Climate Change Adaptation Plan

NorthWoods Stewardship Center

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Prepared by Sam Perron

Prepared using the Adaptation Workbook - AdaptationWorkbook.org

Property details

Acres: 1,473

Ownership: Private Non-Industrial

NorthWoods owns and manages a ~1.473 acre forest. Within this forest we conduct timber and habitat management, maintain recreational trails, and provide educational materials and programming. The purpose of this Adaptation Workbook project is to revisit our 2015 forest management plan, to decide if any modifications should be made with regards to climate change adaptation. Particular attention will be given to stands that are identified as most vulnerable to climate impacts and where management work (logging, precommercial thinning, planting, invasive work, etc.) is planned. One of these areas is a ~16 acre Norway spruce plantation where ongoing small-scale harvesting is underway; this stand/management area is intended as a demonstration site for climate change adapted silviculture. Other areas with planned implementation include a 32.5 acre precommercial thinning funded by NRCS, 0.4 acres of invasive phragmites treatment, and a 228 acre young hardwood stand where pre-commercial regeneration harvesting (areas of non-commercial overstory species) is planned for 20 non-contiguous acres.

1. Project Goals and Objectives

Management goals and objectives capture fundamental information about the project area or property and provide a starting point for considering climate change.

1a. Northern hardwood: Goals and Objectives

Northern hardwood forests are widely distributed over a variety of sites with dry-mesic to wet-mesic conditions and nutrient-poor to rich soils. This forest type is generally found at low to moderate elevations. Species that are commonly dominant include sugar maple, yellow birch, American beech, eastern hemlock, and red spruce.

Northern hardwood forest cover is found over much of the property, and northern hardwood natural communities/variants are the expected natural community for nearly all of the 1473 acres (land use history has led to different existing cover). For this project, the northern hardwood management topic applies to timber stands (including regenerating stands) that currently have northern hardwood or similar forest cover; this includes mixed hardwood/softwood stands that include 25-65% softwood (balsam fir, red/white spruce, white pine, tamarack).

Goal	Objectives and Timeframes
To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.	• Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)* • Re-develop old forest structure, including multiple age classes, legacy trees >20" dbh, cavity trees, snags >15" dbh, and varying sizes of downed wood. *(ongoing)*
To cultivate a variety of forest products while improving long-term timber value and forest productivity and modeling sustainable forestry practices.	• Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)* • Harvest 20-40 cords of firewood annually for NorthWoods facilities. *(annual)* • Promote site-appropriate species with high value for timber and/or non-timber values. Preferred species (depending on site) include sugar maple, yellow birch, red spruce, black cherry, white ash, red maple, paper birch, American beech, and others. *(ongoing)* • Provide for continuous regeneration of preferred species, either through periodic harvests or open forest canopy. *(ongoing)*
To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.	• Maintain existing trails and construct additional multi-use (xc-ski, hiking, forestry access) trail(s) to connect networks on opposite sides of the forest. *(2020)*

1b. Softwood Plantation: Goals and Objectives

Plantations of even-aged Norway spruce, red pine and white pine, generally on northern hardwood sites with agricultural history.

Various softwood plantations are established throughout the property. These stands are typically even-aged (45-75 years old); species include Norway spruce, white pine, red pine, Scots pine, and occasional naturally-regenerated trees of other species. Regeneration varies greatly in density and species, but balsam fir is a common seedling/sapling species, and overall regeneration in plantations is sparse.

Goal	Objectives and Timeframes
To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.	• Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red maple, paper birch, American beech, and others. *(ongoing)* • Limit residual stand damage, including basal scarring, broken branches/tops and root exposure/compaction to 5% or less of residual trees. *(ongoing)* • Re-develop old forest structure, including multiple age classes, legacy trees >20" dbh, cavity trees, snags >15" dbh, and varying sizes of downed wood. *(ongoing)*
To cultivate a variety of forest products while improving long-term timber value and forest productivity and modeling sustainable forestry practices.	• Transition to uneven-aged/irregular forest structure. *(ongoing)* • Conduct timber harvests to provide periodic income (preferably annually, but at least every 3-5 years). *(annual/ongoing)* • Provide for continuous regeneration of preferred species, either through periodic harvests or open forest canopy. *(ongoing)*
To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.	

1c. Lowland and riparian forest: Goals and Objectives

Diverse forested wetlands are found in depressions and low-lying areas, along waterways, and in floodplains. Dominant species may include ash, red or silver maple, swamp white oak, sycamore, American elm, and river birch.

Includes forested wetlands, nonproductive forest, and other areas not suitable/desired for timber management.

Goal	Objectives and Timeframes
To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.	• Maintain 75% or greater canopy cover in riparian areas. *(ongoing)* • Leave at least 50% of harvested material as downed woody material.
To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.	• Maintain trails to reduce/eliminate soil disturbance; trail improvements may include drainage, hardening, limited use (ie frozen-ground-only equipment access) or bridging. *(ongoing)*

1d. Forest Roads and Trails: Goals and Objectives

Includes trails used for non-motorized recreation (cross country skiing, hiking, wildlife observation, etc.) and forestry equipment access.

Goal	Objectives and Timeframes
To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.	• Minimize erosion, rutting, off-trail soil disturbance, and stream impacts from roads and trails. *(ongoing)* • Ensure that roads and trails do not create barriers to wildlife movement or habitat use; site trails to avoid sensitive habitats and riparian areas. *(ongoing)*
To cultivate a variety of forest products while improving long-term timber value and forest productivity and modeling sustainable forestry practices.	• Develop permanent access roads/trails for harvesting equipment. These trails will be used frequently for uneven-aged/irregular harvesting and intermediate treatments, and must be located and designed to withstand equipment use with minimal "closeout" repair after harvests. *(ongoing)*
To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.	• Maintain and enhance aesthetic values of trails, including large trailside trees, wildlife viewing areas, historic sites, and interpretive signage. *(ongoing)*

2. Climate Change Impacts and Vulnerabilities

Climate change will not affect all places in the same way. This section describes the anticipated effects of climate change within a region, and then provides additional details how specific places within the project area may be affected.

2a. Regional Climate Impacts and Vulnerabilities

Potential Climate Impact - Regional	Property or Project Area Considerations
Temperatures in New England are projected to increase 3.5 to 8.5 °F by the end of the century, with the greatest warming expected to occur during winter. (2, 51, 6, 52)	
The growing season in New England and northern New York is generally expected to increase by 20 days or more by the end of the century, due to fewer days with a minimum temperatures below 32°F. (2, 51, 6, 52)	
The winter season will be shorter and milder across New England and northern New York, with less precipitation falling as snow and reduced snow cover and depth. (2, 8, 51)	
Precipitation patterns will be altered, with projected increases in annual precipitation and potential for reduced growing season precipitation in New England and northern New York. (2, 51, 6)	
Intense precipitation events will continue to become more frequent in New England and northern New York. (2, 51, 53)	
Warmer temperatures and altered precipitation in New England and northern New York will interact to change soil moisture patterns throughout the year, with the potential for both wetter and drier conditions depending on the location and season. (2, 18)	
Forest vegetation in New England and northern New York may face increased risk of moisture deficit and drought during the growing season. (2, 18)	
Certain insect pests and pathogens will increase in occurrence or become more damaging in New England and northern New York. (2, 54)	

Potential Climate Impact - Regional	Property or Project Area Considerations
Many invasive plants will increase in extent or abundance in New England and northern New York. (2, 13)	Very few invasives present on the property, but other areas within 100-200 miles have many invasive species. Invasive pressure could increase, and this is something we have not had to deal with extensively yet.
Many northern and boreal tree species will face increasing stress across much of New England and northern New York. (2, 13, 3)	
Habitat will become more suitable in New England and northern New York for some southern species. (2, 3)	
Forest composition will change across the landscape in New England and northern New York. (2)	
Shifts in forest composition in New England and northern New York will take at least several decades to occur in the absence of major disturbance. (2)	
Conditions affecting tree regeneration and recruitment will change in New England and northern New York. (2)	
Forest productivity in New England and northern New York will increase during the next several decades in the absence of significant stressors. (2)	
Low-diversity systems are at greater risk from climate change. (55, 56)	
Species in fragmented landscapes will have less opportunity to migrate in response to climate change. (57, 58)	
Systems that are limited to particular environments will have less opportunity to migrate in response to climate change. (59)	
Systems that are more tolerant of disturbance have less risk of declining on the landscape (60, 61)	

2b. Northern hardwood: Climate Impacts and Vulnerabilities

Potential Impacts: Mixed/Neutral **Adaptive Capacity:** Moderate-High **Vulnerability:** Moderate

Potential Climate Impact - Northern hardwood	Property or Project Area Considerations
Several dominant tree species are at risk of decling by the end of the century, including red spruce and balsam fir. (2)	Balsam fir is a large overstory component in most mixed stands; balsam fir also regenerates aggressively on much of the site. Colder areas of the property (for instance, north facing gullies) may provide habitat/refugia for northern tree species during decline.
Some tree species may be more likley to persist or increase through the end of the century , such as red maple. (2)	
Northern hardwood forests are widely distributed across a variety of sites, increasing adaptive capacity. (2)	
High levels of diversity may increase the ability of forests to adapt to climate change. (2)	
Insect pests and forest diseases could become more problematic in northern hardwood forests under a warmer climate. (2)	
Invasive species such as buckthorn, honeysuckle, and garlic mustard are expected to become more problematic under climate change. (2)	
Changes in herbivore populations may also have substantial effects on forest growth and composition in northern hardwood forests. (2)	

2c. Softwood Plantation: Climate Impacts and Vulnerabilities

Potential Impacts: Disruptive **Adaptive Capacity:** Low-Moderate **Vulnerability:** High

Potential Climate Impact - Softwood Plantation	Property or Project Area Considerations
Species such as Norway spruce may decline over the coming century.	Norway spruce is a major component of some softwood plantations.
Forests lacking species/structure/age diversity may be less resilient to changing disturbance regimes.	Softwood plantations are generally characterized by a single strata, single age class and 1-3 species.
Lack of regeneration in even-aged stands reduces adaptive capacity.	Softwood plantations generally have little or no regeneration; where regeneration is present, balsam fir is common.

2d. Lowland and riparian forest: Climate Impacts and Vulnerabilities

Potential Impacts: Disruptive **Adaptive Capacity:** Moderate-High **Vulnerability:** Moderate

Potential Climate Impact - Lowland and riparian forest	Property or Project Area Considerations
Lowland and riparian forests may have limited tolerance to changes in precipitation and water tables. (2)	
Many tree species could tolerate limited increases in flooding and drought under climate change. (2)	
Many of the dominant tree species are projected to have similar or increased habitat, including American elm, eastern cottonwood, and silver maple. (2)	Lowland and riparian forests on this site tend to have species less adapted to climate change, such as tamarack, balsam fir, black ash, eastern hemlock and northern white cedar.
	These species make up a large percentage of lowland/riparian forests on this site.
Invasive species such as Japanese stiltgrass and buckthorn are expected to become more problematic under climate change. (2)	
Insect pests and forest diseases could become more problematic these forests under a warmer climate. (2)	

2e. Forest Roads and Trails: Climate Impacts and Vulnerabilities

Potential Impacts: Disruptive **Adaptive Capacity:** Low-Moderate **Vulnerability:** High

Potential Climate Impact - Forest Roads and Trails	Property or Project Area Considerations
The winter season will be shorter and milder across New England and northern New York, with less precipitation falling as snow and reduced snow cover and depth.	Reliance on winter harvest conditions may become inadequate for protecting soils while still maintaining harvest productivity.
Intense precipitation events will continue to become more frequent in New England and northern New York.	Current drainage, erosion control and stream crossing structures may be insufficient for protecting trail and environmental integrity.

3. Evaluation of Management Objectives

Climate change might make management objectives for this property harder or easier to achieve, presenting challenges and opportunities. This section also includes a simple rating and description for the feasibility of meeting management objectives under current management. This is a critical step to evaluate whether management objectives are robust, or whether any might need to be changed.

3a. Northern hardwood: Evaluation of Management Objectives

Management Goal: To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.

Management Objective	Challenges and Opportunities	Feasibility
Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)*	**Challenges:** • Increased invasive plant pressure could reduce diversity and vigor of regeneration, and would be likely to out-compete slow growing species and/or shrubs. **Opportunities:** • The "minor" species identified are predicted to adapt well to climate change. In addition, species currently uncommon in northern VT, such as oaks and walnut, could become more common.	**Feasibility:** High **Feasibility Comment:** Current management promotes species diversity, and the flexibility of this objective (promoting many species, without strict percentages of each) makes it very attainable. **Other Considerations:** No other considerations
Re-develop old forest structure, including multiple age classes, legacy trees >20" dbh, cavity trees, snags >15" dbh, and varying sizes of downed wood. *(ongoing)*	**Challenges:** None identified **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** Management of forest structure is not likely to be affected much by climate change impacts. **Other Considerations:** No other considerations

Management Goal: To cultivate a variety of forest products while improving long-term timber value and forest productivity and modeling sustainable forestry practices.

Management Objective	Challenges and Opportunities	Feasibility
Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)*	**Challenges:** • Some commercial species (sugar maple, spruce, balsam fir, yellow birch) are predicted to decline. Under current management, balsam fir regenerates vigorously on many sites, so it may be challenging to secure climate change adapted commercial species in future rotations. Increased storm intensity (ice, wind, etc) may cause damage to high-quality trees, especially those in thinned, small diameter stands. **Opportunities:** • Some current species (black cherry) are predicted to increase with climate change, and additional high-value species currently absent from the property (red oak, black walnut) may have increasingly suitable habitat.	**Feasibility:** High **Feasibility Comment:** Current management promotes high quality, commercial growing stock of various species; management for high quality stems is unlikely to be impacted by climate change, although species selection/proportions may change. **Other Considerations:** No other considerations
Harvest 20-40 cords of firewood annually for NorthWoods facilities. *(annual)*	**Challenges:** • Shorter, warmer, and less predictable winters may hinder access to wet sites for harvesting. **Opportunities:** • Longer growing seasons may increase productivity.	**Feasibility:** High **Feasibility Comment:** Climate change is unlikely to impact forest productivity, especially when species and quality are of less concern. Our current harvest system uses small equipment and staff who can adapt schedules to weather conditions. **Other Considerations:** No other considerations

Management Goal: To cultivate a variety of forest products while improving long-term timber value and forest productivity and modeling sustainable forestry practices.

Management Objective	Challenges and Opportunities	Feasibility
Promote site-appropriate species with high value for timber and/or non-timber values. Preferred species (depending on site) include sugar maple, yellow birch, red spruce, black cherry, white ash, red maple, paper birch, American beech, and others. *(ongoing)*	**Challenges:** • Some species (sugar maple, yellow birch, paper birch) are predicted to decline as a result of climate change, and additional species (white ash) are threatened by forest pest outbreaks. **Opportunities:** None identified	**Feasibility:** Not specified **Feasibility Comment:** No comments **Other Considerations:** No other considerations
Provide for continuous regeneration of preferred species, either through periodic harvests or open forest canopy. *(ongoing)*	**Challenges:** • Increased storm intensity/frequency may cause greater damage to fragile regeneration. **Opportunities:** None identified	**Feasibility:** Medium **Feasibility Comment:** Management of forest structure is unlikely to be impacted by climate change, although species may shift and storm damage may be an increasing concern. **Other Considerations:** No other considerations

Management Goal: To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.

Management Objective	Challenges and Opportunities	Feasibility
Maintain existing trails and construct additional multi-use (xc-ski, hiking, forestry access) trail(s) to connect networks on opposite sides of the forest. *(2020)*	**Challenges:** • Increased storm intensity may require more robust trails, increasing cost and/or limiting 4-season trail accessibility. **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** No comments **Other Considerations:** No other considerations

3b. Softwood Plantation: Evaluation of Management Objectives

Management Goal: To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.

Management Objective	Challenges and Opportunities	Feasibility
Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red maple, paper birch, American beech, and others. *(ongoing)*	**Challenges:** • Climate change may make it difficult to know which species will be best suited to the site by the end of the next rotation (80-100+ years in the future). • Current regeneration includes high proportions of balsam fir, a species predicted to decline in the future. **Opportunities:** None identified	**Feasibility:** Medium **Feasibility Comment:** No comments **Other Considerations:** No other considerations
Limit residual stand damage, including basal scarring, broken branches/tops and root exposure/compaction to 5% or less of residual trees. *(ongoing)*	**Challenges:** None identified **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** This operational objective is currently being met, and is unlikely to be impacted by climate change. **Other Considerations:** No other considerations
Re-develop old forest structure, including multiple age classes, legacy trees >20" dbh, cavity trees, snags >15" dbh, and varying sizes of downed wood. *(ongoing)*	**Challenges:** None identified **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** Management of forest structure is unlikely to be impacted by climate change. **Other Considerations:** No other considerations

Management Goal: To cultivate a variety of forest products while improving long-term timber value and forest productivity and modeling sustainable forestry practices.

Management Objective	Challenges and Opportunities	Feasibility
Transition to uneven-aged/irregular forest structure. *(ongoing)*	**Challenges:** • Future forest pest outbreaks in single-species stands could require early salvage harvesting, resulting in another even-aged stand. **Opportunities:** • Natural disturbance from increased storm intensity could help create irregular forest structure.	**Feasibility:** High **Feasibility Comment:** Although forest dynamics may change in a changing climate, the general disturbance regime of small gap dynamics is likely to continue. **Other Considerations:** No other considerations
Conduct timber harvests to provide periodic income (preferably annually, but at least every 3-5 years). *(annual/ongoing)*	**Challenges:** • Increased invasive pressure, especially in regeneration cuts, may require control tactics that will cut into timber harvesting profit. **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** No comments **Other Considerations:** No other considerations
Provide for continuous regeneration of preferred species, either through periodic harvests or open forest canopy. *(ongoing)*	**Challenges:** • Increased storm intensity/frequency may cause greater damage to fragile regeneration. **Opportunities:** None identified	**Feasibility:** Medium **Feasibility Comment:** Management of forest structure is unlikely to be impacted by climate change, although species may shift and storm damage may be an increasing concern. **Other Considerations:** No other considerations

Management Goal: To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.

Management Objective	Challenges and Opportunities	Feasibility

3c. Lowland and riparian forest: Evaluation of Management Objectives

Management Goal: To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.

Management Objective	Challenges and Opportunities	Feasibility
Maintain 75% or greater canopy cover in riparian areas. *(ongoing)*	**Challenges:** • Some species in riparian areas (balsam fir, eastern hemlock, black ash, yellow birch) are likely to decline. **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** No comments **Other Considerations:** No other considerations
Leave at least 50% of harvested material as downed woody material.	**Challenges:** None identified **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** This objective is met by current management, and is unlikely to be impacted by climate change. **Other Considerations:** No other considerations

Management Goal: To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.

Management Objective	Challenges and Opportunities	Feasibility
Maintain trails to reduce/eliminate soil disturbance; trail improvements may include drainage, hardening, limited use (ie frozen-ground-only equipment access) or bridging. *(ongoing)*	**Challenges:** • Warmer winters may limit access for winter recreation/equipment access on hydric soils. Year-round trails may need substantial improvements to withstand more intense rainfall events. **Opportunities:** None identified	**Feasibility:** Medium **Feasibility Comment:** No comments **Other Considerations:** No other considerations

3d. Forest Roads and Trails: Evaluation of Management Objectives

Management Goal: To promote forest health, including intact natural communities and wildlife habitat values that support a diverse native flora and fauna.

Management Objective	Challenges and Opportunities	Feasibility
Minimize erosion, rutting, off-trail soil disturbance, and stream impacts from roads and trails. *(ongoing)*	**Challenges:** • Increased frequency/intensity of precipitation events may lead to increased erosion potential and times when trails are inaccessible. Warmer, shorter winters may limit frozen conditions on trails that are too wet/soft for non-frozen equipment access. **Opportunities:** None identified	**Feasibility:** Low **Feasibility Comment:** Trail resilience is currently marginal, and often dependent on dry/frozen conditions. **Other Considerations:** No other considerations
Ensure that roads and trails do not create barriers to wildlife movement or habitat use; site trails to avoid sensitive habitats and riparian areas. *(ongoing)*	**Challenges:** None identified **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** Current trail structures do not create major habitat impacts or wildlife barriers; this is unlikely to be impacted directly by climate change. **Other Considerations:** No other considerations

Management Goal: To cultivate a variety of forest products while improving long-term timber value and forest productivity and modeling sustainable forestry practices.

Management Objective	Challenges and Opportunities	Feasibility
Develop permanent access roads/trails for harvesting equipment. These trails will be used frequently for uneven-aged/irregular harvesting and intermediate treatments, and must be located and designed to withstand equipment use with minimal "closeout" repair after harvests. *(ongoing)*	**Challenges:** • Increased frequency/intensity of precipitation events may lead to increased erosion potential and times when trails are inaccessible. Warmer, shorter winters may limit frozen conditions on trails that are too wet/soft for non-frozen equipment access. **Opportunities:** None identified	**Feasibility:** Low **Feasibility Comment:** Many sites are too wet for non-frozen equipment access, and current trail building guidelines (Acceptable Management Practices) may be insufficient for protecting trails/water quality under future climate conditions. **Other Considerations:** No other considerations

Management Goal: To create and maintain outdoor education and recreation values that serve as a community resource and best support the NorthWoods mission.

Management Objective	Challenges and Opportunities	Feasibility
Maintain and enhance aesthetic values of trails, including large trailside trees, wildlife viewing areas, historic sites, and interpretive signage. *(ongoing)*	**Challenges:** None identified **Opportunities:** None identified	**Feasibility:** High **Feasibility Comment:** Trail and forest appearance may change with climatic changes, but aesthetics would likely be unaffected. **Other Considerations:** No other considerations

4. Adaptation Tactics

After considering the challenges and opportunities climate change might present for this management objective, these actions were identified to help prepare for climate change impacts. Each adaptation tactic is linked to one or more Adaptation Strategies and Approaches, which provide connections to more general concepts related to forest management and conservation. Tactics that are recommended can be implemented or explored further.

4a. Northern hardwood: Adaptation Tactics

Tactic: Promote regeneration of native, site-appropriate species that are expected to adapt well to a changing climate. Species to favor include black cherry, white pine, butternut, basswood and red maple. This should be accomplished over several cutting cycles (possibly multiple rotations) when transitioning even-aged stands to uneven-aged/irregular structures. *(ongoing)*

Practicability: High

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Facilitate community adjustments through species transitions. • Favor or restore native species that are expected to be adapted to future conditions	**Benefits:** By increasing the proportion of climate-change-adapted species, future stands should be more resilient to changing climate as well as other stressors such as insect pests, pathogens, variable weather conditions, etc. **Drawbacks and Barriers:** Not specified	• Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)* • Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)*

Tactic: Monitor for invasive plant species and reduce/eliminate them before large populations establish. Property-wide monitoring should be conducted every 10 years (during forest management plan updates) with more frequent monitoring on disturbed sites. Control measures may be manual or chemical and should be completed at appropriate intervals, typically annually. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Reduce the impact of biological stressors • Prevent the introduction and establishment of invasive plant species and remove existing invasive species	**Benefits:** By controlling invasives before they are deeply entrenched, cost and ecological repercussions should be minimized. **Drawbacks and Barriers:** In the event of a large invasive species influx, cost of treatment/control may be prohibitive.	• Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)* • Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)*

Tactic: Use pre-commercial thinnings and commercial harvests to release/favor species predicted to adapt well to climate change. Species include black cherry, white pine, red maple and others. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Facilitate community adjustments through species transitions. • Favor or restore native species that are expected to be adapted to future conditions	**Benefits:** Forest stand improvement work increases stand value and individual tree vigor, as well as selecting for desirable species. Selecting for these species where they already exist will provide seed source for future regeneration. **Drawbacks and Barriers:** Cost of pre-commercial thinning may be prohibitive.	• Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)* • Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)* • Harvest 20-40 cords of firewood annually for NorthWoods facilities. *(annual)* • Promote site-appropriate species with high value for timber and/or non-timber values. Preferred species (depending on site) include sugar maple, yellow birch, red spruce, black cherry, white ash, red maple, paper birch, American beech, and others. *(ongoing)*

Tactic: Maintain, improve and/or construct new trails to withstand more intense rainfall events, and plan wherever possible for non-frozen equipment access. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Reduce the risk and long-term impacts of severe disturbances • Alter forest structure to reduce severity or extent of wind and ice damage	**Benefits:** Improved permanent trails will allow us to meet silvicultural/management objectives by carrying out planned harvests on-schedule while minimizing residual damage. **Drawbacks and Barriers:** Cost of improving/building new trails, bridges, etc may be prohibitive.	• Harvest 20-40 cords of firewood annually for NorthWoods facilities. *(annual)* • Provide for continuous regeneration of preferred species, either through periodic harvests or open forest canopy. *(ongoing)* • Maintain existing trails and construct additional multi-use (xc-ski, hiking, forestry access) trail(s) to connect networks on opposite sides of the forest. *(2020)*

Tactic: Plant seedlings of species (red oak, possibly others) that are currently absent from the site, but are predicted to have suitable habitat AND are native to nearby/surrounding areas. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Facilitate community adjustments through species transitions. • Introduce species that are expected to be adapted to future conditions	**Benefits:** By introducing species earlier rather than later, they will have a chance to establish and grow to seed-producing age to establish natural regeneration in the future. Early introduction will also provide opportunity to test different sites/conditions to determine suitable habitat. **Drawbacks and Barriers:** Cost of planting (rather than allowing natural regeneration) may be prohibitive. Introduction of species may have unintended impacts on ecosystem function (wildlife habitat, etc.)	• Promote site-appropriate species with high value for timber and/or non-timber values. Preferred species (depending on site) include sugar maple, yellow birch, red spruce, black cherry, white ash, red maple, paper birch, American beech, and others. *(ongoing)* • Provide for continuous regeneration of preferred species, either through periodic harvests or open forest canopy. *(ongoing)*

4b. Softwood Plantation: Adaptation Tactics

Tactic: Promote regeneration of native, site-appropriate species that are expected to adapt well to a changing climate. Species to favor include black cherry, white pine, butternut, basswood and red maple. This should be accomplished over several cutting cycles (possibly multiple rotations) when transitioning even-aged stands to uneven-aged/irregular structures. *(ongoing)*

Practicability: High

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Facilitate community adjustments through species transitions. • Favor or restore native species that are expected to be adapted to future conditions	**Benefits:** By increasing the proportion of climate-change-adapted species, future stands should be more resilient to changing climate as well as other stressors such as insect pests, pathogens, variable weather conditions, etc. **Drawbacks and Barriers:** Not specified	• Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red ... *(ongoing)* • Transition to uneven-aged/irregular forest structure. *(ongoing)*

Tactic: Monitor for invasive plant species and reduce/eliminate them before large populations establish. Property-wide monitoring should be conducted every 10 years (during forest management plan updates) with more frequent monitoring on disturbed sites. Control measures may be manual or chemical and should be completed at appropriate intervals, typically annually. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Reduce the impact of biological stressors • Prevent the introduction and establishment of invasive plant species and remove existing invasive species	**Benefits:** By controlling invasives before they are deeply entrenched, cost and ecological repercussions should be minimized. **Drawbacks and Barriers:** In the event of a large invasive species influx, cost of treatment/control may be prohibitive.	• Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red ... *(ongoing)* • Conduct timber harvests to provide periodic income (preferably annually, but at least every 3-5 years). *(annual/ongoing)*

Tactic: Plant seedlings of species (red oak, possibly others) that are currently absent from the site, but are predicted to have suitable habitat AND are native to nearby/surrounding areas. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Facilitate community adjustments through species transitions. • Introduce species that are expected to be adapted to future conditions	**Benefits:** By introducing species earlier rather than later, they will have a chance to establish and grow to seed-producing age to establish natural regeneration in the future. Early introduction will also provide opportunity to test different sites/conditions to determine suitable habitat. **Drawbacks and Barriers:** Cost of planting (rather than allowing natural regeneration) may be prohibitive. Introduction of species may have unintended impacts on ecosystem function (wildlife habitat, etc.)	• Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red ... *(ongoing)* • Transition to uneven-aged/irregular forest structure. *(ongoing)*

Tactic: Maintain, improve and/or construct new trails to withstand more intense rainfall events, and plan wherever possible for non-frozen equipment access. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Reduce the risk and long-term impacts of severe disturbances • Alter forest structure to reduce severity or extent of wind and ice damage	**Benefits:** Improved permanent trails will allow us to meet silvicultural/management objectives by carrying out planned harvests on-schedule while minimizing residual damage. **Drawbacks and Barriers:** Cost of improving/building new trails, bridges, etc may be prohibitive.	• Limit residual stand damage, including basal scarring, broken branches/tops and root exposure/compaction to 5% or less of residual trees. *(ongoing)* • Transition to uneven-aged/irregular forest structure. *(ongoing)* • Conduct timber harvests to provide periodic income (preferably annually, but at least every 3-5 years). *(annual/ongoing)* • Provide for continuous regeneration of preferred species, either through periodic harvests or open forest canopy. *(ongoing)*

4c. Lowland and riparian forest: Adaptation Tactics

Tactic: Maintain at least 75% canopy cover, and retain downed woody material near streams, wetlands and lakeshores. Limit equipment access and soil disturbance in these areas. *(ongoing)*

Practicability: High

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Sustain fundamental ecological functions • Maintain or restore riparian areas	**Benefits:** Protecting riparian areas should provide resilience to future increased flow from storms. **Drawbacks and Barriers:** Not specified	• Maintain 75% or greater canopy cover in riparian areas. *(ongoing)* • Leave at least 50% of harvested material as downed woody material.

Tactic: Maintain, improve and/or construct new trails to withstand more intense rainfall events, and plan wherever possible for non-frozen equipment access. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Reduce the risk and long-term impacts of severe disturbances • Alter forest structure to reduce severity or extent of wind and ice damage	**Benefits:** Improved permanent trails will allow us to meet silvicultural/management objectives by carrying out planned harvests on-schedule while minimizing residual damage. **Drawbacks and Barriers:** Cost of improving/building new trails, bridges, etc may be prohibitive.	• Maintain trails to reduce/eliminate soil disturbance; trail improvements may include drainage, hardening, limited use (ie frozen-ground-only equipment access) or bridging. *(ongoing)*

4d. Forest Roads and Trails: Adaptation Tactics

Tactic: Maintain, improve and/or construct new trails to withstand more intense rainfall events, and plan wherever possible for non-frozen equipment access. *(ongoing)*

Practicability: Medium

Adaptation Strategies and Approaches	Benefits, Drawbacks and Barriers	Associated Management Objectives
Reduce the risk and long-term impacts of severe disturbances • Alter forest structure to reduce severity or extent of wind and ice damage	**Benefits:** Improved permanent trails will allow us to meet silvicultural/management objectives by carrying out planned harvests on-schedule while minimizing residual damage. **Drawbacks and Barriers:** Cost of improving/building new trails, bridges, etc may be prohibitive.	• Minimize erosion, rutting, off-trail soil disturbance, and stream impacts from roads and trails. *(ongoing)* • Ensure that roads and trails do not create barriers to wildlife movement or habitat use; site trails to avoid sensitive habitats and riparian areas. *(ongoing)* • Develop permanent access roads/trails for harvesting equipment. These trails will be used frequently for uneven-aged/irregular harvesting and intermediate treatments, and must be located and designed to withstand equipment use with minimal ... *(ongoing)* • Maintain and enhance aesthetic values of trails, including large trailside trees, wildlife viewing areas, historic sites, and interpretive signage. *(ongoing)*

5. Monitoring Plan

Monitoring is critical for understanding if management actions are e·ective or if management should be altered in the future to account for new information. The following monitoring variables were described for this particular management objective and adaptation tactics.

5a. Northern hardwood: Monitoring Plan

Monitoring Variable: Invasive species

Criteria for Evaluation	Plans for Implementation	Associated Management Objectives
90% removal of existing phragmites patches. 90-100% removal of new invasive populations, if feasible.	Existing invasives, to be treated in 2017 as part of NRCS cost share, will be monitored annually (during June-August) for 5 years after treatment. 1/1000 acre plots will be use to evaluate invasive cover. The entire property will be monitored for new invasives an a 10 year cycle, coinciding with FMP update inventory.	• Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)* • Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)*

Monitoring Variable: Species composition

Criteria for Evaluation	Plans for Implementation	Associated Management Objectives
Increase in proportion (% basal area) of future climate adapted species such as black cherry, white pine, red maple and others. Minor/non-commercial species up to 25% total.	Forest inventory will be conducted on 10 year intervals, coinciding with FMP updates. Variable radius plots used for inventory.	• Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)* • Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)* • Harvest 20-40 cords of firewood annually for NorthWoods facilities. *(annual)*

Monitoring Variable: Regeneration

Criteria for Evaluation	Plans for Implementation	Associated Management Objectives
Regeneration harvests should have at least 350 stems/ac of vigorous seedlings/saplings of desired species within 5 years after harvesting.	Forest inventory will be conducted on 10 year intervals, coinciding with FMP updates. 1/1000th acre plots used to evaluate seedling/sapling density and species composition.	• Maintain 10-25% of stocking in minor species, especially species with high wildlife/non-timber value such as American beech, serviceberry, apple, basswood, mountain ash, eastern hophornbeam and others. *(ongoing)* • Increase percentages of AGS and commercial species through pre-commercial and commercial harvests. *(ongoing)* • Harvest 20-40 cords of firewood annually for NorthWoods facilities. *(annual)*

5b. Softwood Plantation: Monitoring Plan

Monitoring Variable: Invasive species

Criteria for Evaluation	Plans for Implementation	Associated Management Objectives
90% removal of existing phragmites patches. 90-100% removal of new invasive populations, if feasible.	Existing invasives, to be treated in 2017 as part of NRCS cost share, will be monitored annually (during June-August) for 5 years after treatment. 1/1000 acre plots will be use to evaluate invasive cover. The entire property will be monitored for new invasives an a 10 year cycle, coinciding with FMP update inventory.	• Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red ... *(ongoing)*

Monitoring Variable: Species composition

Criteria for Evaluation	Plans for Implementation	Associated Management Objectives
Increase in proportion (% basal area) of future climate adapted species such as black cherry, white pine, red maple and others. Minor/non-commercial species up to 25% total.	Forest inventory will be conducted on 10 year intervals, coinciding with FMP updates. Variable radius plots used for inventory.	• Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red ... *(ongoing)*

Monitoring Variable: Regeneration

Criteria for Evaluation	Plans for Implementation	Associated Management Objectives
Regeneration harvests should have at least 350 stems/ac of vigorous seedlings/saplings of desired species within 5 years after harvesting.	Forest inventory will be conducted on 10 year intervals, coinciding with FMP updates. 1/1000th acre plots used to evaluate seedling/sapling density and species composition.	• Transition to site appropriate species, based on natural community type (typically northern hardwood). Promote species with high value for timber and/or non-timber value, such as sugar maple, yellow birch, red spruce, black cherry, white ash, red ... *(ongoing)* • Transition to uneven-aged/irregular forest structure. *(ongoing)* • Conduct timber harvests to provide periodic income (preferably annually, but at least every 3-5 years). *(annual/ongoing)*

5c. Lowland and riparian forest: Monitoring Plan

5d. Forest Roads and Trails: Monitoring Plan

6. References

This adaptation plan was developed using the Adaptation Workbook (www.adaptationworkbook.org (https://www.adaptationworkbook.org)) and Adaptation Strategies and Approaches developed by the Northern Institute of Applied Climate Science. View the Adaptation Strategies and Approaches at: www.adaptationworkbook.org/strategies (https://www.adaptationworkbook.org/strategies).

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