



A Climate Change Impact Assessment for Upper Connecticut River Valley (NH and VT)

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Highlighted Sectors: Habitat Conservation, Forestry, Agriculture & Nature-based Recreation

Geographic boundaries: The Upper Connecticut River watershed from Claremont (Sugar River) to Littleton.

Description: The Upper Connecticut River Valley has remarkable wildlife habitat, drinking water supplies, forestry, agricultural lands, nature-based recreation, and rural villages and small cities that make this region both ecologically significant and a desirable place to live and visit. Agricultural, urban and residential, and transportation uses have altered this landscape, and the river regime has been changed by channel modification. For these reasons and due to development pressures, it is a high priority area for conservation for New Hampshire. The valley floor has a milder climate than the surrounding hilly regions, and its vegetation includes more southerly species. The northern portion supports some manufacturing. Agriculture is most important in the White River watershed (White River Junction), the Passumpsic River (St. Johnsbury) watershed, and along the main stem of the Connecticut River. Forestry is important in the northern areas and headwater areas. Nature-based recreation is important across the region, with water recreation focused along the CT River and its tributaries, biking along rural roads, and winter recreation at high elevations and in the north. The region is made up of rolling hills and open low mountains with elevations ranging from 500 feet to over 3000 feet. The vegetation types are mostly transition hardwoods (maple-beech-birch, oak-hickory with red oak, white oak, shagbark hickory, and some hemlock and white pine), and northern hardwoods (maple-beech-birch), with lowland spruce-fir and a few patches of high elevation spruce-fir forest. Wetland and riverside communities contain several rare plant and animal species.

Organizations that could contribute to climate change adaptation:

Municipalities with climate change adaptation capacity:

Regional Planning Organizations:

Land Conservation Organizations: Ammonoosuc Conservation Trust, Ausbon Sargent Land Preservation Trust, The Greensboro Land Trust, The Nature Conservancy – NH Chapter, The Nature Conservancy – VT Chapter, Northern Rivers Land Trust (VT), Passumpsic Valley Land Trust Inc. (VT), Pemi-Baker Land Trust, Society for the Protection of New Hampshire Forests, Upper Valley Land Trust (NH), Vermont Land Trust (VT)

Other Conservation Organizations: Bethlehem Conservation Commission (NH), Connecticut River Watershed Council, Connecticut River Watershed Advisory Commission, Connecticut River Joint Commission, Eastern Brook Trout Joint Venture, Essex County NRC (VT), Friends of Pondicherry (VT), Hanover Conservation Council (NH), Haverhill Conservation Commission (NH), Lyme Conservation Commission (NH), NH Audubon Society, NH Rivers Council, Trout Unlimited, VT Natural Resources Council, VT River Conservancy, Vital Communities, Westfield River Watershed Association, White River Partnership (VT)

Major Forest Landowners: Silvio O. Conte National Wildlife Refuge - Pondicherry Refuge unit (6,700 acres)

Recreational Organizations: Upper Valley Trails Alliance, NH Department of Resources and Economic Development - Bureau of Trails. The region has 10 ATV clubs and over two dozen snowmobile clubs.

Educational Institutions: Dartmouth College, University of New Hampshire, University of Vermont

Other: NH Fish and Game, TransCanada Corp. (dam utility, owns ~3500 acres)

Some Key Sector Attributes:

Habitat Conservation: The Connecticut River Valley in New Hampshire and Vermont is about 72% forested. About 38.8% of Grafton County (NH) and 14.1% of Sullivan County are in conservation lands. Habitats which provide some of the rarest and most remarkable ecological communities along the Connecticut River include: floodplain forests, riverside seeps and outcrops (home for rare plants including Jesup's milk-vetch), and calcareous wetlands which support many rare orchids. Northern and high-elevation areas support boreal forest. Two of the several federally listed endangered and threatened species are noteworthy: the dwarf wedge mussel and Jesup's milk-vetch, an endemic species. Exotic aquatic plants (milfoil, Didymo (*Didymosphenia geminata*), Purple Loosestrife (*Lythrum salicaria*), Japanese knotweed (*Polygonatum cuspidatum*) and exotic animals began to affect water bodies in New Hampshire and Vermont in the mid-1960s, and arrived in the Connecticut River in the mid-1990s, when Eurasian milfoil was discovered in Springfield, Vermont. Water quality monitoring in 2004 indicated that the main stem river meets State standards.

Federal Lands: Silvio O. Conte National Wildlife Refuge (31,300 acres of northern forests and wetlands [including floodplain forest])

State lands: Maidstone State Park (VT), Wilgus State Park (VT), Hawk Mountain Wildlife Management Area (VT), Mt. Ascutney State Park (VT), Groton State Forest (VT), Victory State Forest (VT), Mt Cardigan State Park and Forest (NH) Fort Hill Wildlife Management Area (NH, 610 acres, riparian forest and wetlands)

NGO Lands:

Priority conservation areas for the Conte NWR include: Connecticut River (from Claremont to Ompompanoosuc River), White River Watershed (VT), Ammonoosuc and Wild Ammonoosuc River Watersheds (NH), Pondicherry (NH, 5,304 acres managed by Conte NWR), and Victory Basin Watershed (VT).

Priority conservation areas for the Upper CT Mitigation and Enhancement Fund (NH Charitable Foundation): Lower main stem of Nash Stream and confluence with the Upper Ammonoosuc River, main stem of the Connecticut River in Lancaster-Northumberland Reach, lower main stem of the Johns River and its confluence with the Connecticut River, mid-lower main stem of the White River, and the main stem of the Connecticut River from Clark Brook to Eastman Brook.

Forestry: Forestry is the main land use industry. Connecticut River Valley counties are >85% privately owned. About 6% of Grafton County and 15% of Sullivan County is conserved as working forest. The Green Mountain National Forest and White Mountains National Forest lie on the periphery of this region. Eastern Hemlock and white pine are common in the southern half of the region, while red spruce and balsam fir are common in the northern half. Sugar maple is common throughout. Regional pulp markets are increasingly unstable. Many of the U.S. mills are antiquated and rumors of imminent closings are common. Canadian mills, also part of the regional economy, help ameliorate these challenges. Many larger paper companies are moving toward certification because of the demand from European markets. The region has over 30 wood processing mills which are largely small to medium-sized wood products firms. Most sawmills are locally owned and operated. A high percentage of forests are owned by non-industrial private owners and so buyers are concerned about access to a dependable timber supplies. In 1990, Vermont experienced a small infestation of the hemlock woolly adelgid.

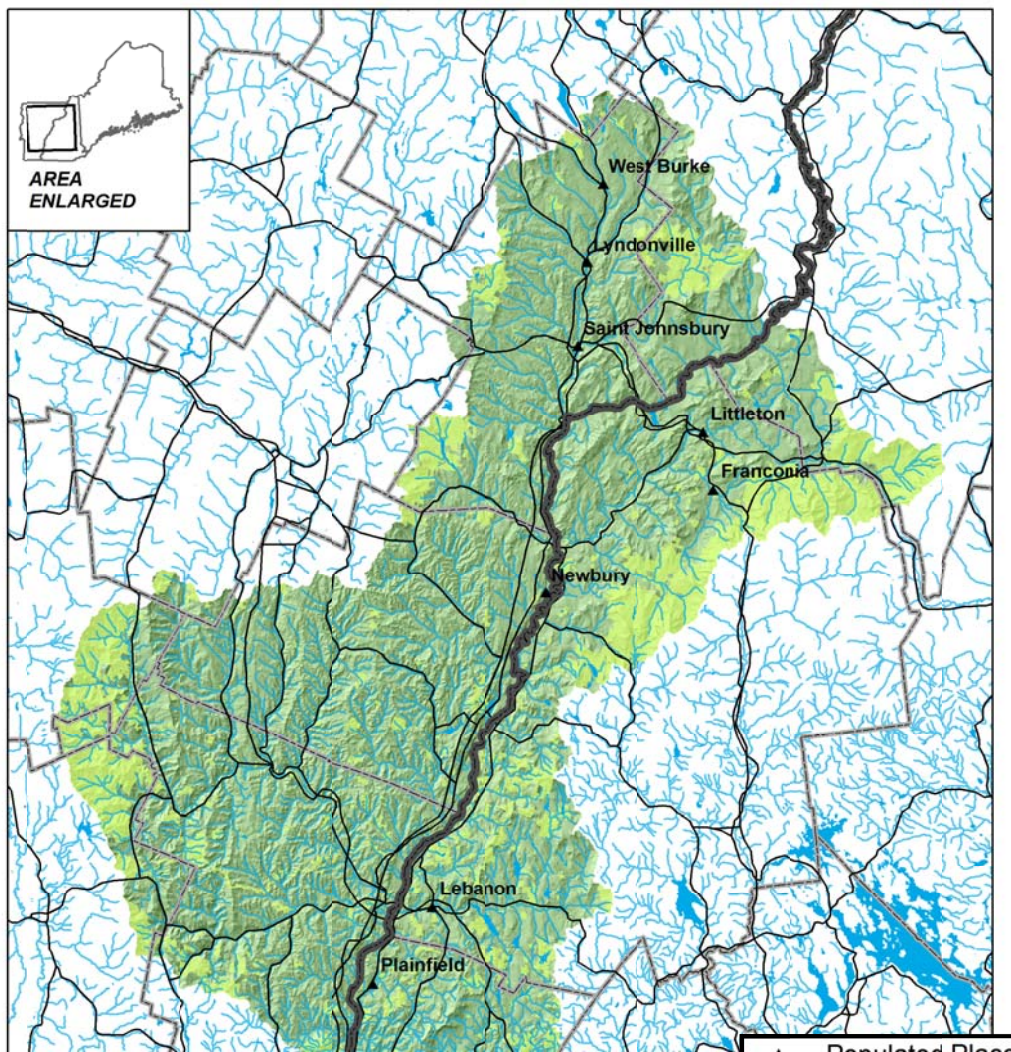
Agriculture: About 6% of this region is in agriculture (Brown 2009). Much of the farmland in this region has been classified as high quality with high development potential. Only about 450 acres of Grafton County have been conserved as working farmland. New Hampshire, the most rapidly developing state in the eastern U.S., has seen a rapid conversion of agriculture lands to development. Agriculture is diversifying in this region from dairy to also feature vegetable and fruit farms, horticultural operations, and a number of horse farms. Dairy farms have consolidated into larger units while small vegetables farms have emerged to reverse the decline in farm numbers. In some areas, most of the moderate and severe erosion sites occurred on agricultural land.

Nature-based Recreation: Grafton County (NH) covers most of the region and has 447 nature-based recreation sites, 15 golf courses, 17 winter sports area, 83 water access points, 115 miles of ATV trail, and five downhill ski areas. There is a Connecticut River Birding Trail and a Connecticut River Paddlers' Trail. The Appalachian National Scenic Trail provides scenic river views. Bike trails are cited in almost every town from Littleton to Walpole. The Connecticut River offers a wide variety of boating opportunities. Access can be gained at any of the approximately 50 access sites along the river in New Hampshire or the 36 sites in Vermont. This section of the Connecticut River supports a trout fishery primarily

downstream of the existing hydro electric dams. The dam reservoirs support important warm water fisheries, but suffer from consumption warnings related to elevated levels of mercury in fish. The NH Fish and Game Department stocks approximately 33,750 trout into the Connecticut River each year. Trout are one of approximately 32 species of fish that reside in the Connecticut River. Warm water species including perch, bass, pickerel, walleye and pike are found in much of the main stem of the river below Lancaster. Cold water species, including trout, are found in the northern stretches of the river as well as in areas below Lancaster at the mouths of tributaries. Combined sewer overflows still exist in Lebanon (NH) and so the state of New Hampshire continues to classify the river as not supporting swimming.

References

- Brown, R. (ed.). 2009. *Where the Great River Rises: An Atlas of the Upper Connecticut River Watershed in Vermont and New Hampshire*. Dartmouth College Press, Hanover, NH.
- Connecticut River Joint Commissions. 2009. *Water Resources Riverbend Subcommittee of the Connecticut River Joint Commissions*. Drafted by the Riverbend Subcommittee with the assistance of Adair D. Mulligan. Connecticut River Joint Commissions. Charlestown, NH.
- State of New Hampshire. 2007. *New Hampshire Outdoors 2008-2013 Statewide Comprehensive Outdoor Recreation Plan*. Department Of Resources and Economic Development. Concord, NH.
- Wake, C. and E. Burakowski. 2006. *Winter Recreation and Climate Variability in New Hampshire: 1984-2006*.
- Wharton, E.H., R.H. Widmann, C.H. Barnett, T. Frieswyk, A. Lister, and B. DeGeus. 2003. *The forests of the Green Mountain State*. Resour. Bull. NE-158. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 25 p.



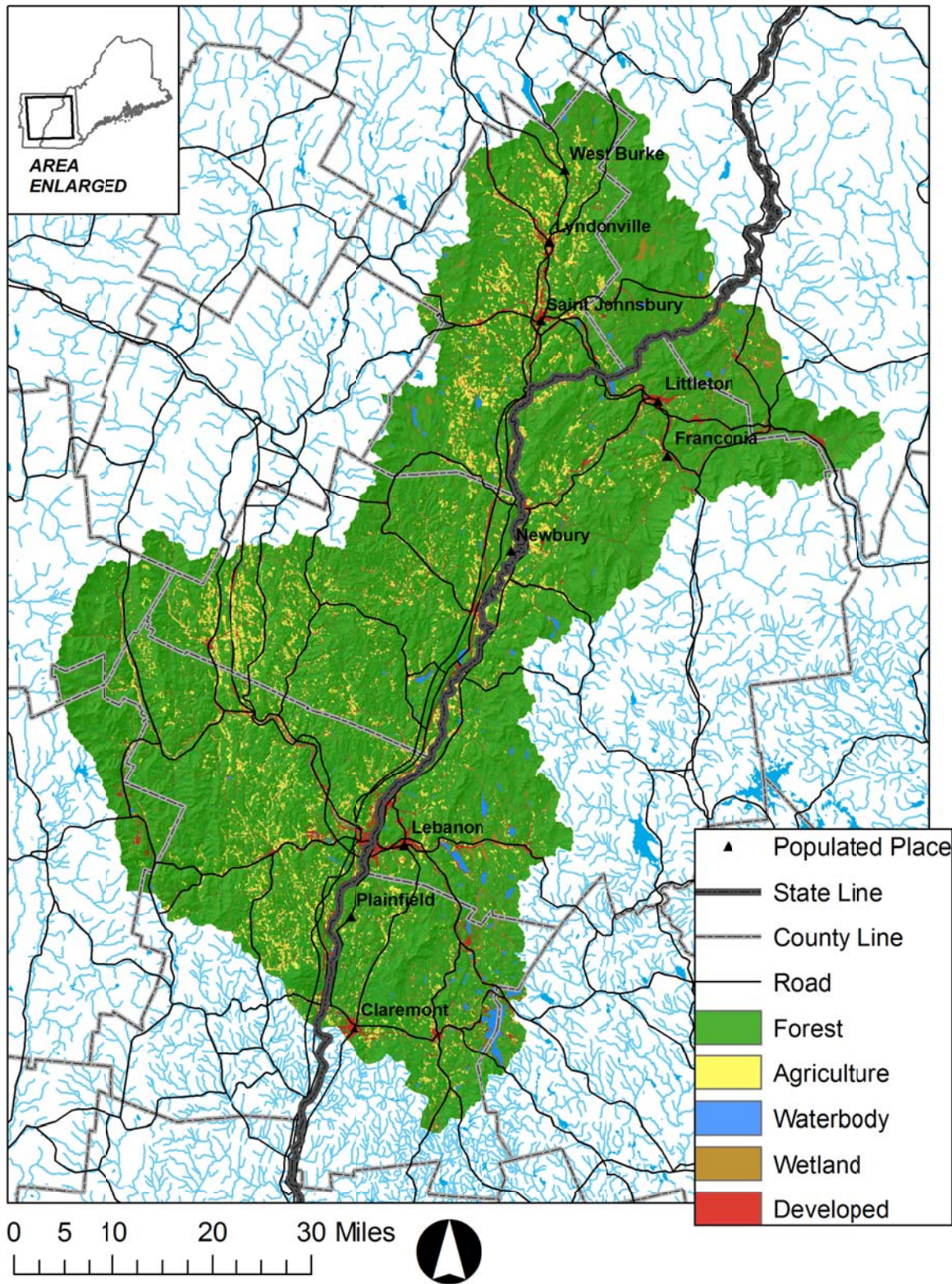


Fig. 1: The Connecticut River Region

Projected Impacts and Strategies for Habitat Conservation, Forestry, Agriculture & Nature-based Recreation

Agriculture

Major Agricultural Sector - Climate changes	Potential Impact on agricultural sectors	Size & Likelihood of Potential Impact without action		Possible Strategies:	What type of actor can best implement the strategy?*	Other sectors to be engaged:
		2010-2040	2041-2100			
Livestock (meat & dairy)						
- warmer temperatures	- reduction in winter feed costs - reduction in summer productivity	Low	Low			
	- increase in mastitis as more of year is muddy due to unfrozen ground	Moderate	Moderate			
- more frequent extreme heat events	- reduction in milk and meat production efficiency	Low	Moderate			
- more frequent drought	- reduced water availability for livestock and increased production costs	Low	Low			
- longer growing season	- longer opportunity to use pasture-based systems	Moderate	High			
Cropping (forages, vegetables, and orchard)						
- warmer temperatures	- greater production for some forage, vegetable, and fruit varieties due to warmer growing season	Moderate	High			
	- reduced production for other forage, vegetable, and fruit varieties due to warmer growing season	Moderate	High			
	- increase in new crop pest and number of generations of current insect pests	High	High			
- warmer winters - less snowfall	- crop losses due winter deacclimatization and winter bud kill of some varieties of forages, blueberries, and fruit trees	Moderate	Moderate			
- more frequent extreme heat events	- more frequent problematic moisture stress to crops	Low	Moderate			
- more frequent drought	- reduction in crop productivity due to lower water availability	Low	Moderate			
- more frequent late growing season drought	- reduced productivity late in season	Low	Moderate			
- longer growing seasons	- more opportunities for additional harvests of forage - more opportunities for growing new, more productive crop and fruit varieties	Moderate	High			
- more frequent extreme rainfall events	- increased difficulty in accessing fields - increased soil erosion - more frequent weather-related crop losses	Moderate	Moderate			
- more variable first frost date	- more frequent weather-related crop losses due to increased flower/fruit mortality from irregular first frost	Low	Low			
- increased CO2 fertilization	- greater crop productivity	Moderate	Moderate			

* e.g., landowner, local/regional government, NGO, state government, and/or federal government.

Habitat Conservation

Biodiversity Component - Climate changes	Potential Impact	Size & likelihood of Potential Impact without Action		Possible Strategies:	What type of actor can best implement the strategy?*	Other sectors to be engaged:
		2010-2040	2041-2100			
Landscape Elements						
Large Blocks of Habitat and Connectivity - warmer temperatures - more frequent drought	- more frequent forest fire and widespread forest pest outbreaks reducing block size and connectivity - more frequent widespread pest outbreaks redblock size	Low	Low			
Enduring features (e.g., soils, aspect etc.) - more frequent late-growing season drought - more frequent drought	- more frequent forest fire increasing soil erosion	Low	Low			
Habitat						
Northern hardwood forest & northern coniferous forest communities - warmer temperatures - more frequent late-growing season drought - more frequent drought	- reduction in extent of northern hardwood forest and northern conifer forests due to less tree regeneration and increase mortality - northward shift of distribution of forest types - increase spread of hemlock wooly adelgid and reduction in hemlock dominated forest	Low	Moderate			
	- more frequent forest fire burning northern conifer types	Low	Low			
Oak and pine forest communities - warmer temperatures - more frequent late-growing season drought - more frequent drought	- increase in extent of oak and pine forests - increase levels of chronic stress due to greater populations of forest pests, pathogens, and invasive spp., deer, and ozone levels.	Low	Moderate			
Freshwater wetlands, stream/river shore plant communities, and waterbodies - drought - increase fluctuations in water levels - more frequent extreme rainfall events	- habitat area may decline in drought years - more frequent stream scouring and sedimentation events from storms - increased levels of eutrophication due to runoff from extreme rain events	Moderate	Moderate			
Species						
Northern species at southern edge of range (e.g., American marten, Blackpoll warbler) - warmer temperatures	- reductions in population size	Low	Moderate			
Southern species at northern edge of range (e.g., white tailed deer, gray fox) - warmer temperatures - less severe winters	- increased population size, expanded range of spp.	Moderate	High			
Wetland and Aquatic Species - winter rain flooding - reduced spring flows - more frequent drought - warmer temperatures - more frequent extreme rainfall events	- reduces populations of cold-water species (e.g., trout) due to increased temperature-related mortality - reduction in populations of wetland species due to stress from more variable hydrology - increased stream sedimentation from storms	Low	Moderate			
Wildlife Health - warmer temperatures	- increase population size of deer - increased tick infestations and frequency of extreme heat reduces moose populations	Low	Moderate			

* e.g. landowner, local/regional government, Forestry, NGO, state government, and/or federal government.

Component of Managed Forest System - Climate changes	Potential Impact	Size & likelihood of Potential Impact without action		Possible Strategies:	What type of actor can best implement the strategy?*	Other sectors to be engaged:
		2010-2040	2041-2100			
Logging Systems						
• Logging Operation						
- more frequent extreme rainfall events - more frequent winter thaws/rains	- additional infrequent saturated and/or unfrozen soil conditions that limit logging operations - shorter winter logging season - possible temporary wood shortages	Moderate	High			
- more frequent drought	- more harvesting of forested wetlands	Low	Moderate			
• Haul Roads						
- more frequent extreme rainfall events - more frequent winter thaws	- more frequent stream crossing "bow outs" - more frequent haul road closings due to unfrozen or saturated soil	High	High			
Forest Health						
Pests, pathogens, and invasive species						
- warmer temperatures	- increase of populations of tree pests & pathogens leads to greater tree mortality	Low	Moderate			
	- Increased populations of invasive plant species reduces tree recruitment	Low	Low			
	- increased white-tailed deer populations reduce tree regeneration	Low	Moderate			
Extreme weather events (including ozone)						
- more frequent extreme heat events	- increased tree damage from O3 which reduces tree growth and recruitment	Low	Low			
- more frequent of droughts & flooding	- reduced tree growth and recruitment - greater tree mortality - greater frequency of forest fire	Low	Low			
- extended winter thaw	- dieback in spruce, birch, and other hardwood spp.	Moderate	Moderate			
Productivity (CO2 fertilization)						
- increases in CO2 levels	- increased tree growth for aspen spp	Low	Moderate			
Forest tree species						
• Northern hardwood and Conifer species						
- warmer temperatures - more frequent late-growing season drought	- shift north of spp. distributions - reduction in tree regeneration - increased growth rates for some spp.	Low	Moderate			
	- reduction in abundance	Low	Moderate			
- warmer winters	- earlier period for maple syrup	Low	Low			
• Southern tree species (Oak and Pine)						
- warmer temperatures - more frequent late-growing season drought	- increase in regeneration & growth rates - shift north of spp. distributions	Low	Moderate			
	- increase in abundance	Low	Moderate			

Nature-based Recreation

Recreation Activities - Climate factors	Potential Impact	Size & likelihood of Potential Impact		Possible Actions:	What type of actor can best implement the action?*	Other sectors to be engaged:
		2010-2040	2041-2100			
Water Recreation						
• Fishing						
- warmer temps. - more frequent extreme heat events	- increased cold water fish mortality & decline in cold water fisheries - increase in warm water fisheries - greater eutrophication with negative impacts on fisheries	Moderate	High			
- shorter season with ice	- shorter ice fishing season or loss of ice fishing season - longer open water fishing season	High	High			
• Boating						
- more frequent drought	- boat launches may become seasonally high/dry and limit water access	Moderate	Moderate			
- warmer temperatures - more frequent extreme heat events	- longer boating season - increased boating	High	High			
• Whitewater Boating						
- more frequent winter thaws - shorter season with ice	- more opportunities for winter whitewater boating	Moderate	Moderate			
- more frequent drought - less snow and lower/earlier spring runoff	- reduced spring whitewater conditions - less water for dam releases for summer season whitewater boating	Moderate	Moderate			
- more frequent extreme rainfall events	- unpredictable opportunities for white water boating during summer	High	High			
Land-based Recreation						
Winter trail sports (snowmobiling, snowshoeing, and X-country skiing)						
- warmer winters - more frequent winter thaws	- Shorter season for winter trail sports - Less snow on trails/reduced trail quality	Moderate	High			
- more frequent extreme rainfall events	- more frequent "blow outs" of constructed trail stream crossings	Moderate	Moderate			
• Downhill skiing						
- warmer winters - more frequent winter thaws	- Shorter season for downhill skiing - Ski season interruptions due to poor snow making conditions	Moderate	High			
- lower late winter water levels	- water conflicts for snow making	Low	Moderate			
Trail sports (ATVing, hiking, mtn. biking, horseback riding)						
- warmer temperatures	- longer trail sport season	High	High			
- more frequent extreme rainfall events	- more frequent "blow outs" of trail stream crossings	Moderate	Moderate			
- warmer summer temperatures - more frequent summer extreme heat events	- hiking and mountain biking less popular in middle of summer	Low	Moderate			
• Camping						
- warmer summer temperatures - more frequent summer extreme heat events - warmer temperature	- mid-summer camping becomes less popular - extended camping season	Low	Moderate			

Recreation Activities - Climate factors	Potential Impact	Size & likelihood of Potential Impact		Possible Actions:	What type of actor can best implement the action?*	Other sectors to be engaged:
		2010-2040	2041-2100			
• Hunting						
- prolonged warm weather in fall period	- best hunting times shift to later in year	Low	Moderate			
- warmer temperature	- increases in white-tailed deer population	Low	Moderate			
• Wildlife Viewing						
- warmer temperatures - more frequent extreme heat events	- northward range shifts of charismatic species (e.g., moose, loons) and boreal bird species, & reduction in their populations - decline in moose viewing due to pop. decline from tick infestations & heat stress - more deer viewing due to population increase	Moderate	High			
• Fall foliage viewing						
- warmer temperatures	- declining in "leaf peeping" due to decline in abundance and extent of "leaf peeping" tree species (northern hardwood) with dramatic fall colors	Low	Moderate			
- prolonged warm weather in fall period	- declining fall leaf color intensity of northern hardwood, birch, & aspen spp. - extended fall tourism season	Moderate	High			

* e.g., landowner, local/regional government, NGO, state government, and/or federal government.