

Adaptation Actions for Northern Forest Ecosystems in New England and New York

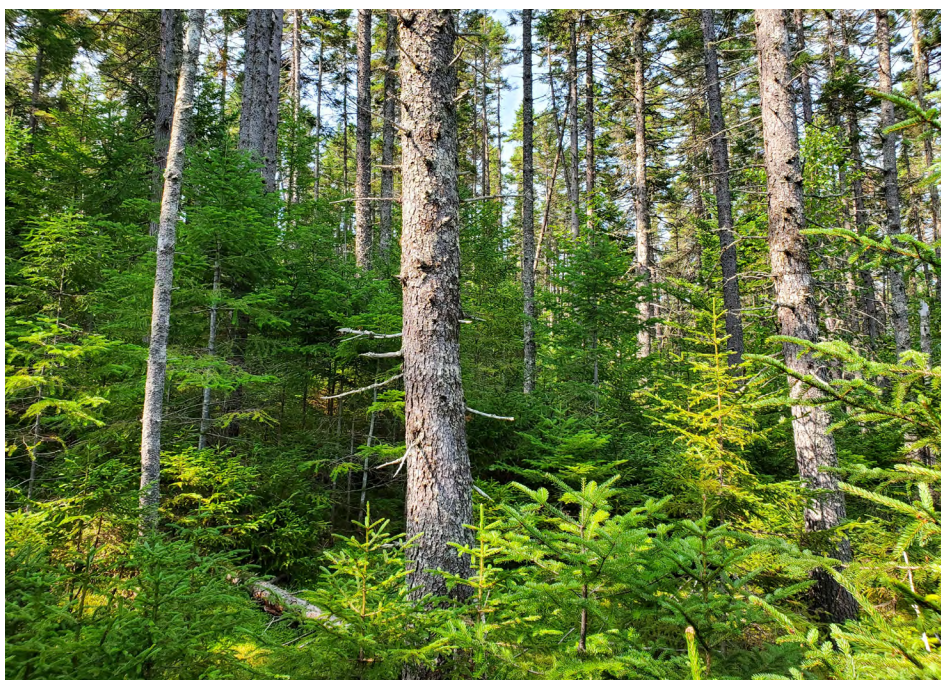
Spruce-Fir

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Spruce-fir forests in New England and New York will be affected by climate change, particularly given some species reach the southern edge of their range in our region, creating challenges for sustaining the many benefits these forests provide. There are many adaptation management actions that can address these key challenges. Adaptation actions are informed by site-specific conditions, including historical land-use legacies, and local manager knowledge and expertise.



Climate Change and Spruce-Fir Forest Ecosystems

Spruce-fir forests are dominated by red spruce and balsam fir, with minor components of hardwoods (yellow birch, paper birch, red maple) and occasionally other conifers (northern white-cedar, hemlock, white pine, black and white spruce). They occur across a range of sites, including poorly drained flats with acidic soils, rocky, well-drained, shallow soils, and cool moist microsites found in montane and coastal environments. Spruce-fir forests have mostly closed or patchy canopies with areas of dense, young trees, standing dead trees, and mature trees, characteristic of windstorms and insect disturbance. Herbaceous species cover can vary from limited to moderate cover in more nutrient-rich sites.

Spruce-fir forests occur across a variety of sites in New England and New York with a range of past management regimes, which means that climate change will affect forests in different ways. Information from this section is summarized from a [vulnerability assessment for regional forests](#).



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Climate Change Impacts

Moderate-High Vulnerability

- Spruce-fir forests may lose suitable habitat to other forest types as temperatures and growing seasons increase, particularly at lower elevations or more southern latitudes.
- Many of the dominant tree species are expected to decline by the end of the century, particularly balsam fir.
- Warmer temperatures have exacerbated the spread and impact of balsam woolly adelgid, while dampening the effects of the eastern spruce budworm in the region.
- Changes in herbivore populations may also have substantial effects on forest regeneration, growth, species composition, and structure.
- Spruce-fir forests at higher elevations (e.g., >3,000 feet) may be more vulnerable to acid rain and temperature increases.

Adaptive Capacity of Spruce-Fir Forests

Adaptive capacity is defined as the range of potential climate impacts a forest is exposed to and how well it can cope with these potential impacts.

These factors may increase adaptive capacity in spruce-fir forests:

- Spruce-fir forests are widely distributed across a variety of sites, increasing adaptive capacity.
- These forests have species that can regenerate prolifically when conditions allow, including red maple and balsam fir.
- Some tree species in spruce-fir forests may be more likely to persist or become more competitive through the end of the century, including white pine, red maple, and some northern hardwood species.
- Dominant conifer species in these forests may persist and outcompete many other species, especially on cold and nutrient-poor sites.
- Montane spruce-fir forests have shown signs of recovery from past stressors such as acid rain and logging that previously reduced the extent of these forests on the landscape, which may increase its adaptive capacity in the coming decades.

These factors may decrease adaptive capacity in spruce-fir forests:

- Spruce-fir forests tend to have relatively low species and genetic diversity and can be dominated by a relatively small number of species, including those at the southern edge of their range (balsam fir), which can reduce rates of recovery in response to disturbance.
- Past and current management often favors the hardwood and balsam fir components in these forests, and additional stress or disturbance may continue to shift forest composition toward hardwood species.
- The location of montane spruce-fir forests located at high elevations presents little opportunity for this forest system to move to new habitats, especially in more southern or fragmented parts of its range.

Site-Level Considerations for Spruce-Fir Forests

Site-level factors could make a spruce-fir stand more or less vulnerable to climate change, and the considerations in Table 1 include some site-level factors that could increase or reduce risk.

Table 1.— Examples of site-level considerations for Spruce-Fir forests that may increase or reduce risks.

Site-level consideration	High-risk condition ←————→ Low-risk condition	
Overstory Composition	The site has had a loss of a historical species, particularly red spruce, due to past harvesting practices, which has led to greater overstory dominance by hardwood species and fir.	Spruce and fir species dominate the overstory (>75% cover).
Regeneration	There is low regeneration potential of historically dominant conifer species on site (i.e., limited to no advance regeneration, few healthy mature spruce seed sources, lack of suitable seedbed conditions-decayed wood).	There is high regeneration potential of historically dominant conifer species on site (i.e., sufficient advance regeneration, healthy mature spruce on site, and abundant, well-decayed wood).
Forest Structure	The stand is young, relatively homogenous, and even-aged with a lack of deadwood due to past intensive timber management.	The stand is mature and uneven-aged with a diversity of ages and size classes, occasional canopy gaps, and sufficient downed deadwood.
Soils and Hydrology	The site has high-quality, well-drained soils which enables balsam fir to outcompete spruce. The site has a history of base cation depletion due to acid rain (montane spruce fir).	The site has shallow or excessively drained soils and a high water table where spruce can persist as the dominant species over balsam fir. The site has soils with base cation levels sufficient for supporting red spruce health.
Insects and Diseases	The site has many overstory trees that are facing damage and mortality from insect pests (e.g., spruce bark beetle, hemlock woolly adelgid, spruce budworm).	Few trees on site display signs of damage or mortality from insect outbreaks.
Landscape Setting and Condition	The site is at a more southern latitude or lower elevation and may be more susceptible to warming temperatures. There are low levels of connectivity to the surrounding landscape.	The site is situated at a more northern latitude, higher elevation, or within a cold pocket and may buffer the effects of warming temperatures. There are high levels of landscape connectivity to the surrounding landscape.



Adaptation Actions for High-Risk Site Conditions in Spruce-Fir Forests

A variety of actions are available for responding to climate change. This section presents examples of adaptation actions to address high-risk conditions in spruce-fir forests. For each example, the corresponding adaptation approaches from the [Forests or Forested Watersheds Adaptation Menus](#) are identified in parentheses. Adaptation demonstration projects that use these actions are also highlighted to help as a starting point for managers who are exploring actions to take on the lands that they manage.

Overstory Composition

- In dense, young stands, favor red spruce over balsam fir in pre-commercial thinning and retain less-common conifers during thinning, including northern white-cedar, white pine, and hemlock (Approach 5.2, 9.3).
- For stands dominated by hardwoods or solely balsam fir in the overstory, restore stand back to its historical spruce-fir condition by gradually facilitating red spruce recruitment in the understory (Approach 5.2). See an example from the [U.S. Fish and Wildlife Service](#).
 - Where red spruce seed sources are present in the overstory, use regeneration methods, like irregular shelterwoods, group selection, and variable density thinning that retain high levels of shade and allow for the development of spruce advance regeneration.
 - If red spruce advance regeneration is not present, create scarified seedbeds for its establishment.
 - If red spruce seed sources are not present in the stand, consider planting spruce in canopy openings.
 - Follow-up release of red spruce may be necessary using mechanical or chemical methods.
- Underplant historically important conifer species that are also expected to be adapted to future conditions (e.g., red spruce, white pine, northern white-cedar, hemlock) and consider planting southern-adapted spruce and fir genotypes (Approach 9.1, 9.2, 9.6). See examples from the [U.S. Fish and Wildlife Service](#) and the [Massachusetts Department of Conservation and Recreation \(DCR\)](#).
- Limit red spruce overstory removals (Approach 5.2).

Regeneration

- Use group selection or irregular shelterwoods in areas with advance spruce regeneration (Approach 5.1).
- Apply herbivore browse protection (e.g., snowshoe hare) for seedlings using tree tubes (Approach 2.3). See an example from the [U.S. Fish and Wildlife Service](#).

Forest Structure

- Encourage multi-aged spruce stands using irregular shelterwood methods to promote spruce over fir and hemlock. This will help establish new cohorts of red spruce and expose residual overstory trees to promote wind-firmness (Approach 3.3, 5.1).
- Reduce tree density using low density thinning or variable density thinning, designating 0.1-0.25 acre gaps and patch reserves (i.e., skips; Approach 1.4, 5.1). See an example from the [U.S. Fish and Wildlife Service](#).
- Increase dead and downed wood where opportunities exist by felling, tipping, or leaving legacy trees (Approach 5.3).
- Plan for post-harvest wind events by changing residual harvest densities and account for these events in coarse woody material targets (Approach 3.3).

Soils and Hydrology

- Identify restricted areas (sensitive and inoperable areas) for winter harvesting and no harvesting to minimize damage to soil and roots and prevent rutting (Approach 1.1). See an example from [Massachusetts DCR](#).
- Enhance downed woody material during harvests (Approach 1.1). See an example from [Massachusetts DCR](#).
- Close and revegetate old logging roads (Approach 1.2, Forested Watershed Menu 6.4).

Insects and Diseases

- In dense hemlock stands, reduce hemlock density and regenerate red spruce/balsam fir or release where already present to aid in recovery to hemlock woolly adelgid (Approach 2.1).
- Thin spruce stands impacted by bark beetle or spruce budworm outbreaks to decrease stand basal area and average tree diameter (Approach 2.1). See an example from [Baxter State Park](#).
- Thin dense balsam fir stands and selectively remove heavily infested individuals affected by balsam woolly adelgid (Approach 2.1).
- Consider sanitation harvests in heavily infested stands to prevent further infestation and encourage regeneration (Approach 2.1). See an example from [Baxter State Park](#).
- Retain canopy trees exhibiting resistance to insects and diseases on site (e.g., spruce budworm, spruce bark beetle, balsam woolly adelgid; Approach 5.3, 8.2).
- Use regeneration harvests that sustain options for threatened species on site as mature canopy trees and in the regeneration layer (e.g., group selection, irregular shelterwoods; Approach 2.1, 5.3).
- Plant species sharing similar ecological and cultural values to threatened species which are also future climate-adapted (i.e., white pine, northern white cedar, red spruce; Approach 9.1, 9.7).

Landscape Setting and Position

- Retain areas of desired spruce-fir forest types to promote forest connectivity (Approach 7.1). See an example from [Massachusetts DCR](#).

Operational Considerations

- With unplanned warmups and mild winters, specify cut-to-length operations where possible to facilitate access on wet soils and minimize damage to established softwood regeneration (Approach 1.1). See an example from [Holt Research Forest](#), and read the [Climate Change Considerations for Forest Operations in Northern Forests](#) guide to learn more.
- Where options for low-grade/softwood lumber markets are limited, drop and leave small and low-quality wood to meet thinning targets and enhance deadwood pools (Approach 1.1).
- Consider contracting to cut during or after a good seed year if possible (Approach 5.3, 8.2).

Silvicultural Strategies in Spruce-Fir Forests

For more information on adaptation in spruce-fir forests, view the presentation, “[Exploring Silvicultural Strategies in Our Changing Forests: Spruce-Fir](#),” by Bob Seymour, Emeritus Professor, University of Maine.

Examples of Adaptation in Action

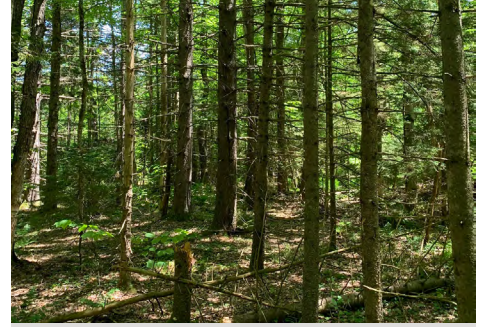
U.S. Fish and Wildlife Service: [Nulhegan Basin](#)



Baxter State Park: [Frost Pond](#)



Massachusetts DCR: [Savoy Landscape Resiliency Project](#)



More Information

This is part of a [collection on Northern Forest Ecosystems in New England and New York](#).

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