an interest in preserving the scenic character of the mountain range, but admitted that the area would be logged because they could not afford to do otherwise.

As a result of this public concern Congress passed the Weeks Act in 1911, which created the White Mountain National Forest (and other National Forests throughout the east). Between 1914 and 1937 much of the land within the forest boundary was returned to public ownership, with the purchase of smaller areas continuing to the present. The forests have largely regenerated, and today the forest encompasses almost 800,000 acres, with more than 100,000 acres lying within the Androscoggin watershed.

The waters of the Androscoggin River also began to make a comeback in the early 1940s. For decades, the river had increasingly become an open sewer, with hundreds of thousands of tons of industrial and municipal waste dumped each year. The situation came to a head in Lewiston, when the smell of sulfur became unbearable during the particularly dry summer of 1941. As a result of public pressure, the upstream paper mills were slowly persuaded to take steps leading to the phase-out of sulfur emissions and other pollutants. Some of the solutions implemented on the Androscoggin were incorporated into the federal Clean Water Act of 1972. Over time, efforts to reduce industrial waste and treat municipal sewage have been extremely successful, and today the river has recovered to the point where it is a valuable ecological, scenic and recreational feature of the landscape.

Over the last several decades, other conservation efforts have shaped the pattern of land ownership and use in the watershed (see Land Conservation, page 78). Today there is increasing recognition that the ecological, social and economic future of the Androscoggin River watershed is intimately tied to how we treat the land. In 1999 the Androscoggin River Watershed Council was formed with the mission "to improve environmental quality and promote healthy and prosperous communities in the Androscoggin River Watershed." Citizens, landowners and public officials searching for answers to the question "How do we use the land without degrading its value to future generations?" are pointing the way to the future.

This millennium's emerging future

Closure of Berlin paper mill. The single-industry dominance and resource exploitation of the past is gone. After decades of decline, the former Brown Company pulp and paper mill closed in 2006 and was demolished. (An adjacent small paper mill in Gorham continues to operate utilizing market pulp.) With the closure of the mill the north country lost a major market for low-grade wood, changing the economics of timberland management throughout the region, though pulp mills in Rumford and Jay, Maine, continue to operate.

Emerging markets for low-grade wood. In 2014 a portion of the former Berlin paper mill site was redeveloped as a wood biomass electrical generating plant. While utilizing less wood than the former pulp mill the plant provides a new market for low-grade wood. In addition, the use of wood (including solid wood, chips and pellets) for heating is increasing throughout the region. In New Hampshire the harvest of wood biomass has doubled since 2005 and now constitutes nearly half of the state's timber harvest (though the proportion is likely lower in the north country due to the continued availability of pulpwood markets in Maine). These emerging markets have helped forest management remain economically viable for landowners. However, biomass harvesting typically removes the whole tree for chipping raising concerns about effects on soil fertility and wildlife habitat.

Continued support for land conservation. The modern era of land conservation in the region since the 1970s has continued. State and federal agencies, conservation organizations, land trusts, and local officials and citizens are working to keep the region's forests as forests and protect the most ecologically, recreationally and scenically significant areas. Since 2003 conservation land increased from 25% to 32% of the upper Androscoggin watershed. In New Hampshire examples include expansion of the Umbagog National Wildlife Refuge and Appalachian National Scenic Trail corridor in Success Township, and creation of the Jericho State Forest in Berlin. In Maine acquisitions and easements in the Mahoosuc Range, Tumbledown Mountain, and Boundary Headwaters along the Maine/Canada border took place (See Land Conservation, page 78).

Continued changes in land ownership. While the rapid pace of land ownership change from the 1990s to the early 2000s has slowed, the changes have continued. GMO Renewable Resources (which acquired the International Paper lands in 2004) sold their land in Maine and New Hampshire to John Malone (the nation's largest private landowner) in 2011, and Plum Creek merged with Weyerhaeuser in 2016. (See Land ownership Change, page 76.)

New recreational infrastructure. There is increasing effort to expand and diversify a year-round recreational economy in the region. The Grafton Loop Trail in the Mahoosucs provides new hiking opportunities, and new public lands (such as the Umbagog NWR and Tumbledown Mountain) provide additional destinations for hikers, paddlers and wildlife viewers. The Jericho State Forest in New Hampshire was established to provide riders of all-terrain vehicles (ATV) a trail network on public land. (See Recreation, page 68.)

Large-scale energy development. The Androscoggin River watershed has long been a major source of hydroelectric power. With the transition away from fossil fuels the upper Androscoggin watershed now contains five wind power facilities and a biomass electrical generation plant. A proposed transmission line to bring Quebec hydropower to southern New England (Northern Pass) would have carved a new 25-mile corridor through the western edge of the watershed, but was denied a permit. These projects were controversial and the appropriate balance between open space conservation and renewable energy projects will continue to challenge the region. (See Energy Development, page 72.)

This millennium holds both new opportunities and challenges for the region. Still to be determined is how the natural character of this special region will be preserved while building a more diverse and sustainable economy.

— Timber Harvesting —

"The first cut was for long logs, fifty-six feet in length. The next was for spruce, fir, and pine with a minimum stump diameter of fourteen inches, breast high. Then it was cut for four-foot pulpwood of spruce, fir, and poplar, at a nine-inch stump diameter. The next cutting was for old-growth maple and yellow and white birch for furniture making, at a stump diameter of over twelve inches. Finally all species of hardwood and softwood with a stump diameter of eight inches or over were cut for four-foot pulpwood."

Robert E. Pike in *Tall Trees, Tough Men* (1967), describing the progression of logging on Dartmouth's Second College Grant between 1887 and 1937.

For two hundred years timber harvesting has shaped the landscape of the upper Androscoggin watershed. While the impacts of development and dam-building are more intense, timber harvesting affects more of the watershed than any other use.

The technology of harvesting has changed considerably since the early years. Crosscut saws and hand axes, horse skidding and river drives were the norm until the Great Depression of the 1930s. Around the time of World War II, chainsaws replaced axes, motorized skidders replaced horses, and hauling by truck replaced the river drives. The last long-log drive on the Androscoggin took place in 1937, though driving of pulpwood continued until 1963. Today a network of logging roads reaches into every corner of the forest. Even chainsaws are disappearing, as more and more harvesting is done with mechanized harvesting machines.

Over the same period the philosophy of land management has also changed. To early settlers, the forest was something to be cleared for other uses. The early timber barons gave no thought to sustainability—the old-growth forests were a resource to be mined, and when the timber was gone they simply moved on to other areas. Even as land came into long-term ownership of paper companies and families, the forests were not truly managed—they were simply allowed to regrow until the trees were once again large enough to harvest.

Following the boom years from the mid-1800s to the early 1900s, harvesting in the region declined as the forests were depleted and the Great Depression reduced demand for wood products. However, with the economic boom that followed World War II, harvesting in the maturing forests of the region picked up.

The last half century has seen a continuing trend of both increasing timber volume and increasing harvest levels. Data from periodic inventories conducted by the US Forest Service (the Forest Inventory and Analysis) show that across northern New Hampshire and western Maine[1], total timber volume increased by more than one-third between the early 1970s and the mid-2000s, though the increase has slowed over the last decade (Fig. 10). At the same time, total harvest in the two western Maine counties increased by more than 80% between the mid-1980s and 2017. (Equivalent data for New Hampshire is not available.)

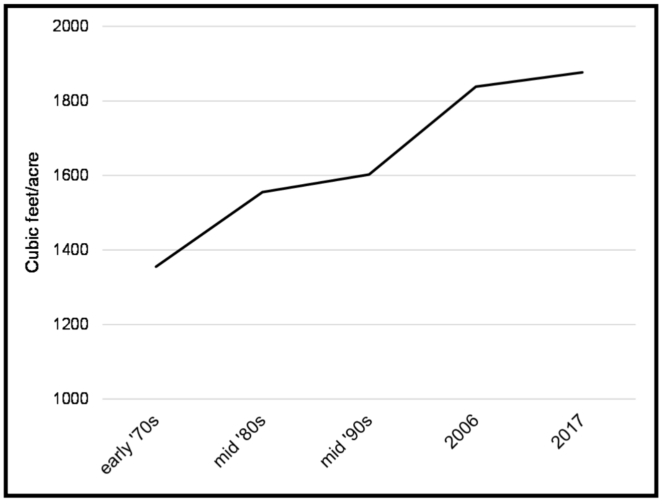


Figure 10 — Merchantable timber volume, northern New Hampshire and western Maine

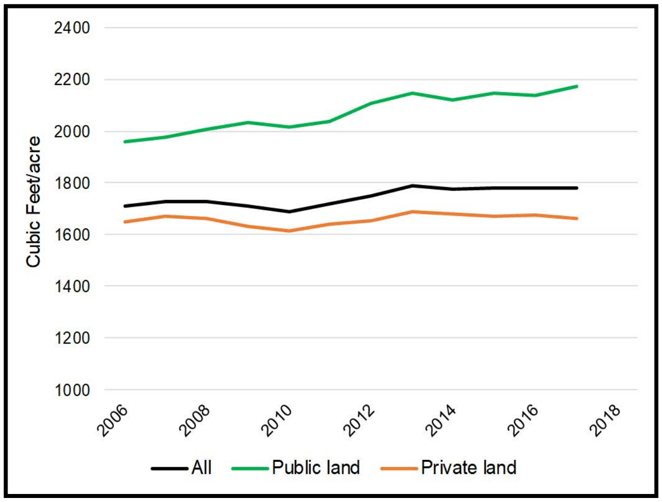


Figure 11 — Merchantable timber volume, Coos and Oxford counties

[1]Carroll, Grafton and Coos counties in New Hampshire and Franklin and Oxford counties in Maine.

The region may now be at a turning point, where harvests have caught up to, and are in relative balance with, growth. Since 2006 timber volume stocking has increased only slightly in the upper Androscoggin watershed region (Coos and Oxford counties) (Fig. 11), and is currently about 1800 ft^3/acre (21 cords/acre). Over this period harvesting has equaled about 95% of net growth. Whether this balance will be maintained over the long term is unknown. Changes in current conditions (such as a major spruce budworm outbreak or changing economic conditions) could lead to changes in harvest levels, particularly on large commercial ownerships.

There is a clear difference in the timber volume trends on public and private lands (Fig. 11). Public lands contain about 16% of the forested land in the upper Androscoggin watershed, large commercial forestland ownerships about 57% and other private lands about 27%. Timber volume on public lands has increased about 1% per year since 2006 and is now about 30% higher than on private lands. In contrast, stocking on private lands has remained relatively unchanged over the same period. The greater maturity of public lands is also reflected in the distribution of stand size classes; private lands have a significantly higher proportion of seedling/sapling stands and a lower proportion of sawtimber stands than public lands (Fig. 12).

The increased harvest levels in recent decades has not resulted in greater employment in the forestry and logging sector. Instead, employment consistently declined from 1990 to the mid-2000s, particularly in Coos County (Fig. 13). This is a result of the increasing mechanization of timber harvesting, with hand crews replaced by more productive mechanized harvesting equipment. However, along with harvest levels employment has remained relatively stable over the last decade, indicating that this trend may have fully penetrated the logging industry.

Clearcut

Today the management of the region's forests is being driven by two opposing forces. On the one hand, forestry is making the transition from managing timber to truly managing forests. Foresters began to apply modern principles of silviculture introduced into this country from Germany in the early 1990s, and timber was increasingly managed as a crop. "Logging" had become "forest management", though the focus was first and foremost on timber, and "sustainability" meant sustaining the flow of wood products.

However, sustainability means more than just maintaining the flow of wood—it means maintaining all aspects of the forest ecosystem. This change has been driven by both increasing public concern about the ecological future of the planet (extending to concerns about forest management) and increasing scientific understanding of forest ecology. Foresters and land managers now realize their job includes more than growing trees—it means identifying and protecting ecologically sensitive areas and ensuring that the full range of biological diversity is being conserved. Ecologically-minded foresters are turning to a more "naturalistic" style of management, using natural patterns of disturbance as a guide to harvesting, with the goal of maintaining a forest that more closely

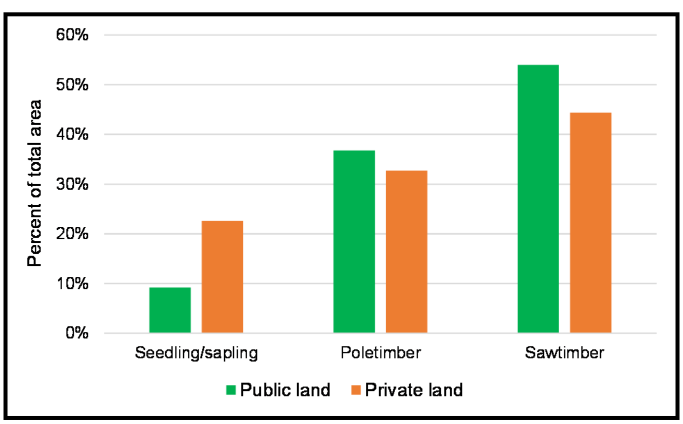


Figure 12 — Stand size class distribution, Coos and Oxford counties, 2017

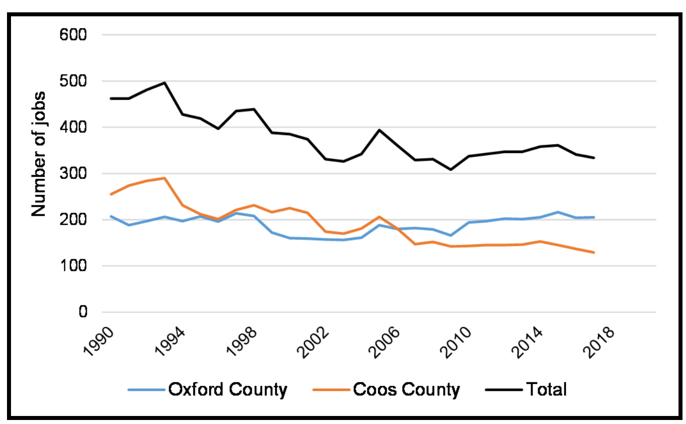


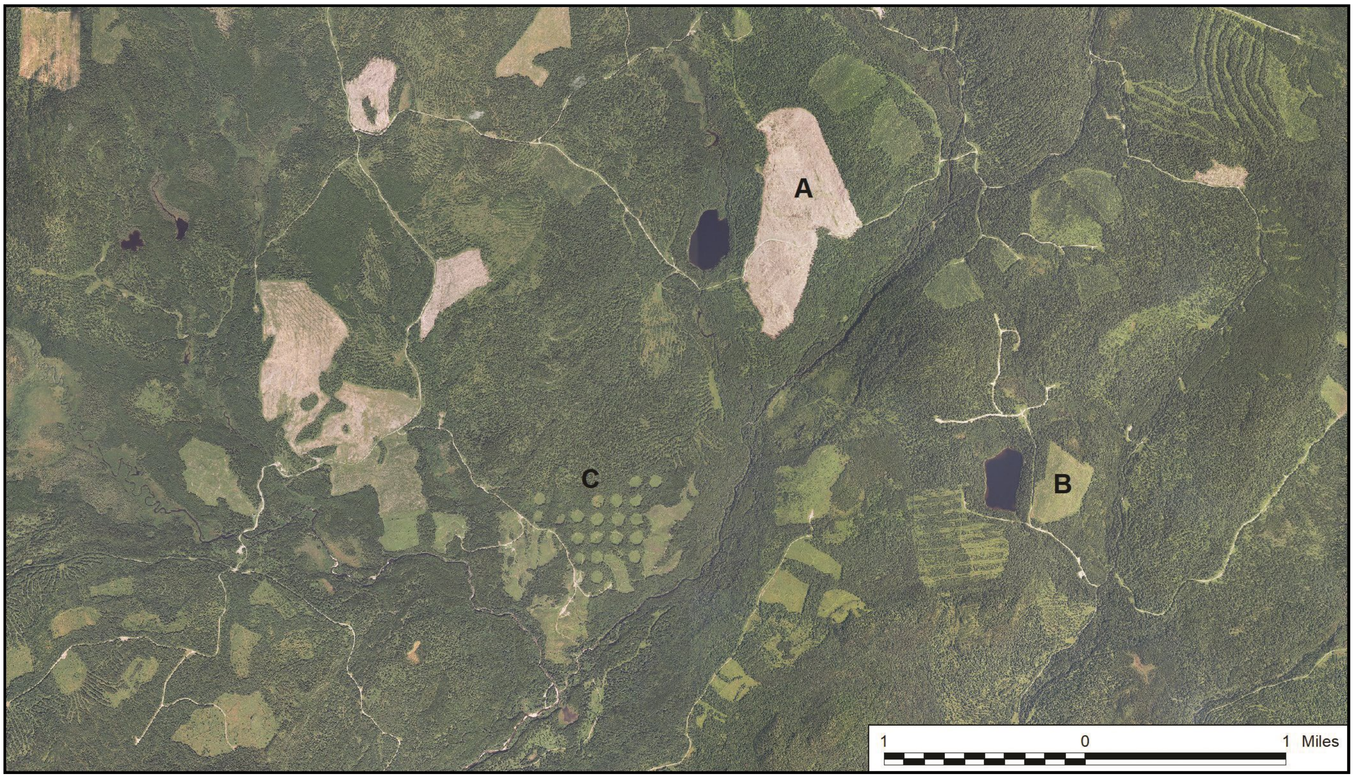
Figure 13 — Employment in the forestry and logging sector

resembles the composition and structure of the natural forests of the region. This means among other things creating and maintaining forests that are dominantly multi-aged rather than even-aged and which contain more large trees and more dead wood. There is little question that the practice of forestry has improved considerably over the past twenty five years.

On the other hand, commercial forest landowners are now part of a global economy. In this highly competitive environment, the corporations and investor groups that own nearly 60% of the upper watershed's forests are under strong pressure to meet the financial expectations of shareholders. Advances in harvesting and wood processing technology are allowing trees to be harvested at ever-younger ages. Practicing ecologically sustainable forestry comes with a cost, as more trees must be left in the woods or allowed to grow to advanced age. From a purely economic perspective, there is little incentive to grow large trees or maintain mature, high volume stands of timber, though these are critical components of a healthy forest ecosystem.

The influence of these two opposing forces will to a large degree determine the future of the region's forests. It remains to be seen whether an appropriate balance can be struck between the "economically rational" and the "ecologically sustainable"—whether the region has left behind the boom and bust cycles and entered a period of true economic and ecological sustainability, or whether economic forces will continue to push the region toward another round of overharvesting and depletion.

Shelterwood harvest



Timber harvesting patterns on private commercial forest land in the upper Androscoggin watershed. Openings range from 225 acres (A) to 50 acres (B) to 2 acres (C).

— Recreation —

Rafting on the Pontook Rapids

The upper Androscoggin River watershed has long been recognized as a premier recreation destination. With the penetration of railroads into the region in the mid-1800s (Gorham became accessible from Portland, Maine by 1851) the region became accessible for mass numbers of urban tourists, eager to escape the unpleasantries of Victorian-era cities. So began the grand hotel era in the White Mountains. In the early 1860s word spread of eight brook trout whose total weight exceeded 52 pounds taken from Rangeley and the town was soon transformed from a small rural farming community into a popular destination for sportsmen and sportswomen. The arduous trip by buckboard was soon supplemented by the steamers plying the lakes as dams were build and the region's lakes expanded in size. By 1891 a narrow gage logging railroad had reached Rangeley, making it more accessible for tourists, which in return catalyzed larger scale camps and hotels with amenities like golf and tennis.

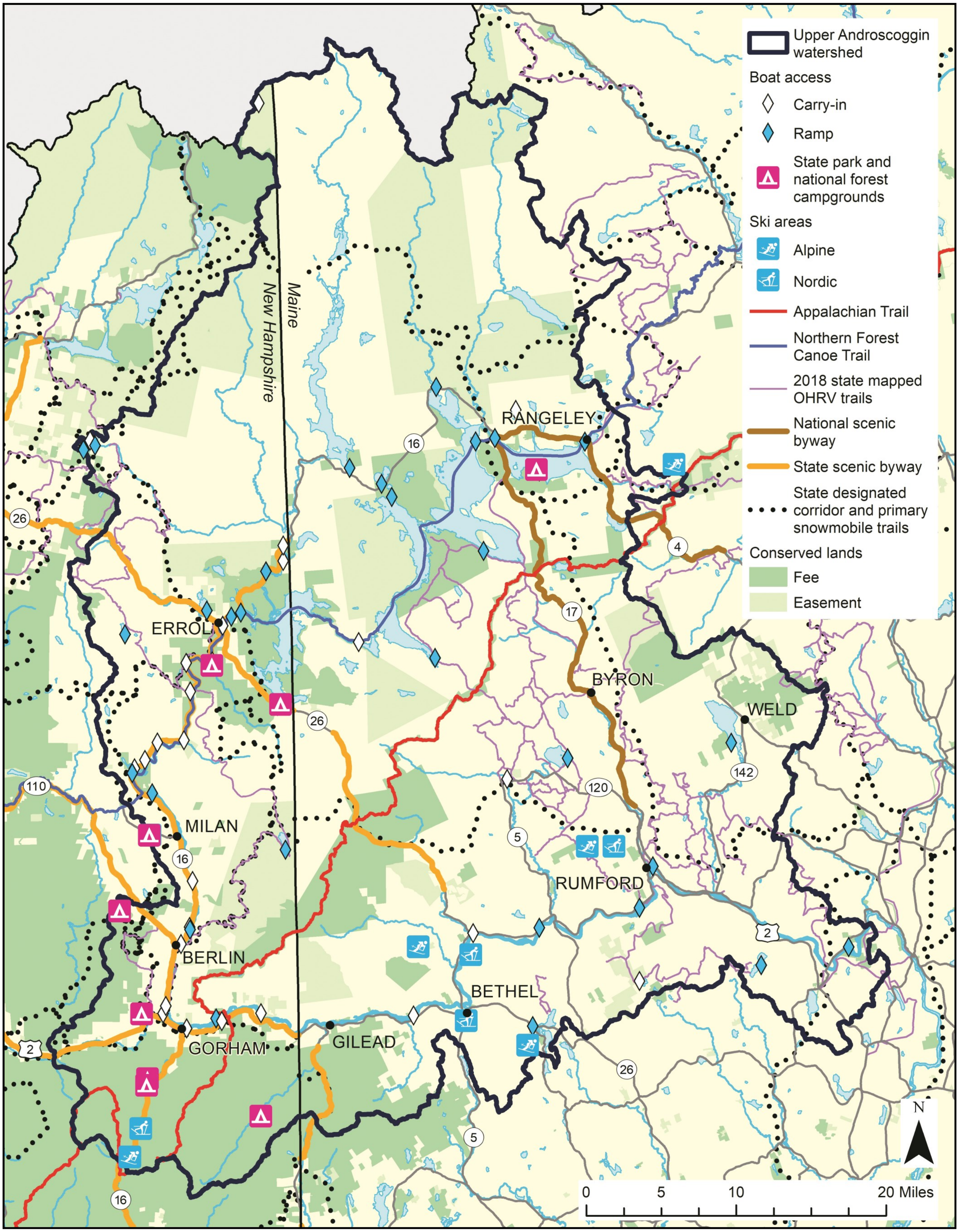
Skiing was first brought to the region by Scandinavians working at the mills in Berlin, N.H. and has become one of the most popular winter activities for residents and visitors alike. Berlin's famous Nansen ski jump hosted the 1938 Olympic trials, attracting 25,000 spectators, and numerous US Championships. After a period of neglect, it was recently renovated and is now within the Nansen Ski Jump State Historic Site, a state park that also features a picnic area and boat launch on the Androscoggin River. Sunday River Ski Resort was started in Newry, Maine, in 1959 as a small local ski mountain; today it is one of the premier alpine ski areas in the East. Commercial cross-country ski areas with groomed trails have also become quite popular since the late 1970s, and snowshoeing has seen a major resurgence. The commercial alpine and cross-country ski areas (Map 38) attract thousands of skiers and now are a major winter contributor to the region's economy.

Hunting and fishing have been part of rural life as long as people have been in the region. While the number of licensed hunters is decreasing in both states and throughout the nation, hunting traditions are still very strong in the upper Androscoggin watershed. Canoeing, once the primary way to access fishing, and now kayaking and rafting as well, have become popular activities in their own right. The Magalloway, Rapid and Androscoggin rivers offer Class I – IV whitewater boating. The Androscoggin Canoe Trail from Lake Umbagog to the sea and the Northern Forest Canoe Trail offer multiday paddling and camping experiences along with the larger lakes. Once highly polluted from Berlin to the ocean, this reach of the Androscoggin River today offers excellent trout and bass fishing. The Androscoggin River upstream of Berlin, N.H. and many lakes and colder tributaries to the Androscoggin still host some of the best remaining cold water fisheries, particularly for native brook trout. The Rangeley region still retains some of the classic sporting camps that go back to the late 1800s, though their business models have expanded beyond the classic hunting and fishing seasons.

In the late 1800s, the Appalachian Mountain Club popularized hiking and camping in the region. Today the region hosts a segment of the 2,174 mile long, world-famous Appalachian National Scenic Trail, along with hundreds of miles of other hiking trails that showcase the region's spectacular topography. The Presidential Rail Trail, Bethel Pathway and other closer to town multi-use trails are now also part of the region's recreational fabric.

Views of rugged ridgelines and wide river valleys, together with spectacular fall foliage, and short hikes as leg-stretching diversions, all contribute to making scenic driving so attractive and one of the most popular pursuits for visitors in this region. Along with sightseeing, studies also identify wildlife-viewing as having one of the highest outdoor activity participation rates, both nationally and in this watershed. Moose watching is one of the favorites and numerous roadside habitats consistently have moose present in this region. Additionally many motorcyclists and bicyclists are attracted to these same attributes. Recently the popularity of mountain biking has expanded, both on specially built trails and the region's numerous dirt roads.

Mechanized outdoor recreation, first in the form of snowmobiling and more recent all-terrain vehicles (ATVs), now is economically important to the area's recreation industry. In New Hampshire, official ATV riding areas in the region include trails in Millsfield and Success, and the newly-created Jericho Mountain State Park in Berlin. Numerous snowmobile and ATV clubs have formed to both maintain the trails and to address the challenges of having their extensive trail networks primarily on private lands. Unlike the boom and bust cycle of the wood industry, the outdoor recreation economy has changed but remained a constant for this region's economy.



Map 38 — Recreation resources

— Shoreline Development —

Compared to other areas in the eastern United States, the upper Androscoggin watershed is a "wild place." Even though the region remains heavily forested, with only a few percent of the land converted to other uses, land near river and lake shorelines is most affected. In hilly and mountainous terrain river and stream valley bottoms typically were the primary sites for the early construction of cities, towns, railroads, agriculture, highways and logging roads. This region was no exception. Even prior to European settlement, Canton Point on the Androscoggin River in Canton, Maine, was the center of the Anasagunticooks (or Androscoggin) Abenaki Indians and the largest Native American village in New England with more than 500 acres cleared for corn. By the early 1900s the log and pulp drives, severe industrial and municipal pollution, and periodic flooding discouraged residential and second home development along the Androscoggin River and its major tributaries. Today most of those inhibitions are a thing of the past and residential and second home shorefront development has been steadily increasing.

The real estate business mantra is "location, location, location" with lake and pond shorefront property being highly desired locations for both year-round and second homes. Historically the region's lake shoreline was much smaller before the damming of the lakes. Aziscohos Lake did not exist until 1911, and the headwater storage lakes were much smaller. Lake Umbagog's size was increased fivefold, Upper and Lower Richardson lakes, and Mooselookmeguntic and Cupsutic lakes, respectively, were merged waterbodies when dams raised their water levels, greatly expanding their shorelines. Unlike the lakes and ponds in central and southern Maine and New Hampshire whose shorelines succumbed to dense development following World War II and the development of major highway systems, shoreline development in the upper Androscoggin River watershed has taken place much more slowly. Important determinants are its distance from major population centers, not being served by high speed roads, and that much of the shoreline of these "working lakes" were owned by paper companies. Historically they leased small hunting and fishing camp lots to their employees. Larger sporting camps also dotted the region's lakes.

The turbulent breakup of the paper companies' mills, hydroelectric dams and lands starting in the 1980s has created new landowners and shoreline development threats. Many of the leased shorefront lots were forced sales at today's prevailing market prices. Old camps along with newer shorefront structures are now rebuilt or constructed for year-round occupancy. These major changes in land ownership also created new opportunities as conservation groups and various agencies focused on

Satellite image showing shoreline development around Bald Mountain. Oquossoc, Maine is in upper center, Rangeley Lake to the right, and Mooselookmeguntic Lake to the left.

protecting the prime shorefront lands, for both their ecological and undeveloped scenic values. Resulting from these new development pressures, particularly on the undeveloped shorelines, Maine's Land Use Regulatory Commission (now Land Use Planning Commission) developed its first Regional Plan in 2001 for the Rangeley area's unincorporated towns, defining six new zoning subdistricts to reduce "rural sprawl" and to focus development in the more developed areas where services are available.

Simplified, the region's shoreline development, though mostly low density and rural in nature outside of the major cities and town areas, can be grouped into four classes (Map 39 and see Appendix A. *Note*: In the case of rivers and streams the roads or development may only be on one riverbank, and fields or forests may buffer this development):

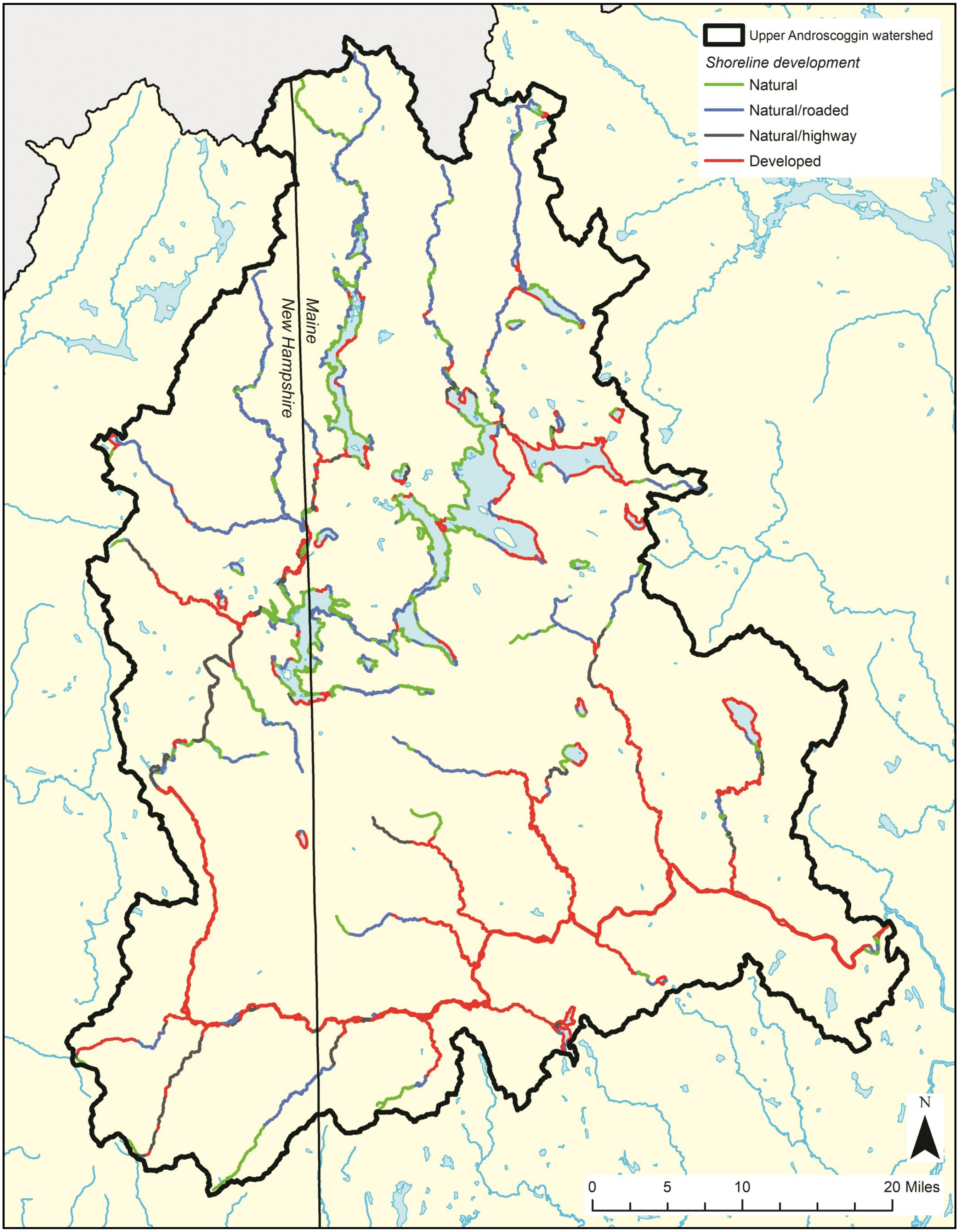
Developed: shorelines containing developed towns and cities, agriculture or clusters of buildings within ¼ mile,

Natural/highway: shorelines surrounded by natural vegetation but with a state or federal highway within ¼ mile,

Natural/roaded: shorelines surrounded by natural vegetation but with a secondary public road or improved private logging road within ¼ mile,

Natural: shorelines without roads or development within ¼ mile.

Downstream of Milan, New Hampshire most of the Androscoggin River, the tributaries downstream of Bethel, Maine, as well as Webb Lake, Rangeley Lake and the eastern shore of Mooselookmeguntic Lake were historically developed to a degree. The other rivers in the upper watershed, outside of headwaters in the White Mountain National Forest, are mostly paralleled by a logging or other road. The most extensive areas of remaining undeveloped lake shoreline are along portions of Kennebago, Mooselookmeguntic, Richardson, Umbagog and Aziscohos lakes.



Map 39 — Shoreline development

— Energy Development —

In addition to timber, the forests and waters of the upper Androscoggin watershed have long provided another valuable resource—energy. With the need to reduce fossil fuel use to address climate change, the energy resources of the watershed are attracting increased interest. Today this watershed's energy is derived from three primary sources—water, wood and wind. Most of this energy is now exported to other New England energy markets.

Water. Early industrial development in the United States relied on waterpower as its primary power source, initially hydromechanical for grist mills and sawmills. With natural waterfalls in the Berlin, Rumford and Jay areas, these sites became the location of the region's pulp and paper industry that required large quantities of power. Most dams in the upper Androscoggin watershed were first developed and operated by the pulp and paper companies to serve their mills—to float logs and to power their mills. The advent of hydroelectric power generation in the early 1900s led to the transformation of hydromechanical to hydroelectric power generation. With the decline of the pulp and paper industry, their hydroelectric generating plants were some of their most valuable assets and were purchased by electric power generating companies.

Today the upper watershed contains 15 hydroelectric dams with a total generating capacity of 120.2 megawatts (MW)[1]. (Map 40; also see Lakes and Rivers, page 48.). They are primarily operated in run-of-river mode, and not to meet daily peak energy demand.

Wood. For the earliest settlers, wood was the primary energy source for heating and cooking. Later wood was used to remove timber from the forests with steam-powered winches, called donkeys, and wood-fired locomotives. The use of wood for heating has fluctuated with the availability and price of other energy sources (primarily oil) but is seeing a resurgence in the region. Whether as solid wood or manufactured pellets, when used in modern stoves and furnaces wood can be an energy-efficient and renewable heating source. There currently is no wood pellet plant in the upper Androscoggin watershed, though its wood is exported to neighboring wood pellet plants.

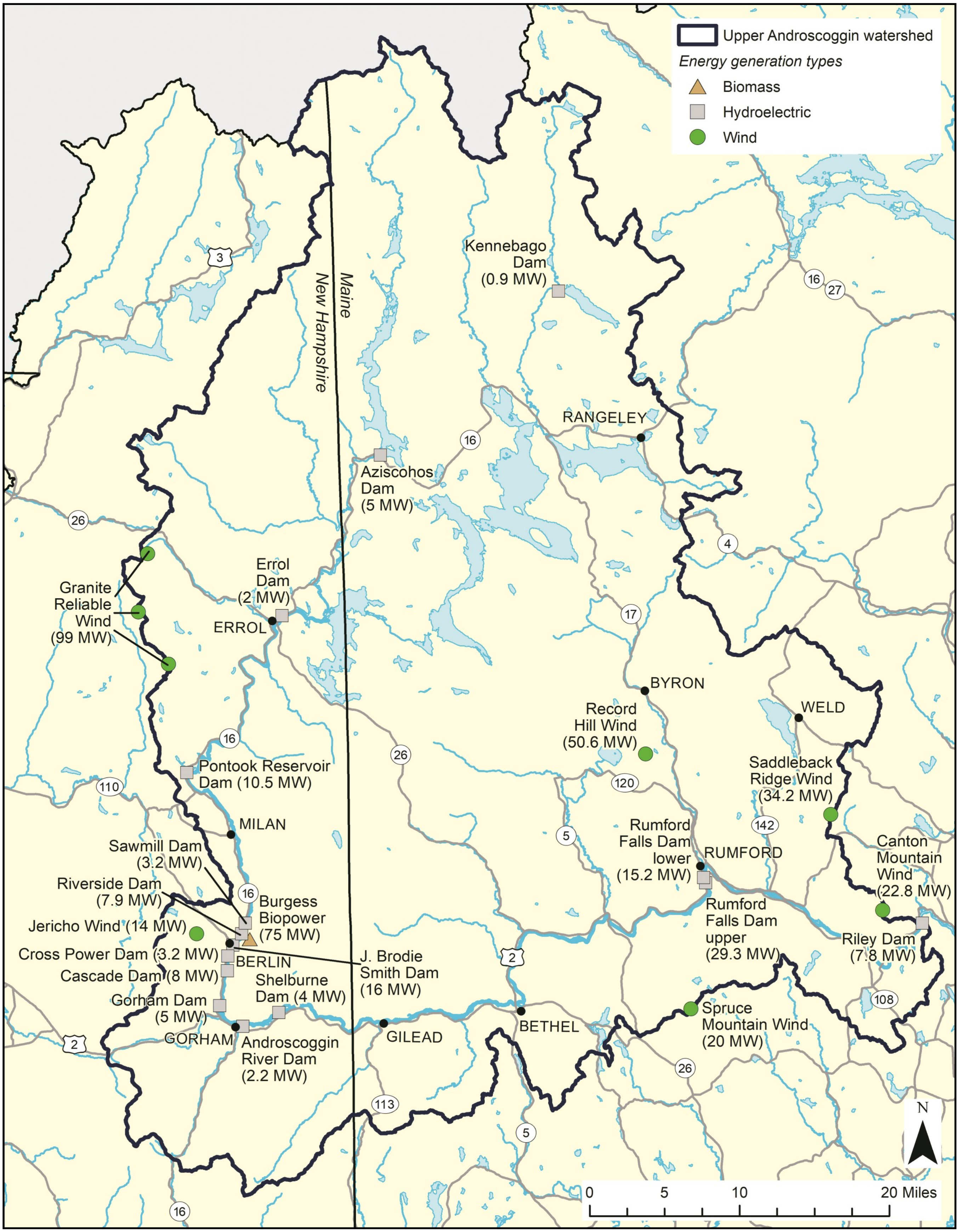
There is also interest in using wood for electrical generation. The 75 MW Burgess BioPower plant in Berlin was constructed on the site of the old pulp mill. This and other similar facilities are controversial; they are a relatively inefficient use of wood and are more likely to remove whole trees from the woods that are then chipped, raising concerns about forest sustainability.

Wind. Since the early 2000s wind power has been the fastest-growing source of new electrical generation in the United States. The upper Androscoggin watershed now contains six utility-scale wind farms with a total capacity of 240.6 MW (Map 40), with the largest wind farm being the 99 MW Granite Reliable Power south of Dixville Notch in New Hampshire. At least two other sites are under consideration for development. Wind turbines are large structures requiring large roads for construction and maintenance. While the tallest turbines in the watershed are about 450 feet tall, projects in other parts of the region are approaching 600 feet tall. Many of these projects have been controversial due to their location on undeveloped ridgelines where the winds are strongest, and their impact on scenic and wildlife habitat.

Other. No utility-scale solar energy facilities currently exist in the upper Androscoggin watershed, though site prospecting is ongoing. However, rapidly declining costs have led to a significant increase in its use for on-site electrical generation at homes and businesses. For example, Mt. Abram Ski Area with its energy-intensive snowmaking now generates 70% of its electric power needs from solar power.

33-turbine (99 MW) Granite Reliable Power wind farm in Dixville and Millsfield, N.H.

[1] A watt is a standard measure of power. A facility's "nameplate capacity" (usually measured in MW, one million watts) is power a facility can instantaneously produce at full capacity. Total energy generation is calculated as power multiplied by time, e.g. megawatt-hour (MWH). The "capacity factor" is the average amount of power generated divided by the nameplate capacity. The capacity factors and electric grid demand dependability of hydro, biomass and wind generation differ considerably because of the inconsistency of winds and river flows, the variability of shutdowns for facility maintenance, and the differing costs to produce the power that influences their salability into the New England region electric grid.



Map 40 — Energy development

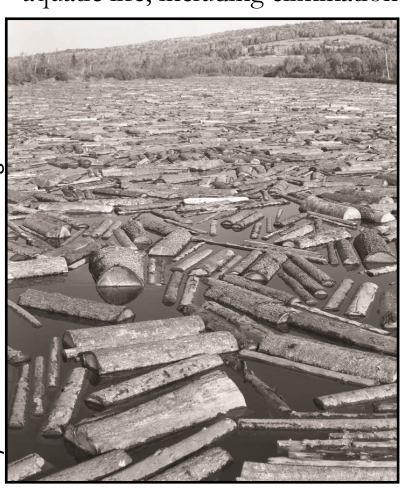
— Water and Air Quality —

As late as the 1970s the Androscoggin was considered one of the most polluted rivers in the United States. Described as "too thick to paddle, to thin to plow," it was a well-landscaped sewer that darkened the paint on nearby buildings and threatened the health of anyone unlucky enough to fall into it.

As manufacturing and industry evolved in the late 1880s, the river was used not only as a log transportation system and as a source of power, but also to dispose of industrial and domestic sewage. Until the 1880s paper was made primarily from rags and some mechanical pulping of wood. With the introduction of the sulphite pulping process the ability to use wood in the papermaking business was greatly increased. Adopted by the Androscoggin River mills the subsequent discharge of this process's untreated waste liquors laden with oxygen-devouring chemicals and insoluble sediment into the river was devasting, gradually covering the river bottom, destroying aquatic life and the river's natural 'self purification' processes that the mill operators contended would take care of their sewage.

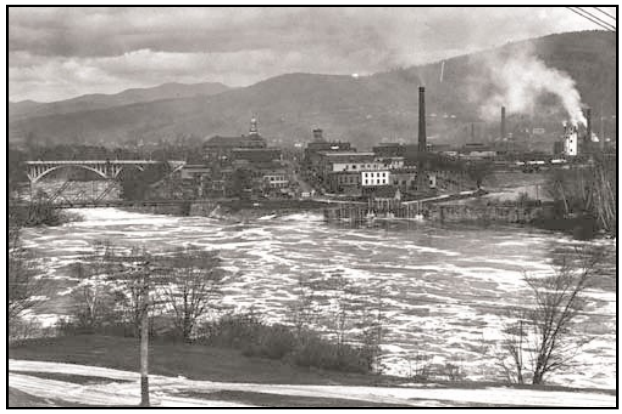
The untreated municipal waste water of the pulp and paper mill towns' burgeoning populations compounded the burden. In addition by 1963 the century plus of log and then pulp river driving resulted in thousands of pulp logs sinking and becoming embedded in the riverbed. As with earlier drives of long logs, bark and resinous sap from the pulp wood discolored the water and deposited solids on the bottom, adding to the already severe water pollution problems.

The construction of dams resulted in the impoundment of water, increasing the water temperature, lowering oxygen levels in the water, and inhibiting fish passage. The cumulative impact of the dams and waste discharges came at the expense of aquatic life, including elimination by the 1880s of the Atlantic salmon that had annually migrated as far upstream as Rumford Falls in Maine. People living near the river were also were affected by the odor of "rotten eggs" emanating from the river, which by the drought year of 1941 caused paint to peel off of buildings. Out of the suffering caused by this pollution came a vocal and politically active populace that gave birth to a nascent movement to recover the river.



Plymouth State Univ.-Brown digital collection

Leachate from log drives added to the river's pollution.



Randall Bennett

River foam in 1934 at the Rumford Mills from tons of untreated industrial and municipal sewage.

Many of the nation's rivers suffered similar fates until the passage of the federal Clean Water Act of 1972 that put an end to untreated point source pollution. This was paralleled by the infusion of millions of federal dollars to subsidize the construction of municipal waste-water treatment plants. Today all of the major industrial discharges are treated and there are four municipal wastewater treatment plants in the upper watershed (at Berlin, Gorham, Bethel and Rumford/Mexico). Many old-timers have a difficult time accepting how clean the river is today. The river once again supports fish, bald eagles and osprey and much of it is clean enough for swimming and boating. However, some outstanding water quality issues still remain, including dioxin and mercury.

Dioxins are a family of chemicals that have a wide range of adverse effects on human health. It is created as a byproduct of chlorine-based pulp and paper bleaching. Though changes in papermaking processes and mill closures have greatly reduced (and will eventually eliminate) dioxin releases to the river, dioxin levels in fish remain a concern. Both Maine and New Hampshire recommend against eating any fish caught in the river from Berlin to Merrymeeting Bay.

Mercury is a toxic metal especially dangerous to pregnant women and young children with eating fish being a primary source. Though mercury is naturally present in soils, the primary sources in this watershed has been long distance atmospheric transport from coal burning power plants and municipal trash incinerator emissions. Because Maine and New Hampshire lie downwind of most major mercury sources, the levels of mercury in the region's lakes and rivers are among the highest in North America. Both states maintain advisories recommending limited consumption of fish due to high mercury levels for all lakes and rivers in this watershed. Regulations to address mercury emissions since 1990 have greatly reduced but not eliminated the atmospheric input of mercury. Unfortunately, the headwater reservoirs and lakes, whose levels are manipulated to store water for downstream use, may be acting as traps for this transported mercury and providing the right conditions for bacteria to convert inorganic mercury to the much more toxic form of methyl mercury that accumulates as it moves up the food chain.

The Rangeley Lakes region is a biological hotspot where mercury levels in loons, bald eagles, otter, mink, brook trout and salmon can exceed levels considered adverse.

More recent analysis of the mountain forest-dwelling songbird, Bicknell's thrush (the most highly ranked migrant songbird for conservation) also show mercury building up in their blood and feathers, with the highest levels in the western Maine mountains. This bird feeds on insects making it susceptible to methylmercury bioaccumulation in the food chain. Montane mountain forests are known to receive high inputs of mercury due to their greater cloud, dry deposition and wet precipitation events.

Today non-point source pollution is the nation's largest water quality problem and the upper Androscoggin is not exempt from it. Non-point source pollution does not arise from a single source (such as a factory or sewer pipe), but rather comes from sources broadly dispersed across the landscape, and is difficult to control. In undeveloped areas the major concern is sediment, which comes primarily from unpaved roads, particularly logging and skid roads. While proper road construction and maintenance can minimize erosion of sediment to streams, heavy rains or blockage of drainage structures can occasionally cause "washouts," leading to large inputs of sediment. In agricultural areas below Bethel, movement of bacteria, sediment, fertilizer and pesticides to rivers and lakes is a concern, and in developed areas road salt, bacteria, heavy metals, toxic chemicals such as oil and cleaning fluids, and trash can all be transported to nearby waters.

Sportsmen also contribute to lead pollution. Decades after the United States banned lead in gasoline, it is still found in shotgun ammunition used for waterfowl hunting, and fishing tackle. Loons and other waterfowl swallow gravel for their gizzards to grind up food and in the process ingest shotgun pellets and lost lead fishing sinkers. The lead leaches into their bodies causing lethargy, paralysis and then death if they have not already been killed by a predator. From 1989 to 2012 forty-four percent of loon mortality in New Hampshire was caused by lead fishing tackle. New Hampshire and Maine now ban lead sinkers less than one ounce in size.

Both New Hampshire and Maine have classified rivers based on desired water quality and allowable uses. New Hampshire has two classes (A and B) that apply to both lakes and rivers. Maine has four classes (AA, A, B and C) that apply to rivers and one (GPA) that applies to all lakes and ponds. The higher the classification, the more stringent are the water quality goals and standards. Maine's Class AA rivers are considered outstanding natural resources where the goal is to maintain water quality parameters at natural levels, whereas Class C allows the greatest degree of change to water quality. Discharge of treated wastewater is prohibited in New Hampshire Class A and Maine Class AA waters but allowed for all other classes. However, the goal for all classes in both states is to maintain water that is swimmable, fishable, suitable for drinking after treatment, and which supports aquatic life.

In New Hampshire, most waters (with the exception of public drinking water supplies) are Class B. In Maine, the Cupsuptic, Kennebago, Rapid and Bear rivers are Class AA, the Androscoggin River (between the New Hampshire border and its confluence with the Ellis River, Maine) and the lower portion of the Swift River are Class B, and the Androscoggin River downstream of the Ellis River is Class C. All other rivers in Maine's upper Androscoggin watershed are Class A. States also maintain lists of "water-quality impaired" rivers and lakes. Most waters assessed are not impaired with the exceptions of the mercury advisory that applies to all lakes and rivers, and the dioxin advisory on the Androscoggin River downstream of Berlin. Both Aziscohos and Richardson lakes are considered impaired due to habitat concerns from the large fluctuations in lake levels that result from dam operations.

Serious air quality problems that plagued the mill towns are now a thing of the past. However, AMC's research on Mount Washington has shown that higher elevations in the watershed are subject to higher levels of acidic deposition due to long-distance transport of pollution and high levels of precipitation and "fog drip" from clouds. Acidic deposition is declining following the passage of the Clean Air Act Amendments of 1990. This Act also contributed to the reduction in regional haze and improved visibility. Long distance atmospheric transport above the planetary boundary layer also results in higher elevations having greater concentrations of ozone from urban smog.

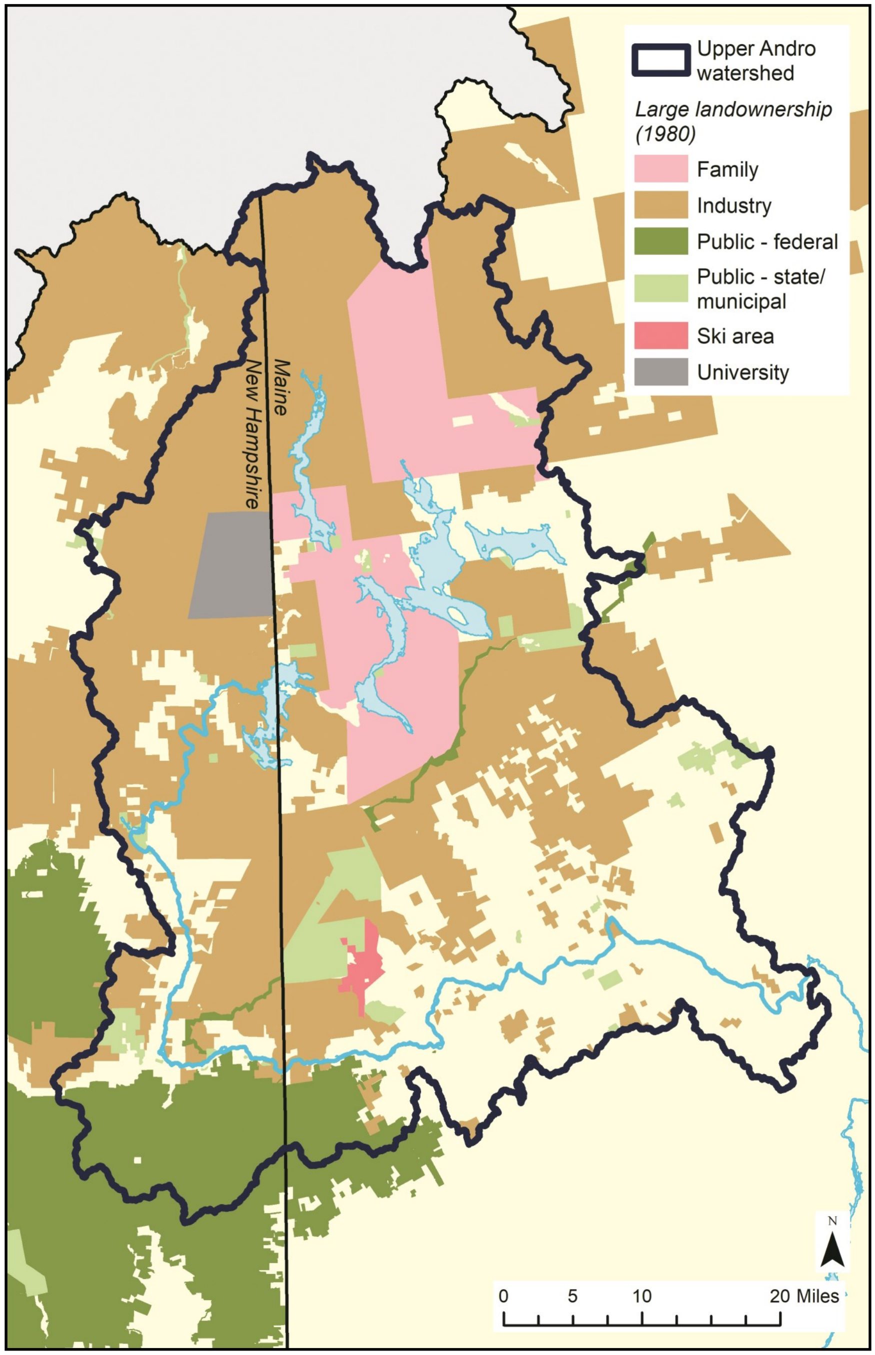
— Land Ownership Change —

Throughout the early and mid-20th century the "land beyond the notches" was the domain of timber and paper companies. Land ownership was dominated by long-established companies that owned mills and land to supply timber to the mills. The other major category of landowner was family ownerships descended from the timber barons of the late 18th and early 19th centuries.

A 1962 map of forest ownership in Maine showed the upper Androscoggin watershed dominated by three owners—the Brown Company, International Paper and the Pingree family. Other major owners in New Hampshire included St. Regis Paper Company, Diamond International and Dartmouth College's Second College Grant. The only large public ownership was the White Mountain National Forest.

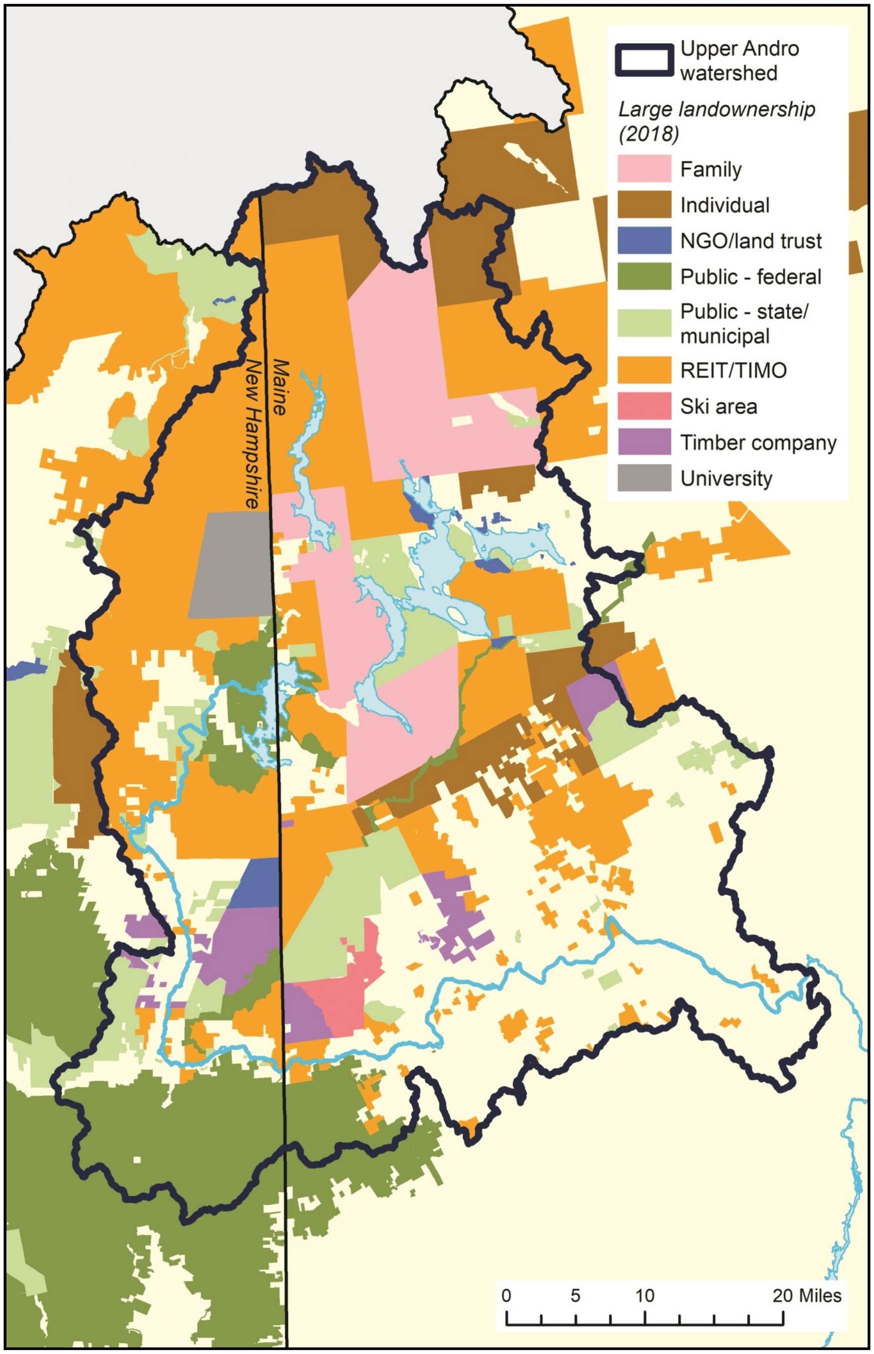
The 1970s saw the beginning of changes that would transform the ownership landscape. The once-vast holdings of the Brown Company were being sold off, the designation of the Appalachian Trail and the consolidation of Maine's Public Reserved Lands were increasing the amount of public land, and multinational corporations made their first appearance with the acquisition of Oxford Paper Company and significant amounts of Brown Company land by Boise Cascade.

However, though the names were changing, in 1980 ownership in the watershed was still dominated by industrial companies (Table 11 and Map 41a). Major private landowners included Brown, Pingree, International Paper, Boise Cascade, St. Regis, Diamond and Dartmouth. Of these only the long-standing Pingree and Dartmouth ownerships remain today.



Map 41a — Major land ownership categories in the upper Androscoggin watershed, 1980

More significant changes in the land ownership landscape took place from the 1980s through the 2000s. The first was the acquisition and breakup of Diamond International by the English corporate raider Sir James Goldsmith in the late 1980s. The 1990s saw the wholesale divestment of land by the industrial companies, driven by changing economic circumstances and tax laws. Within the upper Androscoggin watershed nearly two-thirds of industrial lands went to a new class of investment-oriented owners—Real Estate Investment Trusts (REITs) and Timberland Investment Management Organizations (TIMOs). These companies own and manage land for income and growth in value, and today are the most significant class of large landowner in the watershed (Table 11 and Map 41b). Other new landowners included wealthy individuals (represented in the region by John Malone, the nation's largest private landowner) and smaller timber companies without mills (most notably T.R. Dillon in New Hampshire).



Map 41b — Major land ownership categories in the upper Androscoggin watershed, 2018

The changes during this time were rapid and even dizzying. Large landowners who entered the watershed after 1980 but were gone by 2018 include Champion International, James River and Crown Vantage (industrial), Hancock Timber Resources Group and GMO Renewable Resources (TIMOs) and Plum Creek (REIT). Today the largest private landowners in the area are Bay Root (TIMO), Pingree, Malone, Forestland Group (TIMO), Weyerhauser (REIT) and Yankee Forest (TIMO).

This change from industrial to investment-oriented ownership has created both concerns and opportunities across the region. The major concern is the increased chance of land being sold for development. While many smaller parcels have been sold off, the only major development proposal has been Plum Creek's (now Weyerhauser) large-scale development plan for the Moosehead Lake region in the 2000s.

At the same time, the investment owners have been more willing to sell land or easements for conservation as part of their overall investment strategy. Within the watershed public land ownership has increased by 60% since 1980, non-governmental organizations and land trusts are increasingly active in the region, and about 16% of the former industrial land in the watershed is now encumbered by conservation easement (see the next chapter on Land Conservation).

The story of this land ownership transition is not yet complete. Many of the investment owners have relatively short time horizons, and the potential for additional land sales is high. What new owners emerge in the region, and whether additional conservation opportunities can be realized, remains to be seen.

Table 11 — Land ownership in the upper Androscoggin watershed

	1980	2018
Public land		
Federal	7%	9%
State/municipal	3%	8%
Total public	**11%**	**17%**
Private land		
Industry	45%	
Family	12%	10%
Individual		6%
REIT/TIMO		29%
Small timber company		3%
University	2%	2%
Ski area	<1%	1%
NGO/land trust		1%
Other[1]	30%	31%
Total private	**89%**	**83%**

1 Small ownerships for which no information is available.

— Land Conservation —

Land conservation means different things to different people. At the most basic level it means ensuring that forests remain forests, so that they can continue to provide traditional uses such as timber management, wildlife habitat, and recreation. At its strongest it means permanent designation as wilderness or ecological reserve that allows the area to be restored to a relatively natural condition.

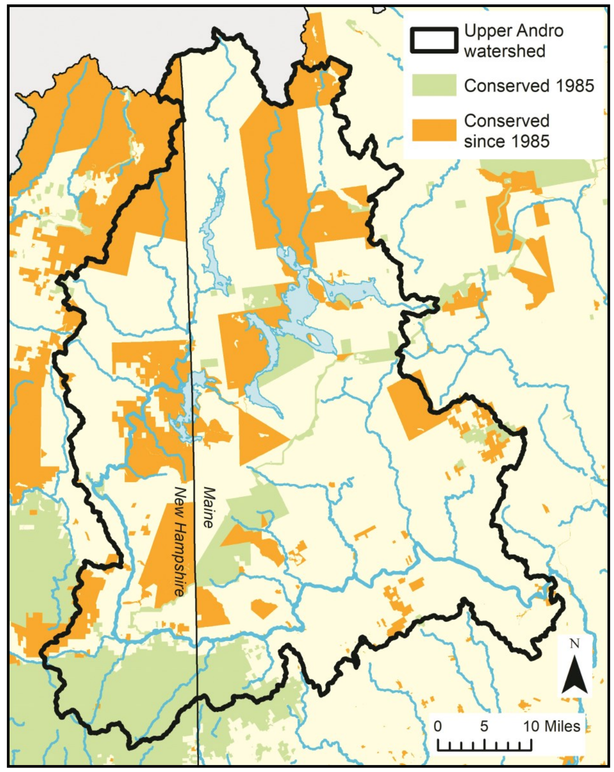
Currently nearly one-third of the land in the upper Androscoggin watershed has some form of conservation protection (Table 12 and Map 43). Ownership by federal agencies (the U.S. Forest Service, National Park Service and Fish and Wildlife Service); state forest, park and wildlife agencies; towns, private conservation organizations and land trusts encompass about 17% of the watershed. Another 15% is encumbered by conservation easements held by both public agencies and private land trusts.

The land conservation movement in the United States arose in the late 19th century—the time of Teddy Roosevelt, John Muir and Gifford Pinchot. Their efforts led to the establishment of the National Forest and National Park systems. The federal Weeks Act of 1911 expanded the National Forest system to the eastern United States and led to the establishment of the White Mountain National Forest in 1918 due to public concern over unconstrained logging and the subsequent severe fires that contributed to much downstream flooding. Much of the land that makes up the White Mountain National Forest was acquired prior to World War II. Additional land conservation prior to the 1970s was limited to the establishment of state parks and other small areas designed to conserve places of particularly high scenic or recreational value.

Two events led to additional land conservation in the 1970s. The first was the establishment of the Appalachian Trail as a National Scenic Trail as part of the National Park system in 1968. Though construction of the trail began in the 1920s, this formal designation began efforts to protect the trail corridor under National Park Service ownership.

Table 12 — Land conservation in the upper Androscoggin watershed

Ownership	Acres	Percent of water-shed
Federal ownership	140,134	9.0%
State ownership	97,079	6.2%
Municipal ownership	21,281	1.4%
NGO/land trust ownership	7,401	0.5%
Conservation easement	234,663	15.0%
Total	**500,558**	**32.0%**



Map 42 — Land conserved since 1985

The second event was the consolidation of Maine's Public Reserved Lands. These were small lots reserved for public use when townships were first surveyed in the 1800s. It was intended that they would serve as town commons and sites for schools and churches when these areas were settled. However, many of these townships were never settled, and the lots remained as forgotten and undesignated pieces held in common ownership with other landowners until rediscovered and combined into a few larger public tracts. The consolidation led to the creation of the state's Mahoosuc, Richardson Lake and Four Ponds units in the 1970s and 1980s.

By the mid-1980s about 10.5% of the watershed was conserved, with more than 85% of this in the White Mountain National Forest and Maine's Mahoosuc and Richardson units. However, the last three decades have seen a new era of conservation that has tripled the amount of conservation land in the watershed (Map 42).

For decades much of the private land across northern New England and New York (the Northern Forest region) had been held by timber and paper companies. However, the acquisition and breakup of Diamond International Corporation by a corporate raider led to public concern over the future of these lands and the ecological and recreational values they provided. These concerns led to the U.S. Forest Service's Northern Forest Lands Study (1990) and the recommendations of the Northern Forest Lands

Council (1994), which recognized the need for additional land conservation in the region.

At the same time, changes in tax laws and other factors led to a large-scale selloff of the landholdings of the timber and paper companies (see Land Ownership Change, page 76). Much of this land was acquired by private investment companies who were more amenable to selling land or conservation easements as part of their overall investment strategy.

The combination of willing sellers, increased public support for land conservation, and increased public and private land conservation funding led to a significant increase in conservation land within the upper Androscoggin watershed and across the broader region beginning in the 1990s and continuing to the present. Major conservation projects within the watershed over this time include:

Umbagog National Wildlife Refuge. The refuge was designated in 1992 to protect the critical wetlands and wildlife habitats around the lake. To date more than 25,000 acres within the refuge boundary has been conserved, primarily through federal ownership.

Mahoosuc Range. Since 2000 nearly 20,000 acres in the Mahoosuc Range of Maine and New Hampshire has been conserved through federal and state acquisition and conservation easement.

Rangeley Lakes Heritage Trust. Since 1991 this land trust has conserved nearly 14,000 acres and 50 miles of lake and river shoreline in the Rangeley Lakes region. These lands are now protected by a combination of public and RLHT ownership and conservation easements.

Tumbledown/Mount Blue. Since 1990 nearly 26,000 acres have been conserved around Mount Blue State Park and the nearby Tumbledown Mountain through state purchase and conservation easement.

Town forests. Since 1990 four New Hampshire towns (Randolph, Gorham, Milan and Errol) have acquired land for town forests. These lands provide a sustainable source of revenue as well as local recreational opportunities.

Working forest conservation easements. The Northern Forest region has been a leader in the use of large "working forest" conservation easements to protect forest land from development. These easements maintain the land in private ownership and allow continued use for timber management and other purposes while restricting development and subdivision. Among the projects lying at least partially within the watershed are the Pingree Forest Partnership (Maine), the Connecticut Lakes Headwaters (N.H.), the Androscoggin Headwaters around the Umbagog NWR (N.H.), and Success Township (N.H.).

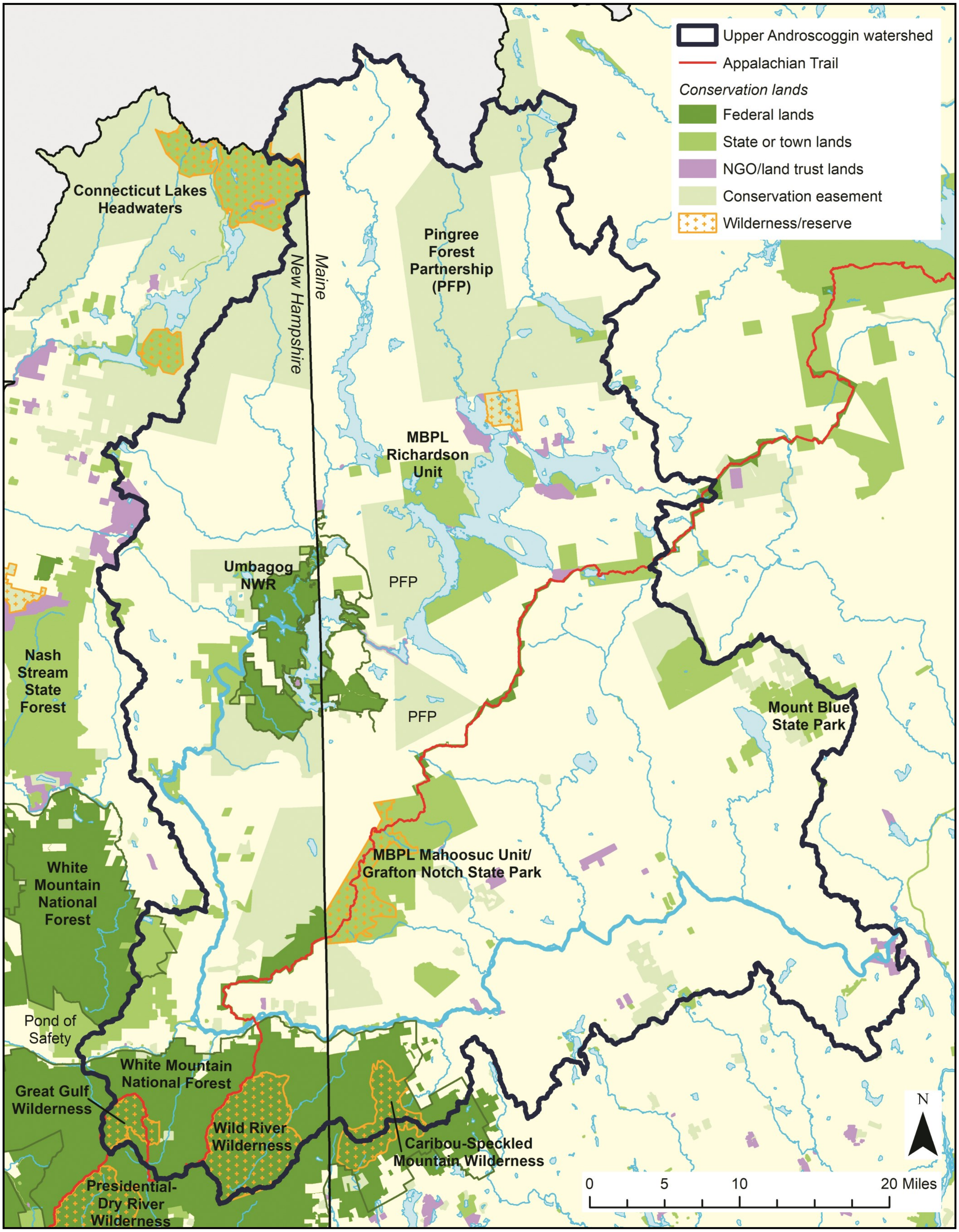
Land conservation efforts are continuing across the region. While the threats faced by the north country are less severe than in more rapidly-growing areas to the south, the region is not immune to change. Improved road access is making remote areas more attractive to people seeking refuge from the hectic pace of urban life. Short-term economic pressures on both large and small landowners create incentives for overharvesting or subdivision. Local citizens and officials, public agencies, land trusts, landowners and conservation organizations are continuing the effort to create a conservation landscape that maintains the ecological, economic and social values of the region's forests and waters.

Wilderness and Ecological Reserves

Well-managed timberlands provide many values besides wood products, including habitat for most wildlife species and opportunities for many types of recreation. However, there are some values that are best provided by lands that are left alone—places where natural forces rather than human manipulation shapes the landscape.

"Wilderness" and "ecological reserve" are terms used to describe land permanently set aside as natural areas. These lands allow for the restoration of the complex old-growth forest habitat that is favored by many species. They provide the opportunity for scientific study of the workings of natural ecosystems. They provide opportunities for backcountry recreation and for the types of education and spiritual renewal that can only be provided by natural areas. They serve as an "ecological insurance policy," ensuring that unappreciated aspects of biodiversity are not lost through ignorance. In addition, visitors attracted to these natural areas are an important part of the region's tourist economy.

Several areas within the upper Androscoggin watershed have been permanently designated as wilderness or ecological reserve. These lands generally allow low-impact recreational use (such as hiking, hunting and fishing) but prohibit timber harvesting, road construction, or motorized travel. They include the Wild River, Great Gulf and Caribou/Speckled Mountain Wilderness Areas on the White Mountain National Forest, Maine's Mahoosucs Ecological Reserve and a "forever wild" easement held by the Rangeley Lakes Heritage Trust along the lower Kennebago River. These areas total around 54,000 acres or about 3.5% of the land area of the upper Androscoggin watershed, with the largest being almost 24,000 acres. Other areas (including large parts of the White Mountain National Forest and the Umbagog NWR, the Appalachian Trail corridor and state parks) are also managed for relatively natural conditions without being permanently designated as wilderness or reserve; in total they amount to about an additional 5% of the watershed.



Map 43 — Conservation land in the upper Androscoggin watershed

— Forest Carbon Sequestration —

Forests are a major component of the global carbon cycle and are the dominant pool of carbon in terrestrial vegetation. Forests remove carbon from the atmosphere through photosynthesis and sequestration in biomass (primarily wood). When vegetation dies (through either natural or human causes) carbon is released to the atmosphere through decomposition. The balance between these two processes determine whether forests are a net source or a sink for atmospheric carbon, and the extent to which they can contribute to the mitigation of climate change.

The dynamic nature of the relationship between forests and the atmosphere can be seen in measurements of atmospheric CO_2 from the Mauna Loa Observatory in Hawaii (Fig. 14). There is a clear seasonal cycle. The primary driver of this cycle is Northern Hemisphere temperate and boreal forests—atmospheric CO_2 declines during the growing season when photosynthesis exceeds respiration and increases during the dormant season when the reverse is true.

For much of the United States' history forests were a source of carbon into the atmosphere as forests were cleared for development and agriculture and high volume virgin forests were liquidated. Globally forests are still a carbon source (primarily due to continued loss of tropical forests) and currently contribute about 16% of global carbon emissions. However, in the United States forests are now a net sink of carbon, due to the reversion of agricultural land to forest cover and the increase in more sustainable forest management. Currently forest carbon sequestration is estimated to offset about 15% of carbon dioxide emissions in the country.

Eastern forests have been a carbon sink since the latter part of the 19th century due to the abandonment and reforestation of agricultural lands, and this trend is continuing. In Maine and New Hampshire live above-ground forest carbon increased by 0.5% to 0.7% per year between 2005 and 2017 (Fig. 15). A similar rate of increase has occurred in the upper Androscoggin watershed region (Coos and Oxford counties).

There is considerable spatial variation in above ground live biomass within the watershed (Map 44). (Biomass is about 50% carbon.) Forests also store considerable carbon below ground in root systems and soil organic matter, but this requires labor-intensive field sampling to quantify. The highest levels of above-ground biomass are found on public lands (particularly the White Mountain National Forest and Maine's Mahoosuc unit), steep and mountainous areas, and non commercial private ownerships in the southern part of the watershed. Lower levels of biomass are found on the large commercial ownerships which are subject to heavier harvesting and generally managed for a younger forest.

The type of management has a major influence on how much carbon is stored in forests. Mature sawtimber stands store much more carbon in live and dead biomass than younger poletimber and seedling/sapling stands (Fig. 16). The highest levels of carbon storage are found in overstocked sawtimber stands; these are generally stands that have not been harvested for many decades and are moving towards a late-successional and eventually old-growth condition. Prior to European settlement these types of stands dominated the northern forest landscape, but today they are mostly found on public lands (especially lands reserved from harvesting) and smaller unmanaged private lands. Large commercial forest ownerships have a higher proportion of younger stands with lower carbon storage.

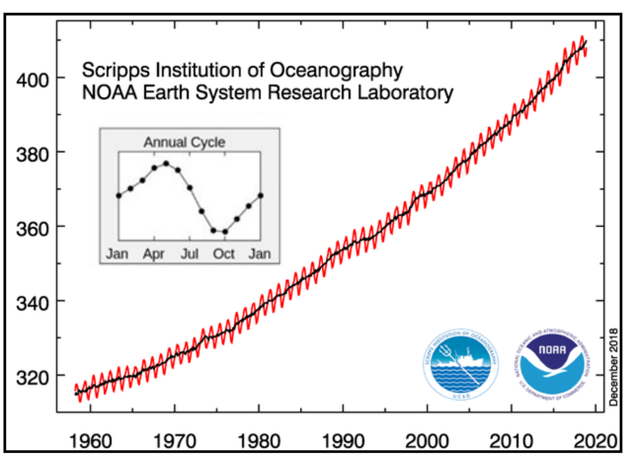


Figure 14 — Atmospheric CO_2, Mauna Loa Observatory (parts per million)

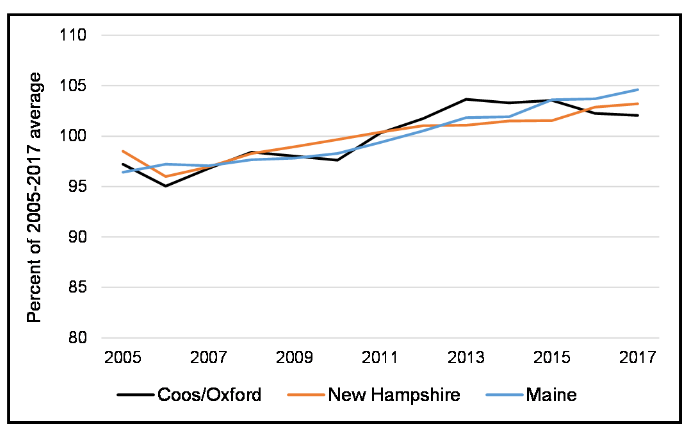


Figure 15 — Above-ground live forest carbon relative to 2005-2017 average

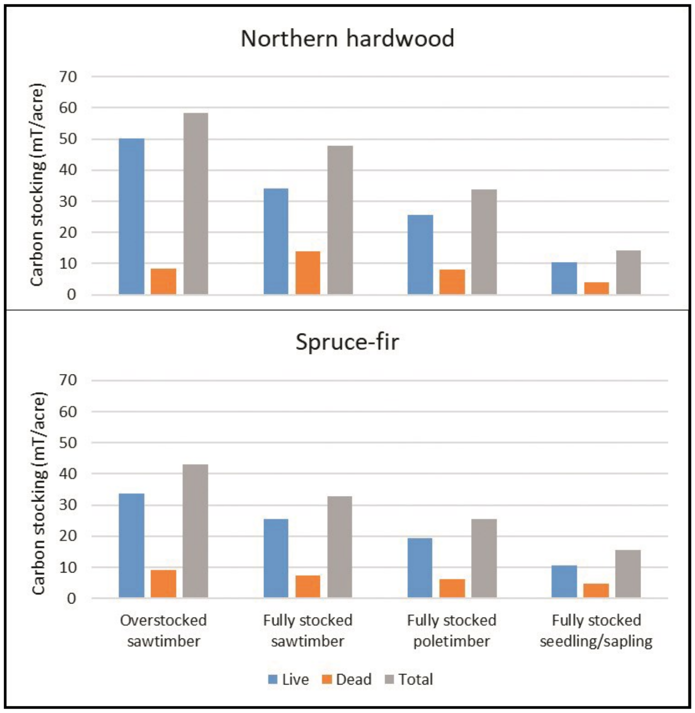


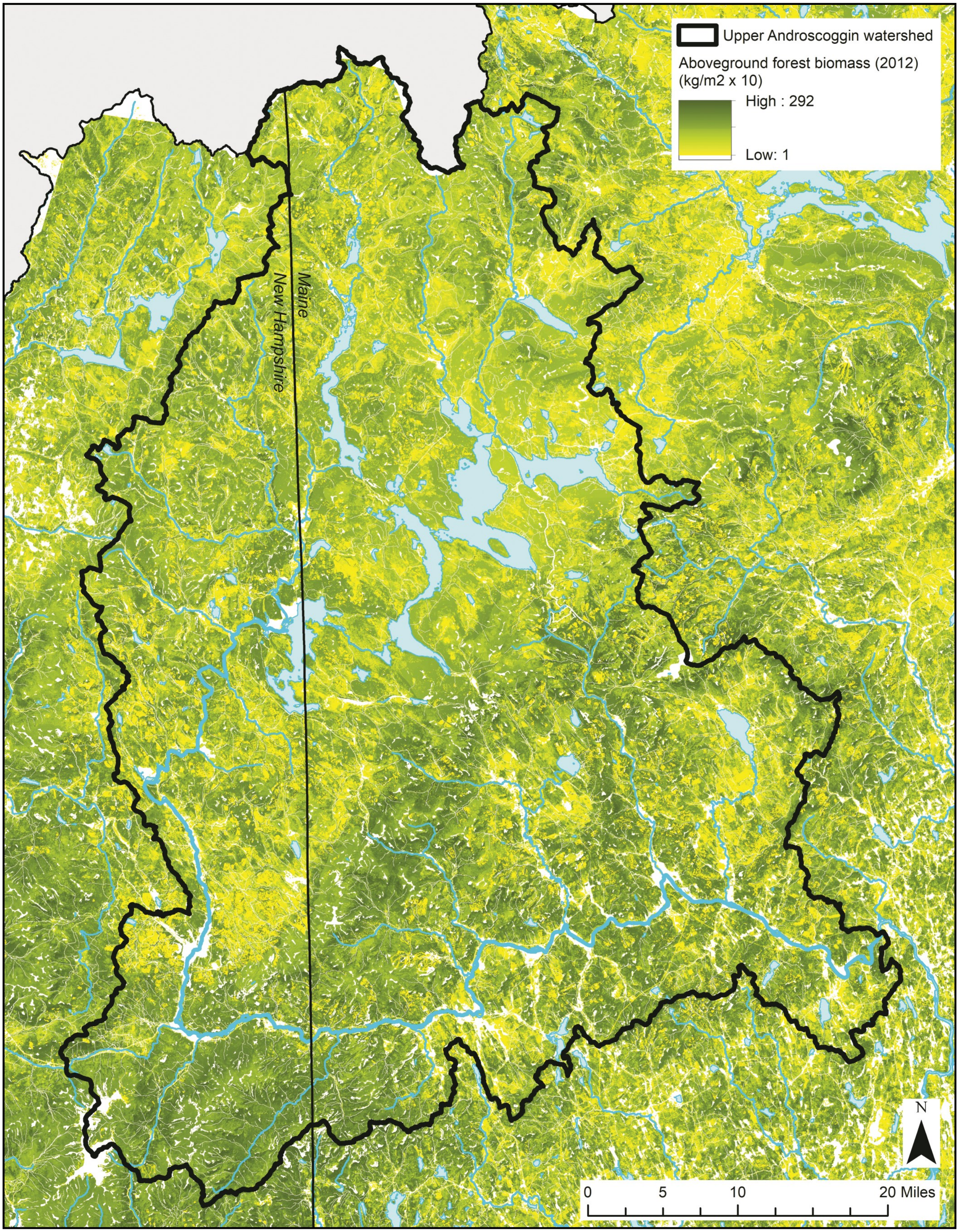
Figure 16 — Carbon stocking (live vegetation and dead wood) for different stand types

There is considerable opportunity to enhance the role of the region's forests in climate change mitigation, as current levels of forest carbon storage are well below the full potential. At a minimum this requires minimizing additional loss of forest and continuing the trend of increasing forest carbon sequestration. However, fully realizing this potential will require changes in management that move more of the forest into a mature high-carbon condition. These include harvesting less than growth, increasing rotation lengths and the proportion of sawtimber, reducing the heavy harvesting of existing mature stands, increasing the development and retention of large old trees and dead wood, and minimizing the disturbance and exposure of soil to prevent the release of soil carbon.

However, harvesting less than growth, retaining trees beyond the economically optimal rotation and letting more trees grow old and die comes with a financial cost. While some public and non-profit landowners are incorporating carbon sequestration into their forest management goals, this cost is a serious impediment for private (especially commercial) landowners.

Over the last decade forest carbon "offset" markets have emerged that compensate landowners for maintaining high levels of carbon stocking on their lands. However, these markets are not viable for smaller landowners (generally 2,000-3,000 acres of well-stocked forest are required for a financially viable offset project) or those with low levels of carbon stocking. Currently carbon offset prices are too low to drive a change in management—trees are still more valuable when harvested for timber than retained for carbon. However, public policies that increase the value of forest carbon (such as cap-and-trade systems or a carbon tax) could significantly enhance the incentive for landowners to move towards more "carbon-friendly" management.

Large live trees (left) and dead wood (right) are significant reservoirs of forest carbon.



Map 44 — Aboveground live biomass in 2012

— Afterword —

Aziscohos Lake bald eagle chick—a once imperiled species that has recovered in the watershed.

From the wetlands of Lake Umbagog to the alpine areas of the Presidential Range, from the unpopulated headwaters of the Magalloway River to the historic mill towns of Berlin and Rumford, the upper Androscoggin River watershed is a special place. It has absorbed the worst that uncontrolled human use can do to it—the massive liquidation of its vast old-growth forests, the thoughtless pollution of the Androscoggin River—and now it stands at the brink of a new era.

The landscape of the upper watershed can be thought of as five distinct regions, each with its own ecological and cultural character. At the head of the watershed lie the northern tributaries—the Swift Diamond, Dead Diamond, Magalloway, Cupsuptic and Kennebago rivers. It is an area of long winters, low mountains, and slaty soils, where northern species such as white spruce, balsam poplar and boreal chickadee drop south from Canada. Mostly unpopulated, this part of the watershed is controlled by five large landowners.

Below that lie the large lakes—Rangeley, Mooselookmeguntic, Cupsuptic, Richardson, Aziscohos and Umbagog—lying in a broad valley underlain by eroded granitic plutons. For 150 years loggers and tourists have shared this landscape. Here lie the northernmost settlements in the watershed—Rangeley, Oquossoc, Wilson's Mills, Wentworth's Location, and Errol.

Next comes the most rugged part of the watershed—the high peaks of the White Mountains and the Mahoosuc Range, stretching to the northeast across Bemis and Elephant Mountains to Saddleback and beyond. Traversed by the Appalachian Trail, this is a land of steep slopes, tough rock, and thin acidic soils.

Below these mountains lies the foothills region of the middle Androscoggin valley, stretching from Bethel to Riley. This is a transition zone between the northern and southern parts of the Androscoggin watershed. Many species more common to the south reach the northern limit of their range in this part of the watershed. Here settlement, industrialization and agriculture have been more widespread, and it is the only part of the upper watershed where most of the land lies in organized towns.

Finally there is the Androscoggin River itself, for 10,000 years the focus of human activity in the region. Even today, of the approximately 40,000 people who call the upper watershed their home, perhaps 85% live within a few miles of the river.

The upper watershed is in some ways a land of contradictions. On the one hand, this is a relatively wild and natural landscape. Human settlements cover but a few percent of the land, and its vast forests still support most wildlife species native to the region. On the other hand, it is a landscape that is thoroughly dominated by humans. The large lakes and the Androscoggin River have been tamed by dams, their levels and flows determined more by human decisions than by natural patterns of rain and snowmelt. Populations of deer, moose, bear and other game species are controlled by wildlife managers. The largest carnivores, wolf and cougar, as well as caribou and blueback trout were long ago eliminated from the region. A network of logging roads reaches into the remotest corners of the watershed. And the forests themselves have been changed. They are much younger and less complex than those encountered by the first settlers, with a greater proportion of hardwoods and early-successional species. The large trees that were once common (the two-foot diameter spruce, the three-foot diameter maple, birch and hemlock, the four-foot diameter white pine) have been almost totally eliminated. Today the age, structure and composition of the region's forests are to a large degree determined by the decisions of foresters and landowners.

Larger forces beyond the control of local residents are also shaping the landscape. The ever-growing human population and the globalization of the economy are putting previously unknown pressures on landowners, local communities and the natural landscape. Until the deposition rates of acidic compounds in precipitation (sulfate from the burning of coal, nitrate from automobile exhausts) were put in reverse, the soils were leached of essential calcium and the cold tolerance of spruce at high elevations was reduced. The most significant impacts may come from changes in the global climate caused primarily by burning fossil fuels. These will affect the region in ways that are increasingly well understood—shorter and milder winters, greater frequency of floods, and longer growing seasons. Over the next century red spruce, balsam fir and other northern species will decline across the region, replaced by species of warmer climates such as pine, oak and hemlock. The range of cold-water fish species such as brook trout may constrict as the climate warms.

There is much to celebrate in the region. There is a growing awareness that both economic prosperity and the quality of life in the upper Androscoggin watershed are intimately tied to the

Bryan Wentzell

Relict alpine habitat on Sunday River-Whitecap

Umbagog National Wildlife Refuge - an ecological, recreational and national treasure

health and sustainable management of the natural landscape. The Androscoggin River has recovered from the damage caused by log driving and pollution. The management of the region's forests and the operation of the region's dams are taking a more environmentally sensitive approach. Many species at the brink of regional extinction like the moose, bald eagle, osprey and turkey are at healthy levels again. The overall landscape is largely intact, not highly fragmented, and topographically and ecologically diverse. Its forests have the potential to sequester considerable carbon dioxide and it is a landscape that offers much adaptive potential to retain portions of ecosystems threatened by climate change. Action is still ongoing to conserve open space and undeveloped shorelines for both ecological and economic reasons, to compliment the recent conservation projects that have protected large, contiguous areas of the upper watershed. The establishment of wilderness areas and ecological reserves will over time allow old-growth forests to be restored to parts of the landscape.

The region's economies and populations also suffered considerably from the boom and bust cycle of the logging and paper industry. Tourism has evolved and remains a steady backbone to the regional economy. Energy development is increasing. Efforts are ongoing to bring cell phone coverage, broadband internet and other infrastructure to the region so that it can participate on an equal footing in the evolving digital economy.

Just as the current landscape has been shaped by decisions made over the past two hundred years, so decisions being made today will shape the landscape that citizens inhabit a century from now. In 1787, as he emerged from the Constitutional Convention, Benjamin Franklin was asked what the convention had given the American people. "A republic, if you can keep it," he replied.

Much the same could be said about the upper Androscoggin River watershed. We have been given a productive and beautiful landscape—if we can keep it.

— Appendix A: Notes, Sources and Additional Information —

Introduction

The delineation of the upper Androscoggin River watershed and HUC 10 watersheds were based on 1:24,000 scale digital watershed data obtained from the USGS National Hydrography Dataset (NHD) Best Resolution HU4-8 20180301 for HU-4 Subregion Shapefile Model Version 2.2.1. The lower Androscoggin River watershed and the watersheds shown in Map 1 were derived from U.S. Geological Survey (USGS) 1:2,000,000 scale digital hydrologic unit data obtained from the USGS National Atlas website (http://nationalatlas.gov).

Base data appearing in Map 1 and many subsequent maps, including lakes, rivers, state and town boundaries, and highways, were derived from USGS 1:100,000 scale Digital Line Graph data. Selection of features to include in the maps was made by AMC.

Topographic representation (Maps 2 and 5) was derived from U.S. Geological Survey 30-meter resolution Digital Elevation Model data.

Major roads (Map 4) shows all roads coded as "highways" in USGS 1:100,000 DLG data.

Population density (Map 3) was derived from U.S. Census Bureau 2010 census data.

Land use (Map 4) was derived from U.S. Environmental Protection Agency Multi-Resolution Land Characteristics (MRLC) 2011 data (http://www.epa.gov/mrlc/).

Topography

Topographic information (including elevation, slope and shaded relief) was derived from U.S. Geological Survey 30-meter resolution Digital Elevation Model data. Slope was developed using ArcView Spatial Analyst slope calculation function.

Watersheds

See Introductions chapter for HUC digital data sources. Fig. 1 and the description of the Strahler stream order are from https://usgs-mrs.cr.usgs.gov/NHDHelp/WebHelp/NHD_Help/Introduction_to_the_NHD/Feature_Attribution/Stream_Order.htm .

Geology

Bedrock geology was derived from digital bedrock geology data for Maine and New Hampshire obtained from Maine Office of GIS and New Hampshire GRANIT. Assignment of geological formations to the broad classes shown in Maps 19, 20 and 21 was based on the interpretation of this data and other information by AMC.

Map 18 was adapted from data in Robinson, G.R. Jr. and K.E. Kapo. 2003. Generalized Lithology and Lithogeochemical Character of Near-Surface Bedrock in the New England Region. US Geological Survey Open-File Report 03-225. (https://pubs.usgs.gov/of/2003/of03-225/)

The description of the geologic history of the upper Androscoggin River watershed was developed from a wide range of sources, primarily:

- Campbell, D.W. 1998. Roadside Geology of Maine. Mountain Press Publishing Company, Missoula, MT.
- Van Diver, B. B. 1987. Roadside Geology of Vermont and New Hampshire. Mountain Press Publishing Company, Missoula, MT.
- Stearn, C. W., R. L. Carroll and T. H. Clark. 1979. Geologic Evolution of North America. John Wiley & Sons, New York, NY.
- Marvinney, R.G. and W. B. Thompson. 2000. A Geologic History of Maine. Maine Department of Conservation, Geologic Survey website (http://www.state.me.us/doc/nrimc/pubedinf/factsht/bedrock/megeol.htm)

Soils

Information on soils in the region was derived from U.S. Natural Resources Conservation Service State Soil Geographic Database (STATSGO) data. Assignment of soil mapping units to the broad groups shown in Map 22 was based on NRCS state soil catena keys:
Maine: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_002105.pdf
New Hampshire: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_015169.pdf

Map 23 was developed from NRCS U.S. General Soils Map data (STATSGO2). The STATSGO data show soils mapped at a very broad level.

Information and data for more detailed county-level soil surveys may be obtained at:
Maine: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=ME
New Hampshire: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=NH

Climate

Climate data for local weather stations was obtained from the U.S. National Oceanographic and Atmospheric Administration's National Centers for Environmental Information (Land-Based Station Data web site at https://www.ncdc.noaa.gov/data-access/land-based-station-data).

Data on modeled precipitation (Map 25) was obtained from the PRISM Climate Group at Oregon State University (http://prism.oregonstate.edu/normals/).

Information on historical and projected future climate was obtained from a wide range of sources, including:

- U.S. National Oceanographic and Atmospheric Administration's National Centers for Environmental Information (Climate at a Glance web site at https://www.ncdc.noaa.gov/cag/).
- U.S. Global Change Research Program National Climate Assessment (https://nca2014.globalchange.gov/).
- Jacobson, G.L., I.J. Fernandez, P.A. Mayewski, and C.V. Schmitt (editors). 2009. Maine's Climate Future: An Initial Assessment. Orono, ME: University of Maine.
- Fernandez, I.J., C.V. Schmitt, S.D. Birkel, E. Stancioff, A.J. Pershing, J.T. Kelley, J.A. Runge, G.L. Jacobson, and P.A. Mayewski. 2015. Maine's Climate Future: 2015 Update. Orono, ME: University of Maine.
- Rangeley Lake ice-out data: http://www.rangeley-maine.com/rangeley-lake-ice-out/.
- Mount Washington and Pinkham Notch climate data: Mount Washington Observatory and AMC.

Ecological Land Classification

Ecoregion data and descriptions were obtained from the following sources:

- Map 26: World Wildlife Fund Terrestrial Ecosystems of the World (https://www.worldwildlife.org/publications/terrestrial-ecoregions-of-the-world); data downloaded from the Data Basin web site (https://databasin.org/datasets/68635d7c77f1475f9b6c1d1dbe0a4c4c).
- Maps 27-29: U.S. Environmental Protection Agency Ecoregions (https://www.epa.gov/eco-research/ecoregions).

Land Use and Land Cover

Map 30 and associated data were derived from the 2011 National Land Cover Dataset developed by the federal Multi-Resolution Land Characteristics Consortium (https://www.mrlc.gov/).

Forests

The list of tree species shown in Appendix B was derived from species range maps in the following sources:

- Fowells, H.A. 1965. Silvics of Forest Trees of the United States. U.S. Department of Agriculture Handbook No. 271. Washington, D.C.
- Preston, R. J. Jr. 1976. North American Trees, 3rd edition. MIT Press, Cambridge, MA.

Data on forest cover types and volumes was derived from US Forest Service Forest Inventory and Analysis data obtained from the Forest Service's EVALIDATOR web site (https://apps.fs.usda.gov/Evalidator/evalidator.jsp).

Information on future changes in tree species in the region was obtained from the US Forest Service's Climate Change Atlas (https://www.fs.fed.us/nrs/atlas/).

Natural Communities

The list of natural communities likely to be present within the upper Androscoggin watershed (Appendix C) was developed by AMC based on community descriptions in the following sources:

- Sperduto, D.D. and W.F. Nichols. 2011. Natural Communities of New Hampshire. 2nd ed. NH Natural Heritage Bureau, Concord, NH. Pub. UNH Cooperative Extension, Durham, NH.
- Gawlor, S. and A. Cutko. 2018. Natural Landscapes of Maine: A Guide to Natural Communities and Ecosystems. Maine Natural Areas Program, Augusta, ME.

Information on documented occurrences of rare natural communities within the watershed was provided by New Hampshire Natural Heritage Bureau and Maine Natural Areas Program.

Rare Plants

Data on documented occurrences of rare plants within the upper Androscoggin watershed was provided by New Hampshire Natural Heritage Bureau and Maine Natural Areas Program. Additional information was derived from materials on the NHNHB and MNAP web sites and the New England Wild Flower Society's Go Botany web site (https://gobotany.newenglandwild.org/).

Subalpine and Alpine Ecosystems

More general information on the alpine zone can be found in:

- Slack, N. G. and A.W. Bell. 1995. Field Guide to the New England Alpine Summits. Appalachian Mountain Club, Boston, MA.

References on the subalpine forest, paleobotanical studies, fir-waves, and Mahoosucs alpine communities include:

- Publicover, D.A. and Kimball, K.D., 2011. High-elevation spruce–fir forest in the northern forest: an assessment of ecological value and conservation priorities. Appalachian Mountain Club Research Department, Gorham, NH. (at http://hydrodictyon.eeb.uconn.edu/projects/nealpine/Publicover%20and%20Kimball%20-%20ECANUSA%20proceedings.pdf)
- Spear, R.W., 1989. Late-Quaternary history of high-elevation vegetation in the White Mountains of New Hampshire. *Ecological Monographs, 59(2),* pp.125-151.

- Foster, J.R., 1988. The potential role of rime ice defoliation in tree mortality of wave-regenerated balsam fir forests. *The Journal of Ecology, 76(1),* pp.172-180.
- Doyle, K.M., Fahey, T.J. and Paratley, R.D., 1987. Subalpine heathlands of the Mahoosuc Range, Maine. Bulletin of the Torrey Botanical Club, 114 (4) pp.429-436.

Natural communities of the alpine zone of the Presidential Range were mapped by AMC researchers in the mid-1990s. Information on this project can be found in the paper "Alpine Vegetation Communities and the Alpine-Treeline Ecotone Boundary in New England as Biomonitors for Climate Change" available at http://www.wilderness.net/pubs/science1999/Volume3/Kimball_3-13.pdf.

Wildlife

Information on rare wildlife species present within the upper Androscoggin watershed was provided by the New Hampshire Natural Heritage Bureau and the Maine Department of Inland Fisheries and Wildlife.

Information on the recent range of the gray wolf and cougar obtained from the USGS National Gap Analysis Project (GAP) | Species Data Portal (https://gapanalysis.usgs.gov/species/data/download/).

Fish and wildlife references include:

- Bennett, D.B. 2009. Nature and renewal, Wild River Valley & Beyond. Tilbury House Publishers, Gardiner, ME.
- Kays, R. 2018. Coyote continent. *Natural History, 126(7),* pp. 22-27.
- Jones, H., P.J. Pekins, L. Kantar, I. Sidor, D. Ellingwood, A. Lichtenwalner, and M. O'Neal. 2018. Mortality assessment of calf moose (Alces alces) during successive years of winter tick (Dermacentor albipictus) epizootics in New Hampshire and Maine. *Canadian Journal of Zoology*, https://doi.org/10.1139/cjz-2018-0140 .
- Grosmana, P. D., J.A.G. Jaegera, P. M. Birona, C. Dussault, and J-P. Ouell, etc. 2011. Trade-off between road avoidance and attraction by roadside salt pools in moose: An agent-based model to assess measures for reducing moose-vehicle collisions. *Ecological Modelling 222(8),* pp. 1423-1435. https://doi.org/10.1016/j.ecolmodel.2011.01.022 .
- Gunson, K.E., G. Mountrakis and L.J. Quackenbush. 2011. Spatial wildlife-vehicle collision models: A review of current work and its application to transportation mitigation projects. *Ecological Modelling 222(8).* pp. 1423-1435.
- Yoder, C.O., B.H. Kulik, J. M. Audet, and J. D. Bagley. 2006.The Spatial and Relative Abundance Characteristics of the Fish Assemblages in Three Maine Rivers. Technical Report MBI/12-05-1.
- Brown, M.E., J. Maclaine, and L. Flagg. 2006. Androscoggin River Anadromous Fish Restoration Program. Annual Report State of Maine Department of Marine Resources. Augusta, Maine.
- John H. Perry. 1999. Historic Fisheries Timeline for the Upper and Middle Dam Storage projects. Prepared for Union Water Power Company by E/Pro Engineering and Environmental Consulting.

Lakes and Rivers

Representation of lakes and rivers was derived from USGS 1:100,000 scale Digital Line Graph data. Selection of features to include in the maps was made by AMC.

Information on the ratings of rivers was taken from the following studies. The two studies took similar but not identical approaches, and the ratings of the rivers in the two states should not be considered fully equivalent. New Hampshire did not assign letter rankings; rivers classified as "Class A" were those listed in the "highest composite river resource values" category. For individual resource rankings of New Hampshire rivers ,those given a rating of "4" (highest significance) were considered "outstanding," and those given a rating of "2" (high significance) were considered "significant." Those given a rating of "1" (significant) are not shown; by excluding these the overall depiction of river values is more comparable to the standards used in the Maine study.

- Maine Rivers Study. Maine Department of Conservation, Augusta, ME, 1982.
- New Hampshire River Protection and Energy Development Project Final Report. New England Rivers Center, Boston, MA, 1983.

Information on Maine lakes was taken from the following sources:

- Databases for the Maine Wildlands Lakes Assessment and the Maine Lakes Study provided to AMC by the Maine Land Use Regulation Commission and the Maine State Planning Office.
- Maine's Finest Lakes: The Results of the Maine Lakes Study. Maine State Planning Office, Augusta, ME, 1989.

The history of the storage dams and their statistics are from:

- FPL Energy Maine Hydro. Balancing Act, The Lakes of the Upper Androscoggin - Operation of the Androscoggin River Storage System and the Effect on Summer Levels. 20 pp.

Wetlands

Information on the distribution of wetlands was derived from digital wetlands data (May 2018) obtained from the U.S. Fish and Wildlife Service National Wetlands Inventory program (https://www.fws.gov/wetlands/).

Information on the Umbagog National Wildlife Refuge is from:

- Final Comprehensive Conservation Plan (CCP) for Umbagog National Wildlife Refuge (NWR) and Environmental Impact Statement. (https://www.fws.gov/refuge/Umbagog/what_we_do/finalccpeis.html)

Historical Use of the Landscape

Information on land use history was derived from a wide variety of sources. However, the three main sources were:

- Jones, P.H. 1975. Evolution of a Valley: the Androscoggin Story. Phoenix Publishing, Canaan, NH. (A fairly complete historical treatment of entire region, with emphasis on river industrial pollution and clean-up.)
- Wight, D.B. 1967. The Androscoggin River Valley: Gateway to the White Mountains. Charles E. Tuttle Co., Inc. Rutland, VT. (A thorough treatment of early settlement history.)
- Shirrefs, H.P. 1995. The Richardson Lakes: Jewels in the Rangeley Chain. Bethel Historical Society, Bethel, ME. (A thorough historical account of Richardson Lake area with emphasis on recreation/tourism history.)

Descriptions of the historical development of the timber industry may be found in:

- Rolde, N. 2001. The Interrupted Forest: A History of Maine's Wildlands. Tilbury House Publishers, Gardiner, ME.
- Pike, R. E. 1967. Tall Trees, Tough Men. W.W. Norton & Company, New York, NY.
- Irland, L. C. 1999. The Northeast's Changing Forest. Harvard University Press, Petersham, MA.

Timber Harvesting

Data on timber volumes within the watershed was derived from US Forest Service Forest Inventory and Analysis data obtained from the Forest Service's EVALIDATOR web site (https://apps.fs.usda.gov/Evalidator/evalidator.jsp).

Employment data was derived from the Quarterly Census of Employment and Wages obtained from the following state web sites:

- Maine: https://www.maine.gov/labor/cwri/qcew.html
- New Hampshire: https://www.nhes.nh.gov/elmi/statistics/qcew-data.htm

Recreation

Information on the locations of recreation and cultural sites in the upper Androscoggin river watershed (Map 38) was developed from several sources including the Appalachian Trail Conservancy, AMC, Maine DOT Explore Maine (http://exploremaine.org/byways/); Maine GeoLibrary, Maine Snowmobile Association (https://webapps2.cgis-solutions.com/mainesnowmobile/); National Register of Historic Places – NPS (https://irma.nps.gov/DataStore/Reference/Profile/2210280); NHDOT Scenic and Cultural Byways (https://www.nh.gov/dot/programs/scbp/tours/index.htm); NH GRANIT (New Hampshire's Statewide Geographic Information System (GIS) Clearinghouse); NH Interactive Snowmobile Trail Conditions Map (http://www.gpstrailmasters.com/content/goomap/nh-snowmobile-trail-map-conditions_E.html); Northern Forest Canoe Trail (https://www.northernforestcanoetrail.org/); and US Department of Transportation Federal Highway Administration America's Byways (https://www.fhwa.dot.gov/byways).

Shoreline Development

The delineation of shoreline development (Map 39) was developed by AMC by reference to several sources, including NLCD data (see Land Use and Land Cover, above), USGS 1:100,000 Digital Line Graph roads data, USGS 1:24,000 quad maps, Delorme state road atlases, Maine Land Use Planning Commission digital zoning data, and aerial photography viewed on Google Earth. Shorelines were classified as follows:

- Developed: Shorelines within ¼ mile of areas shown as developed agricultural classes in NLCD data. Additional development was identified by searching for clusters of structures on USGS 1:24000 quad maps, within LUPC development zones or visible on Google Earth imagery. Any shorelines within ¼ mile of these clusters were also labeled as developed. (Isolated single structures were not considered.) All other shorelines were considered to be bordered by natural vegetation.
- Natural – Highway: Shorelines within ¼ mile of highways shown in USGS DLG roads data.
- Natural – Roaded: Shorelines within ¼ mile of improved roads shown in USGS DLG roads data. This data was corrected and augmented as necessary by reference to Delorme atlases and Google Earth imagery.
- Natural: All remaining shorelines.

Note that the classification is highly dependent on the width of the buffer zone around shorelines used for analysis (in this case ¼ mile). If a narrower buffer were used there would be a noticeable shift in the classification toward the more natural end of the spectrum.

Energy Development

Information on the location of dams in the upper Androscoggin river watershed (Map 40) was developed from several sources, including USGS 1:100,000 Digital Line Graph hydrology data; Delorme

Atlases for Maine and New Hampshire; "Hydropower Projects in Maine" (Maine Department of Environmental Protection, June 2000); and numerous documents filed with the Federal Energy Regulatory Commission related to licensing applications for various projects within the region. Location of wind power projects was based on Federal Aviation Administration data obtained from the US Fish and Wildlife Service (https://www.fws.gov/southwest/es/Energy_Wind_FAA.html)

Water and Air Quality

Information on the water quality classification of Maine's rivers and lakes was obtained from The Maine Department of Environmental Protection Bureau of Land and Water Quality (see http://www.state.me.us/dep/blwq/class.htm; click on the link for "The Blue Book" for a summary document on Maine standards).

Information on water quality in New Hampshire was obtained from the New Hampshire Department of Environmental Services Watershed Management Bureau 2000 Section 305(b) water quality report (see http://www.des.state.nh.us/wmb/wqsac/).

Historic water quality information was from the Bethel Historical Society at https://www.bethelhistorical.org/legacy-site/A_River%27s_Journey.html.

Mercury and lead information was from:

- Chambliss. L. 2018. A leaded weight on loon recovery. *LivingBird 37(3)*. pp. 40-47.
- Evers, D.C. 2005. Mercury connections: The extent and effect of mercury pollution in northeastern North America. Biodiversity Institute. Gorham, ME. 28 pp.

Land Ownership Change

Ownership change (Map 41) was based on 1995 data on large forestland owners in Maine and New Hampshire acquired by AMC from James W. Sewall Company and conserved lands data obtained from Maine Office of GIS and New Hampshire GRANIT. AMC has been tracking changes in land ownership in the watershed since the mid-1990s. Ownership in 1980 was determined as best as possible from multiple sources; while ownership of individual parcels is not always certain, the assignment to broad categories (industrial, family, etc.) should be reasonably accurate.

Additional information on land ownership changes in the region is available in:

- Weinberg, A. and C. Larson. 2008. Forestland for Sale: Challenges and Opportunities for Conservation over the Next Ten Years. Open Space Institute, New York, NY.
- Hagan, J.M., L.C. Irland, and A.A. Whitman. 2005. Changing timberland ownership in the Northern Forest and implications for biodiversity. Manomet Center for Conservation Sciences, Report # MCCS -FCP-2005-1, Brunswick, Maine.
- Clark, S.A. and P. Howell. 2007. From Diamond International to Plum Creek: The Era of Large Landscape Conservation in the Northern Forest. *Maine Policy Review* 16(2): 56-65.
- Irland, L.C., J. Hagan and J. Lutz. 2010. Large Timberland Transactions in the Northern Forest 1980 – 2006: Analyzing an Historic Landownership Change. Global Institute of Sustainable Forestry Research Paper 011. Yale University School of Forestry and Environmental Studies, New Haven, CT.

Land Conservation

Current and past land conservation was derived from conserved lands data obtained from Maine Office of GIS and New Hampshire GRANIT since the mid-1990s. Where the date of conservation for specific parcels was not provided in this data it was determined as best as possible from available sources.

Forest Carbon Sequestration

Data on carbon stocking was derived from US Forest Service Forest Inventory and Analysis data obtained from the Forest Service's EVALIDATOR web site (https://apps.fs.usda.gov/Evalidator/evalidator.jsp).

Aboveground live biomass data (Map 44) was developed by researchers at the University of Massachusetts and obtained from Data Basin (https://databasin.org/datasets/e41f3f04b51041acb37fadd2d73c8e3b).

— Tree species of the Upper Androscoggin River watershed —

Common Name	Scientific Name	Habitat
Softwoods		
Eastern white pine	Pinus strobus	Common, more so southward; on sandy soils at lower elevations.
Red pine	Pinus resinosa	Occasional; dry or rocky soils.
Jack pine	Pinus banksiana	Rare (Lake Umbagog shoreline only); dry or rocky soils; fire-dependent.
Tamarack	Larix laricina	Occasional, more so northward; wooded swamps and bogs.
Red spruce	Picea rubens	Very common and widespread; coniferous and mixed forests and wooded swamps.
White spruce	Picea glauca	Occasional, more so northward; upland coniferous forests.
Black spruce	Picea mariana	Occasional; wooded swamps and bogs and krummholz.
Balsam fir	Abies balsamea	Very common and widespread; coniferous and mixed forests and wooded swamps.
Eastern hemlock	Tsuga canadensis	Common, more so southward; cool acidic soils in valley bottoms and ravines.
Northern whitecedar	Thuja occidentalis	Occasional, more so northward; rich wooded swamps and bogs, occasionally in upland coniferous forests.
Hardwoods		
Black willow	Salix nigra	Uncommon (more common southward); riverbanks and riparian forests.
Quaking aspen	Populus tremuloides	Common and widespread; an early-successional species of upland forests.
Bigtooth aspen	Populus grandidentata	Occasional; an early-successional species of upland forests.
Balsam poplar	Populus balsamifera	Uncommon, more common northward; low wet areas.
Hophornbeam	Ostrya virginiana	Occasional, more so southward; rich hardwood forests.
Ironwood	Carpinus caroliniana	Uncommon, more common southward; moist rich hardwood forests.
White (paper) birch	Betula papyrifera	Common and widespread; an early-successional species of upland forests and wooded swamps.
Yellow birch	Betula alleghaniensis	Common and widespread; hardwood and mixed forests on cool moist soils.
Gray birch	Betula populifolia	Occasional, more so southward; an early successional species on poor soils.
Heartleaf white birch	Betula cordifolia	Uncommon; disturbed high-elevation forests and krummholz.
American beech	Fagus grandifolia	Common and widespread; hardwood and mixed forests on drier soils.
Northern red oak	Quercus rubra	Common, more so southward; hardwood and mixed forests on warm dry soils.
American elm	Ulmus americana	Occasional; floodplain forests and wooded swamps.
Black cherry	Prunus serotina	Occasional, more common southward; old farmsteads and abandoned agricultural lands.
Pin (fire) cherry	Prunus pensylvanica	Occasional; an early-successional species of burns and disturbed areas.
American mountain-ash	Sorbus americana	Uncommon; high-elevation coniferous forests.
Sugar maple	Acer saccarum	Very common and widespread; hardwood and mixed forests; dominant on better soils.
Red maple	Acer rubrum	Very common and widespread; hardwood and mixed forests and swamps.
Silver maple	Acer saccharinum	Occasional; floodplain forests.
Striped maple	Acer pensylvanicum	Common and widespread; an understory tree of hardwood and mixed forests.
Basswood	Tilia americana	Uncommon, more common southward; rich hardwood forests.
White ash	Fraxinus americana	Common and widespread; rich moist hardwood forests.
Black ash	Fraxinus nigra	Occasional; floodplain forests and wooded swamps.
Green ash	Fraxinus pennsylvanica	Occasional, more so southward; floodplain and riparian forests.

Natural communities of northern New Hampshire and northwestern Maine

Maine community types	New Hampshire community types
Matrix forests: Common and widespread forest communities that cover the majority of the landscape at lower and middle elevations	
Beech - Birch - Maple Forest (S4)* Red Oak - Northern Hardwoods - White Pine Forest (S4)* Spruce - Northern Hardwoods Forest (S4)* Spruce - Fir - Broom-moss Forest (S4)*	Sugar maple - beech - yellow birch forest (S5)* Hemlock - oak - northern hardwood forest (S4) Northern hardwood - spruce - fir forest (S4)* Lowland spruce - fir forest (S3)*
High-elevation forests: Characteristic evergreen forest communities of upper mountain slopes	
Spruce - Fir – Wood-sorrel – Feathermoss Forest (S4)* Fir - Heartleaved Birch Subalpine Forest (S3)*	High-elevation spruce - fir forest (S4)* High-elevation balsam fir forest (S3S4)* Montane black spruce - red spruce forest (S1)
Other upland forest communities	
Aspen - Birch Woodland/Forest Complex (S5) Hemlock Forest (S4)* Maple - Basswood - Ash Forest (S3)* Oak - Pine Forest (S4) Red Pine - White Pine Forest (S3)* Semi-rich Northern Hardwood Forest (S3)* White Pine - Mixed Conifer Forest (S4)	Beech forest (S4) Dry red oak – white pine forest (S3S4)* Hemlock - spruce - northern hardwood forest (S3S4)* Hemlock forest (S4) Red pine - white pine forest (S2S3) Rich mesic forest (S3)* Semi-rich mesic sugar maple forest (S3S4)*
Woodlands: Open-canopy stunted forests of thin rocky soils	
Birch - Oak Talus Woodland (S3)* Ironwood - Oak - Ash Woodland (S2S3)* Jack Pine Woodland (S3)* Oak - Pine Woodland (S4)* Red Pine Woodland (S3)* Red Spruce - Mixed Conifer Woodland (S4)* Spruce Talus Woodland (S4)	Birch – mountain maple wooded talus (S3)* Montane heath woodland (S2)* Northern white cedar forest/woodland (S1) Red oak – pine rocky ridge (S3S4)* Red pine rocky ridge (S2) Red spruce - heath - cinquefoil rocky ridge (S3S4)* Spruce - moss wooded talus (S2S3)* Subalpine cold-air talus shrubland (S1)*
Open uplands: Nonforested communities of thin, dry or rocky soils at low to mid-elevations	
Acidic Cliff – Gorge (S4)* Blueberry – Lichen Barren (S2) Boreal Circumneutral Open Outcrop (S2)* Crowberry – Bilberry Summit Bald (S3)* Labrador Tea Talus Dwarf-shrubland (S2)* Rocky Summit Heath (S4)* Three-toothed Cinquefoil - Blueberry Low Summit Bald (S3)*	Montane - subalpine acidic cliff (S4)* Montane - subalpine circumneutral cliff (S2S3)* Montane landslide barren and thicket (S3S4) Montane lichen talus barren (S3)* Temperate acidic cliff (S4) Temperate lichen talus barren (S2S3)
Alpine communities	
Alpine Cliff (S1) Bilberry - Mountain Heath Alpine Snowbank (S1) Cotton-grass - Heath Alpine Bog (S1)* Diapensia Alpine Ridge (S1) Dwarf Heath - Graminoid Alpine Ridge (S2)* Heath - Lichen Subalpine Slope Bog (S1)* Mountain Alder - Bush-honeysuckle Subalpine Meadow (S1) Spruce - Fir - Birch Krummholz (S3)*	Alpine heath snowbank (S1S2) Alpine herbaceous snowbank/rill (S1)* Alpine ravine shrub thicket (S1S2) Alpine/subalpine bog (S1) Bigelow's sedge meadow (S1) Black spruce - balsam fir krummholz (S2S3)* Diapensia shrubland (S1) Felsenmeer barren (S2) Labrador tea heath - krummholz (S2)* Moist alpine herb - heath meadow (S1) Sedge - rush - heath meadow (S1)* Sheep laurel - Labrador tea heath - krummholz (S2) Subalpine dwarf shrubland (S2) Subalpine rocky bald (S2) Wooded subalpine bog/heath snowbank (S1S2)

*Community documented by Natural Heritage programs within the upper Androscoggin River watershed. (Other communities may be included within documented ecosystems (ME)/natural community systems (NH) but are not individually listed.)

Shoreline and floodplain communities	
Silver Maple Floodplain Forest (S3)* Hardwood River Terrace Forest (S2)* Lakeshore Sand/Cobble Beach (S4) Twisted Sedge Cobble Rivershore (S4) Alder Floodplain (S4)*	Acidic riverbank outcrop (S3)* Acidic riverside seep (S1)* Alder alluvial shrubland (S3)* Bluejoint-goldenrod-virgins bower riverbank/floodplain (S3S4) Boulder - cobble river channel (S3) Cobble - sand river channel (S3S4) Herbaceous riverbank/floodplain (S4) Meadowsweet alluvial thicket (S3S4) Mesic herbaceous river channel (S4) Mixed alluvial shrubland (S4) Montane sandy pond shore (S1) Silver maple-false nettle-sensitive fern floodplain forest (S2)* Silver maple - wood nettle - ostrich fern floodplain forest (S2) Sugar maple - ironwood - short husk floodplain forest (S1) Sugar maple-silver maple-white ash floodplain forest (S1S2)* Twisted sedge low riverbank (S3S4) Water lobelia aquatic sandy pond shore (S2) Willow low riverbank (S3)
Forested wetlands: Forests of poorly drained mineral or shallow organic soils	
Black ash swamp (S4)* Cedar - Spruce Seepage Forest (S3) Hardwood Seepage Forest (S3) Northern Whitecedar Swamp (S4) Red Maple - Sensitive Fern Swamp (S4) Spruce - Fir Cinnamon Fern Forest (S4)	Acidic northern white cedar swamp (S1)* Circumneutral hardwood forest seep (S3)* Larch - mixed conifer swamp (S3) Northern hardwood - black ash - conifer swamp (S3)* Northern hardwood seepage forest (S3)* Northern white cedar - balsam fir swamp (S2)* Northern white cedar - hemlock swamp (S2) Northern white cedar seepage forest (S2) Red spruce swamp (S3)*
Woodland wetlands: Open-canopy stunted forests of poorly drained organic soils	
Northern Whitecedar Woodland Fen (S4)* Red Maple Wooded Fen (S4) Spruce - Larch Wooded Bog (S4)	Black spruce swamp (S3)* Northern white cedar circumneutral string (S1)
Shrub wetlands: Shrub and dwarf shrub communities of poorly drained soils	
Alder Shrub Thicket (S5) Leatherleaf Boggy Fen (S4) Mountain Holly - Alder Woodland Fen (S4) Sedge - Leatherleaf Fen Lawn (S5) Sheep Laurel Dwarf Shrub Bog (S4) Shrubby Cinquefoil - Sedge Circumneutral Fen (S2)* Sweetgale Mixed Shrub Fen (S4)	Alder - lake sedge intermediate fen (S2S3) Alder seepage thicket (S3) Alder wooded fen (S3S4)* Highbush blueberry - mountain holly wooded fen (S3S4) Highbush blueberry-sweet gale-meadowsweet thicket (S4) Highbush blueberry - winterberry shrub thicket (S4) Leatherleaf - black spruce bog (S3) Leatherleaf - sheep laurel shrub bog (S2S3) Montane level fen/bog (S2) Mountain holly - black spruce wooded fen (S3) Sweet gale - meadowsweet - tussock sedge fen (S4) Wire sedge - sweet gale fen (S3)
Herbaceous wetlands: Sedge, grass and moss-dominated communities of poorly drained soils	
Bluejoint Meadow (S4) Bog Moss Lawn (S4) Cattail Marsh (S5) Low Sedge – Buckbean Fen Lawn (S3) Mixed Graminoid Shrub Marsh (S5)* Mixed Tall Sedge Fen (S4) Tussock Sedge Meadow (S3)	Calcareous sedge - moss fen (S2)* Cattail marsh (S4) Cicumneutral – calcareous flark (S1) Emergent marsh (S5) Floating marshy peat mat (S3S4) Herbaceous seepage marsh (S3) Lake sedge seepage marsh (S3) Large cranberry - short sedge moss lawn (S3) Mixed tall graminoid - scrub-shrub marsh (S4S5) Montane sloping fen (S1) Sedge meadow marsh (S4)* Short graminoid - forb meadow marsh/mudflat (S4)* *Sphagnum rubellum* - small cranberry moss carpet (S3)* Tall graminoid meadow marsh (S4)
Aquatic bed communities: Herbaceous plant communities growing in shallow water	
Pickerelweed - Macrophyte Aquatic Bed (S5) Water-lily - Macrophyte Aquatic Bed (S5) Pipewort - Water Lobelia Aquatic Bed (S5)* Bulrush Bed (S4) Circumneutral – Alkaline Water Macrophyte Suite (S2)	Aquatic bed (S5)

— Rare Plants and Animals known from the upper Androscoggin watershed —

Latin name	Common Name	# sites[1]		Rank[2]			Status[3]		Habitat
		NH	ME	G	NH	ME	NH	ME	
PLANTS									
Adiantum aleuticum	Aleutian maidenhair fern		1/0	G5	x	S1		E	Ultramafic rocky summits
Agrostis mertensii	Boreal bentgrass		1/1	G5	p	S2		T	Alpine
Allium tricoccum	Wild leek		1/2	G5	p	S3		SC	Rich woods
Arctuous alpine	Alpine bearberry	1/1		G5	S1	S1	E	T	Alpine
Arethusa bulbosa	Dragon’s-mouth	1/0		G5	S1	p	E		Bogs, fens and meadows
Argentina anserina	Common silverweed	1/0		G5	S1	p	E		Wet meadows and river shores
Arnica lanceolata ssp lanceolota	Lance-leaved arnica	1/2		G3	S1	S2	E	T	Alpine
Asplenium platyneuron	Ebony spleenwort		0/2	G5	p	S2		SC	Ledges and rocky slopes
Aureolaria pedicularia	Fern-leaved false foxglove		0/1	G5	p	S3		SC	Ledges and oak woodlands
Betula glandulosa	Glandular birch	1/1		G5	S2	S1	T	E	Alpine
Betula minor	Dwarf birch	3/2		G4	S2	S1	T	E	Alpine
Botrychium lunaria	Moonwort		1/0	G5	x	S1		E	Swamp margins
Calamagrostis stricta ssp inexpansa	Northern neglected reed grass	0/1		T5	S2	S1	T	E	Alpine
Cardamine bellidifolia var bellidifolia	Alpine bitter-cress	1/2		G5	S1	S1	E	E	Alpine
Carex alopecoidea	Foxtail sedge		0/1	G5	x	SH		PE	Rich riparian forests and marshes
Carex atratiformis	Black sedge		0/1	G5	S1	S2	E	SC	Rich seeps and riverbanks
Carex baileyi	Bailey's sedge		0/1	G4	S2	SH	T	PE	Wooded swamps
Carex bigelowii ssp bigelowii	Bigelow's sedge	3/0	5/1	G5	S2	S2	T	SC	Alpine
Carex capillaris ssp fuscidula	Hair-like sedge	0/1	1/0	G5	S1	S2	E	SC	Alpine
Carex arctogena	Capitate sedge	0/1		T4	S1	x	E		Alpine
Carex chordorrhiza	Rope-root sedge	3/0		G5	S1	p	E		Fens and marshes
Carex diandra	Lesser tussock sedge	0/1		G5	S2	p	T		Open wetlands
Carex eburnea	Ebony sedge		1/0	G5	S1	S1	E	E	Rich cliffs and rivershores
Carex exilis	Meager sedge	2/0		G5	S1	p	E		Peatlands
Carex livida var radicaulis	Livid sedge	1/0	1/0	G5	S1	S2	E	SC	Rich peatlands
Carex media	Intermediate sedge		0/1	G5	x	S1		E	Rich cliffs
Carex siccata	Dry land sedge		0/1	G5	S1	S2	E	SC	Ledges, fields and woodands
Carex sparganioides	Bur-reed sedge		1/0	G5	S1	S1	E	E	Rich woods
Carex tenuiflora	Sparse-flowered sedge	1/0	2/0	G5	S1	S3	E	SC	Rich peatlands
Castilleja septentrionalis	Northern painted-cup	1/4		G5	S1	S3	E	SC	Alpine
Clematis occidentalis ssp occidentalis	Purple virgin’s-bower	0/2	1/2	G5	S1	S3	E	SC	Rich rocky slopes and open woods
Cynoglossum virginianum var boreale	Northern wild comfrey		1/0	G5	S1	S1	E	E	Rich woods
Cypripedium arietinum	Ram's-head lady's-slipper	0/1	1/1	G3	S1	S1	E	E	Damp or mossy woods or bogs
Cypripedium parviflorum var makasin	Greater yellow lady's-slipper	0/1		T4	S1	p	E		Moist woods, fens and wet shores
Cypripedium parviflorum var pubescens	Large yellow lady's-slipper	1/1		T5	S2	p	T		Rich woods
Cypripedium reginae	Showy lady’s-slipper		0/2	G5	S1	S3	E	SC	Northern whitecedar swamps
Diapensia lapponica ssp lapponica	Diapensia	3/1	5/0	G4	S2	S2	T	SC	Alpine
Dicentra canadensis	Squirrel-corn		0/3	G5	p	S1		T	Rich woods
Diphasiastrum sitchense	Sitka ground-cedar	0/1		G5	S1	S1	E	T	Alpine
Draba cana	Canescent whitlow-mustard	1/0		G5	S1	S1	E	E	Rich cliffs and slopes
Dryopteris filix-mas ssp brittonii	Male wood fern		0/1	G5	S1	S1	E	E	Rich ledges and rocky woods
Dryopteris fragrans	Fragrant wood fern	3/3	2/2	G5	S2	S3	T	SC	Rich cliffs and rocky slopes
Dryopteris goldiana	Goldie's fern		4/4	G4	p	S2		SC	Rich woods
Eleocharis ovata	Ovoid spikesedge	0/3		G5	SH	p	E		Rich shores and meadows
Eleocharis quinqueflora ssp fernaldii	Few-flowered spikesedge	0/1	0/1	G5	S1	S2	E	SC	Rich shores and fens
Epilobium lactiflorum	White-flowered willow-herb	0/2		G5	SH	SH	E	PE	Alpine
Epilobium hornemannii ssp hornemannii	Hornemann’s willow-herb	3/9	1/0	G5	S2	S1	T	E	Alpine
Equisetum palustre	Marsh horsetail	0/1		G5	SH	p	E		Swamps, meadows and streambanks
Eragrostis capillaris	Tiny lovegrass		0/2	G5	p	SH		PE	Open ledges
Euphrasia oakesii	William’s eyebright	0/1		G4	S1	SH	E	PE	Alpine
Festuca prolifera	Proliferous fescue	1/0		G4	S1	S1	E	E	Alpine

Latin name	Common Name	# sites[1]		Rank[2]			Status[3]		Habitat
		NH	ME	G	NH	ME	NH	ME	
Galearis spectabilis	Showy orchis		0/3	G5	S2	S1	T	E	Rich woods
Galium kamtschaticum	Boreal bedstraw		5/2	G5	p	S2		SC	Rich cool woods and streamsides
Geocaulon lividum	False toadflax	2/2	2/5	G5	S1	S3	E	SC	Alpine or peatlands
Geranium carolinianum	Carolina crane’s-bill	1/0		G5	S1	p	E		Rocky woods and dry fields
Geum peckii	White Mountain avens	5/0		G2	S2	x	T		Alpine
Omalotheca supinum	Alpine arctic-cudweed	0/1		G5	S1	S1	E	E	Alpine
Hackelia deflexa ssp americana	Nodding stickseed	0/1		G5	SH	S1	E	E	Rich bluffs and rocky woods
Harrimanella hypnoides	Moss-plant	3/4		G5	S1	S1	E	T	Alpine
Hieracium robinsonii	Robinson's hawkweed	1/0		G3	S1	S1	E	E	Rich bluffs and rocky woods
Anthoxanthum monticola ssp monticola	Alpine sweet grass	1/5	1/1	G5	S2	S1	T	T	Alpine
Hippuris vulgaris	Common mare's-tail	3/0		G5	S2	p	T	SC	Quiet water
Huperzia appressa	Mountain firmoss	1/0	3/0	G5	S1	S2	E	SC	Damp rocks and barrens
Huperzia selago	Northern firmoss		0/1	G5	SH	S2	E	T	Boreal forests and ledges
Impatiens pallida	Pale jewel-weed		3/7	G5	p	S2		SC	Rich wet woods
Isoetes acadiensis	Acadian quillwort		1/0	G3	SH	S2	E	SC	Quiet shallow water
Juncus stygius var americanus	Moor rush	1/0		T5	S1	S2	E	SC	Rich peatlands
Juncus vaseyi	Vasey’s rush		0/1	G5	x	S1		E	Rich shorelines
Lechea tenuifolia	Slender pinweed		0/1	G5	S1	SX	E	PE	Ledges and woodlands
Lonicera oblongifolia	Swamp honeysuckle		1/0	G5	x	S3		SC	Rich swamps
Neottia auriculata	Auricled twayblade	1/3	0/1	G3	S1	S2	E	T	Alluvial banks and alder swamps
Neottia convallarioides	Broad-leaved twayblade	4/0		G5	S2	p	T		Moist woods, swamps and fens
Neottia cordata	Heart-leaved twayblade	2/2		G5	S2	p	T		Moist woods and bogs
Kalmia procumbens	Alpine-azalea	1/0		G5	S2	S1	T	T	Alpine
Luzula confusa	Northern wood rush	0/2		G5	SH	S1	E	E	Alpine
Luzula spicata	Spiked wood rush	4/5		G5	S1	S1	E	T	Alpine
Malaxis monophyllos ssp brachypodia	White adder's-mouth		0/2	G5	SH	S1	E	E	Open woods, swamps and bogs
Mikania scandens	Climbing hempvine	1/0		G5	S1	SH	E	PE	Thickets, swamps and streambanks
Minuartia glabra	Smooth sandwort		0/1	G4	S1	S3	E	SC	Ledges and rocky slopes
Minuartia groenlandica	Mountain sandwort		9/3	G5	p	S3		SC	Alpine
Osmorhiza berteroi	Mountain sweet-cicely	1/5		G5	S1	p	E		Rich woods
Oxyria digyna	Mountain-sorrel	1/0		G5	S1	x	E		Alpine
Packera paupercula	Balsam groundsel	0/1		G5	S2	p	T		Ledges and shorelines
Panax quinquefolius	American ginseng	1/0	2/4	G3	S2	S3	T	E	Rich woods
Paronychia argyrocoma	Silverling		5/0	G4	S2	S1	T	T	Ledges and shorelines
Petasites frigidus var palmatus	Northern sweet-coltsfoot	0/2		T5	S1	p	E		Moist meadows and swamps
Phegopteris hexagonoptera	Broad beech fern		0/1	G5	p	S2		SC	Wet forests and wetland margins
Phleum alpinum ssp alpinum	Mountain timothy	1/1		G5	S1	S2	E	T	Alpine
Phyllodoce caerulea	Purple mountain-heath	6/1		G5	S2	S1	T	T	Alpine
Pinus banksiana	Jack pine	4/1		G5	S2	p	T		Rocky shores and ledges
Piptatherum canadense	Canada mountain-ricegrass		0/2	G5	S1	S2	E	SC	Open dry areas
Platanthera flava var herbiola	Pale green orchis		0/1	G4	S2	S2	T	SC	Swamps and shorelines
Poa laxa ssp fernaldiana	Wavy blue grass	1/5		T3	S1	S1	E	E	Alpine
Poa glauca ssp glauca	Glaucous blue grass	0/3	1/0	G5	SH	S1	E	T	Rich ledges and ridges; alpine areas
Poa pratensis ssp alpigena	Alpine Kentucky blue grass	0/1		T5	S1	x	E		Alpine
Bistorta viviparum	Alpine bistort	1/2		G5	S1	S1	E	E	Alpine
Potamogeton nodosus	Long-leaved pondweed	0/1		G5	S2	x	T		Streams and ponds
Nabalus boottii	Boott's rattlesnake-root	4/0		G2	S1	S1	E	E	Alpine
Pyrola minor	Lesser wintergreen		2/0	G5	p	S2		SC	Boreal/subalpine forest
Pyrola asarifolia ssp asarifolia	Pink shinleaf	2/3		G5	S1	x	E		Rich wet forests,shores and swamps
Rhinanthus minor ssp groenlandicus	Greenland little yellow-rattle	1/1		T5	S1	x	E		Alpine
Rhododendron lapponicum	Lapland rosebay	1/1		G5	S2	S1	T	T	Alpine
Rubus chamaemorus	Baked-apple-berry	3/1		G5	S2	p	T		Alpine
Sagittaria cuneata	Northern arrowhead	0/3		G5	S1	p	E		Shallow water and muddy shores
Salix exigua ssp interior	Sandbar willow		1/0	G5	S1	S1	E	E	Shorelines
Salix herbacea	Snow-bed willow	1/1		G5	S1	S1	E	T	Alpine

Latin name	Common Name	# sites[1]		Rank[2]			Status[3]		Habitat
		NH	ME	G	NH	ME	NH	ME	
Salix pellita	Satiny willow	0/5		G5	S1	p	E		Damp thickets and wet shores
Salix planifolia ssp planifolia	Tea-leaved willow	3/1		G5	S2	S1	T	T	Alpine
Salix uva-ursi	Bearberry willow	2/0		G5	S2	S1	T	T	Alpine
Sanguisorba canadensis	Canada burnet		0/1	G5	p	S1		T	Shorelines and wet meadows
Saxifraga paniculata ssp neogaea	Livelong saxifrage		1/0	G5	S1	S1	E	E	Alpine
Saxifraga rivularis ssp rivularis	Alpine-brook saxifrage	1/1		G5	S1	x	E		Alpine
Silene acaulis	Moss campion	1/5		G5	S1	SX	E	PE	Alpine
Solidago leiocarpa	Cutler's goldenrod		2/0	G5	S2	S1	T	T	Alpine
Sphagnum contortum	Peat moss	1/1		G5	S2	p	T		Peatlands
Spiranthes casei var casei	Case's ladies'-tresses	0/1		G4	S1	p	E		Dry bluffs and sandy places
Spiranthes lucida	Shining ladies'-tresses		0/1	G4	S1	S1	E	T	Meadows and shorelines
Trillium grandiflorum	Large white trillium		0/1	G5	p	SH		PE	Forests and rocky slopes
Triphora trianthophora	Nodding pogonia		2/0	G4	S2	S2	T	T	Moist forests
Ulmus rubra	Slippery elm		0/1	G5	p	SH		PE	Rich floodplains
Vaccinium boreale	Northern blueberry	2/4	4/0	G4	S2	S2	T	SC	Alpine
Vaccinium cespitosum	Dwarf blueberry	1/6		G5	S2	p	T		Ledges and shorelines
Vahlodea atropurpurea	Arctic hair grass	0/9		G5	SH	S1	E	E	Peatlands
Veronica wormskjoldii var wormskjoldii	American alpine speedwell	1/0		G5	S1	S1	E	E	Alpine
Viburnum edule	Squashberry	0/4		G5	SH	p	T		Alpine
Viola canadensis	Tall white violet; Canada violet		0/1	G5	p	SH		PE	Rich woods
Viola palustris var palustris	Northern marsh violet	1/1		G5	S2	S1	T		Alpine
Woodsia alpina	Northern cliff fern		0/1	G5	x	SH		PE	Rich cliffs
Woodsia glabella	Smooth cliff fern	0/2	2/0	G5	S1	S1	E	T	Rich cliffs
FISH[4]									
Phoxinus neogaeus	Finescale dace	0/4		G5	S3	p	SC		Cool headwater streams and ponds
AMPHIBIANS AND REPTILES									
Glyptemys insculpta	Wood turtle	5/0	*[5]	G3	S3	S4	SC	SC	Sandy streams and terrestrial uplands
Gyrinophilus porphyriticus porphyriticus	Northern spring salamander		*	G5	x	?		SC	Mountain streams
Lithobates pipiens	Northern leopard frog	2/0		G5	S3	S3	SC	SC	Streams, marshes and ponds
Opheodrys vernalis	Smooth green snake	1/0		G5	S3	p	SC		Fields, meadows and openings
BIRDS									
Aquila chrysaetos	Golden eagle		*	G5	SH	S1	E	E	Cliffs and open areas
Ardea herodias	Great blue heron		*	G5	p	S4		SC	Wetlands, lakes and rivers
Catharsus bicknellii	Bicknell's thrush		*	G4	S2	S3	SC	SC	Subalpine forest
Chordeiles minor	Common nighthawk	0/1		G5	S1B	p	E		Sandy or gravelly openings
Circus hudsonius	Northern harrier	2/3		G5	S1B	*	E	SC	Fields, meadows and marshes
Euphagus carolinus	Rusty blackbird		*	G4	S3	S3	SC	SC	Stunted softwood forest and wetlands
Falco peregrinus anatum	Peregrine falcon	3/0	*	T4	S2	S2	T	E	Cliffs
Gavia immer	Common loon	45/0		G5	S2B	p	T		Lake shore wetlands
Haliaeetus leucocephalus	Bald eagle	12/0		G5	S2	S4	SC	SC	Lake and river riparian areas
Petrochelidon pyrrhonota	Cliff swallow	1/0		G5	S3B	p	T		Cliffs and structures
Podilymbus podiceps	Pied-billed grebe	2/1		G5	S2B	p	T		Pond and streamside wetlands
Porzana carolina	Sora	1/0		G5	S3B	p	SC		Marshes
MAMMALS									
Lynx canadensis	Canada lynx	3/0		G5	S1	S2	E	SC	Softwood forest
Martes americana	American marten	60/1		G5	S2	p	SC		Mature softwood and mixed forest
Myotis septentrionalis	Northern long-eared bat	1/0		G1	S1	S4	E	E	Mines and caves; mature forest
Synaptomys borealis sphagnicola	Northern bog lemming	0/1		T3	S1	S1	SC	T	Boreal bogs and mossy forest

[1] The first number is occurrences that have been confirmed since 1998, the second number is records more than 20 years old.
[2] See Appendix E for a full explanation of global and state ranks; "p" - species is present but not listed as rare; "x" – species is not present.
[3] E – Endangered, T – Threatened, SC – Special Concern PE – Possibly Extirpated.
[4]Additional Special Concern fish species recorded as being present in the upper Androscoggin watershed by Maine Department ofInland Fisheries & Wildlife: American eel (*Anguilla rostrata*), bridle shiner (*Notropis bifrenatus*), brook stickleback (*Culaea inconstans*), creek chubsucker (*Erimyzon oblongus*), lake whitefish (*Coregonus clupeaformis*), longnose dace (*Rhinichthys cataractae*).
[5] Confirmed presence in the watershed. Maine does not provide specific occurrence data for wildlife species.

— Natural Heritage Rarity Ranking System —

This ranking system is used by state Natural Heritage Programs to describe the rarity of plant and animal species and natural communities. Ranks describe rarity both throughout a natural community's or a species' range (globally, or "G" rank) and within a particular state (statewide, or "S" rank). The rarity of sub-species and varieties is indicated with a taxon ("T") rank. For example, a G5T1 rank shows that the species is globally secure (G5) but the sub-species is critically imperiled (T1).

Code	Examples	Description
1	G1 S1	Critically imperiled because extreme rarity (generally one to five occurrences) or some factor of its biology makes it particularly vulnerable to extinction.
2	G2 S2	Imperiled because rarity (generally six to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction or decline.
3	G3 S3	Either very rare and local throughout its range (generally 21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction or decline because of other factors.
4	G4 S4	Widespread and apparently secure, although the species may be quite rare in parts of its range, especially at the periphery. Common natural communities may be ranked S4 if examples are not adequately protected.
5	G5 S5	widespread and secure, although the species may be quite rare in parts of its range, particularly at the periphery.
U	GU SU	Status uncertain, but possibly in peril. More information needed.
H	GH SH	Known only from historical records, but may be rediscovered. A G5 SH species is widespread throughout its range (G5), but considered historical in the state (SH).
X	GX SX	Believed to be extinct. May be rediscovered, but evidence indicates that this is less likely than for historical species. A G5 SX species is widespread throughout its range (G5), but extirpated from the state (SX).

Modifiers are used as follows.

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

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

G4G5	The species may be globally secure (G5), but appears to be at some risk (G4).
G5T2T3	The species is globally secure (G5), but the sub-species is somewhat imperiled (T2T3).
G4?Q	The species appears to be relatively secure (G4), but more information is needed to confirm this (?). Further, there are questions or problems with the species' taxonomy (Q).
G3G4Q S1S2	The species is globally uncommon (G3G4), and there are questions about its taxonomy (Q). In the state, the species is very imperiled (S1S2).

— Wildlife species of the upper Androscoggin River watershed —

Common name	Scientific name
Amphibians	
Blue-spotted salamander	Ambystoma laterale
Spotted salamander	Ambystoma maculatum
Eastern newt	Notophthalmus viridescens
Dusky salamander	Desmognathus fuscus
Northern two-lined salamander	Eurycea bislineata
Spring salamander	Gyrinophilus porphyriticus
Redback salamander	Plethodon cinereus
American toad	Bufo americanus
Gray treefrog	Hyla versicolor
Spring peeper	Pseudacris crucifer
Bullfrog	Rana catesbeiana
Green frog	Rana clamitans
Pickerel frog	Rana palustris
Northern leopard frog	Rana pipiens
Mink frog	Rana septentrionalis
Wood frog	Rana sylvatica
Reptiles	
Snapping turtle	Chelydra serpentina
Painted turtle	Chrysemys picta
Wood turtle	Clemmys insculpta
Ringneck snake	Diadophis punctatus
Milk snake	Lampropeltis triangulum
Northern water snake	Nerodia sipedon
Smooth green snake	Liochlorophis vernalis
Redbelly snake	Storeria occipitomaculata
Eastern ribbon snake	Thamnophis sauritus
Common garter snake	Thamnophis sirtalis
Birds (breeding only)	
Common loon	Gavia immer
Pied-billed grebe	Podilymbus podiceps
American bittern	Botaurus lentiginosus
Great blue heron	Ardea herodias
Green heron	Butorides virescens
Canada goose	Branta canadensis
Wood duck	Aix sponsa
Green-winged teal	Anas crecca
Mallard	Anas platyrhynchos
American black duck	Anas rubripes
Blue-winged teal	Anas discors
Ring-necked duck	Aythya collaris
Common goldeneye	Bucephala clangula
Hooded merganser	Lophodytes cucullatus
Common merganser	Mergus merganser
Red-breasted merganser	Mergus serrator
Osprey	Pandion haliaetus
Bald eagle	Haliaeetus leucocephalus
Golden eagle	Aquila chrysaetos
Northern harrier	Circus cyaneus
Sharp-shinned hawk	Accipiter striatus
Cooper's hawk	Accipiter cooperii
Northern goshawk	Accipiter gentilis
Red-shouldered hawk	Buteo lineatus
Broad-winged hawk	Buteo platypterus
Red-tailed hawk	Buteo jamaicensis
American kestrel	Falco sparverius
Merlin	Falco columbarius
Peregrine falcon	Falco peregrinus
Spruce grouse	Falcipennis canadensis
Ruffed grouse	Bonasa umbellus

Common name	Scientific name
Birds (continued)	
Virginia rail	Rallus limicola
Sora	Porzana carolina
Killdeer	Charadrius vociferus
Spotted sandpiper	Actitis macularia
Common snipe	Gallinago gallinago
American woodcock	Scolopax minor
Herring gull	Larus argentatus
Black tern	Chlidonias niger
Mourning dove	Zenaida macroura
Black-billed cuckoo	Coccyzus erythropthalmus
Yellow-billed cuckoo	Coccyzus americanus
Great horned owl	Bubo virginianus
Barred owl	Strix varia
Long-eared owl	Asio otus
Northern saw-whet owl	Aegolius acadicus
Common nighthawl	Chordeiles minor
Whip-poor-will	Caprimulgus vociferus
Chimney swift	Chaetura pelagica
Ruby-throated hummingbird	Archilochus colubris
Belted kingfisher	Ceryle alcyon
Yellow-bellied sapsucker	Sphyrapicus varius
Downy woodpecker	Picoides pubescens
Hairy woodpecker	Picoides villosus
Three-toed woodpecker	Picoides tridactylus
Black-backed woodpecker	Picoides arcticus
Northern flicker	Colaptes auratus
Pileated woodpecker	Dryocopus pileatus
Olive-sided flycathcer	Contopus cooperi
Eastern wood-pewee	Contopus virens
Yellow-bellied flycatcher	Empidonax flaviventris
Alder flycatcher	Empidonax alnorum
Willow flycatcher	Empidonax traillii
Least flycatcher	Empidonax minimus
Eastern phoebe	Sayornis phoebe
Great crested flycatcher	Myiarchus crinitus
Eastern kingbird	Tyrannus tyrannus
Horned lark	Eremophila alpestris
Tree swallow	Tachycineta bicolor
Northern rough-winged swallow	Stelgidopteryx serripennis
Bank swallow	Riparia riparia
Cliff swallow	Petrochelidon pyrrhonota
Barn swallow	Hirundo rustica
Canada jay	Perisoreus canadensis
Blue jay	Cyanocitta cristata
American crow	Corvus brachyrhynchos
Common raven	Corvus corax
Black-capped chickadee	Poecile atricapillus
Boreal chickadee	P oecile hudsonicus
Tufted titmouse	Baeolophus bicolor
Red-breasted nuthatch	Sitta canadensis
White-breasted nuthatch	Sitta carolinensis
Brown creeper	Certhia americana
House wren	Troglodytes aedon
Winter wren	Troglodytes troglodytes
Golden-crowned kinglet	Regulus satrapa
Ruby-crowned kinglet	Regulus calendula
Blue-gray gnatcatcher	Polioptila caerulea
Eastern bluebird	Sialia sialis
Veery	Catharus fuscescens
Bicknell's thrush	Catharus bicknelli
Swainson's thrush	Catharus ustulatus

Common name	Scientific name
Birds (continued)	
Hermit thrush	Catharus guttatus
Wood thrush	Hylocichla mustelina
American robin	Turdus migratorius
Gray catbird	Dumetella carolinensis
Northern mockingbird	Mimus polyglottos
Brown thrasher	Toxostoma rufum
American pipit	Anthus rubescens
Cedar waxwing	Bombycilla cedrorum
Blue-headed vireo	Vireo solitarius
Yellow-throated vireo	Vireo flavifrons
Warbling vireo	Vireo gilvus
Philadelphia vireo	Vireo philadelphicus
Red-eyed vireo	Vireo olivaceus
Tennessee warbler	Vermivora peregrina
Nashville warbler	Vermivora ruficapilla
Northern parula	Parula americana
Yellow warbler	Dendroica petechia
Chestnut-sided warbler	Dendroica pensylvanica
Magnolia warbler	Dendroica magnolia
Cape May warbler	Dendroica tigrina
Black-throated blue warbler	Dendroica caerulescens
Yellow-rumped warbler	Dendroica coronata
Black-throated green warbler	Dendroica virens
Blackburnian warbler	Dendroica fusca
Pine warbler	Dendroica pinus
Palm warbler	Dendroica palmarum
Bay-breasted warbler	Dendroica castanea
Blackpoll warbler	Dendroica striata
Black-and-white-warbler	Mniotilta varia
American redstart	Setophaga ruticilla
Ovenbird	Seiurus aurocapillus
Northern waterthrush	Seiurus noveboracensis
Mourning warbler	Oporornis philadelphia
Common yellowthroat	Geothlypis trichas
Wilson's warbler	Wilsonia pusilla
Canada warbler	Wilsonia canadensis
Scarlet tanager	Piranga olivacea
Northern cardinal	Cardinalis cardinalis
Rose-breasted grosbeak	Pheucticus ludovicianus
Indigo bunting	Passerina cyanea
Eastern towhee	Pipilo erythrophthalmus
Chipping sparrow	Spizella passerina
Field sparrow	Spizella pusilla
Vesper sparrow	Pooecetes gramineus
Savannah sparrow	Passerculus sandwichensis
Song sparrow	Melospiza melodia
Lincoln's sparrow	Melospiza lincolnii
Swamp sparrow	Melospiza georgiana
White-throated sparrow	Zonotrichia albicollis
Dark-eyed junco	Junco hyemalis
Bobolink	Dolichonyx oryzivorus
Red-winged blackbird	Agelaius phoeniceus
Eastern meadowlark	Sturnella magna
Rusty blackbird	Euphagus carolinus
Common grackle	Quiscalus quiscula
Brown-headed cowbird	Molothrus ater
Baltimore oriole	Icterus galbula
Purple finch	Carpodacus purpureus
Red crossbill	Loxia curvirostra
White-winged crossbill	Loxia leucoptera
Pine siskin	Carduelis pinus
American goldfinch	Carduelis tristis
Evening grosbeak	Coccothraustes vespertinus

Common name	Scientific name
Mammals	
Masked shrew	Sorex cinereus
Water shrew	Sorex palustris
Smoky shrew	Sorex fumeus
Long-tailed shrew	Sorex dispar
Pygmy shrew	Sorex hoyi
Northern short-tailed shrew	Blarina brevicauda
Star-nosed mole	Condylura cristata
Hairy-tailed mole	Parascalops breweri
Little brown myotis	Myotis lucifugus
Northern myotis	Myotis septentrionalis
Eastern small-footed myotis	Myotis leibii
Silver-haired bat	Lasionycteris noctivagans
Eastern pipistrelle	Pipistrellus subflavus
Big brown bat	Eptesicus fuscus
Eastern red bat	Lasiurus borealis
Hoary bat	Lasiurus cinereus
Snowshoe hare	Lepus americanus
Eastern chipmunk	Tamias striatus
Woodchuck	Marmota monax
Eastern gray squirrel	Sciurus carolinensis
Red squireel	Tamiasciurus hudsonicus
Northern flying squirrel	Glaucomys sabrinus
American beaver	Castor canadensis
Deer mouse	Peromyscus maniculatus
White-footed mouse	Peromyscus leucopus
Southern red-backed vole	Clethrionomys gapperi
Meadow vole	Microtus pennsylvanicus
Rock vole	Microtus chrotorrhinus
Woodland vole	Microtus pinetorum
Muskrat	Ondatra zibethicus
Southern bog lemming	Synaptomys cooperi
Northern bog lemming	Synaptomys borealis
Meadow jumping mouse	Zapus hudsonius
Woodland jumping mouse	Napaeozapus insignis
Common porcupine	Erethizon dorsatum
Coyote	Canis latrans
Red fox	Vulpes vulpes
Common gray fox	Urocyon cinereoargenteus
Black bear	Ursus americanus
Common raccoon	Procyon lotor
American marten	Martes americana
Fisher	Martes pennanti
Ermine	Mustela erminea
Long-tailed weasel	Mustela frenata
Mink	Mustela vison
Striped skunk	Mephitis mephitis
Northern river otter	Lutra canadensis
Lynx	Lynx canadensis
Bobcat	Lynx rufus
White-tailed deer	Odocoileus virginianus
Moose	Alces alces

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