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## Increasing the Resiliency of Forests in New England: A Weather-Wise Worksheet for Private Woodland Owners

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### Introduction

Manomet Center for Conservation Sciences developed this worksheet to help New England woodland owners deal with changing weather and climate. Landowners are encouraged to use this worksheet with their forester. It is designed to align with forest management plans so that landowners and their foresters can readily streamline selected elements of this workbook into their existing management efforts. The notion of taking action on climate change may seem overwhelming; however, **you can pick and choose what makes sense for your woodlot and values.**

Over the last two decades, New England has experienced significant changes in its weather patterns. These changes are expected to continue over the next fifty years and beyond. New England is predicted to become warmer and wetter, storms are projected to become more frequent and intense, periods of extreme heat are expected to increase, as will the frequency and severity of short- and long-term drought. These changes will increase the frequency and size of forest disturbance events, worsen the impacts of invasive and non-native plants and pests, shift distributions of trees and wildlife habitats, alter the woods-based economy, and change the way the public uses and values woodlands. Although we cannot control these changes in climate, private landowners can manage their forests to help shape and sustain our future forest lands.

Our experience and knowledge about adapting to climate change is relatively young, but growing. These steps can help make your woodlot more resilient in the face of climate change and help ensure that New England forests as a whole continue to provide benefits for future generations. You may have applied some of these strategies already, taking tangible steps to adapt and respond to climate change.

This workbook lays out four steps to help you prepare for climate change:

- › **Step 1 – Prepare for Change.** Learn about predicted changes in weather and climate and how your properties might be affected.
- › **Step 2 – Plan for Change.** Develop or adapt a plan for your woodlot that guides you to action.
- › **Step 3 – Apply Key Strategies.** Select from a suite of strategies and on-the-ground practices, ranging from simple to more complex, to make your lands more resilient to changes in weather and climate.
- › **Step 4 – Monitor and Adjust.** Develop a cost-effective monitoring plan to determine the success of your efforts and inform future plans and practices.

### Step 1: Prepare for Change

Climate change is expected to raise air temperatures, alter precipitation patterns, and increase the viability of non-native plants and animals, the combination of which has the potential to result in wide-ranging changes to your woods. Keeping up to date about changes in weather and climate is an important first step to prepare for climate change.

#### Strategy #1: Increase your knowledge about climate change

- Attend talks, field trips, or workshops about climate change.
- Understand how some trees and forest habitats may be vulnerable to climate change.
- Learn what other landowners are doing to respond to climate change and how to apply that knowledge to your woodland.

## Strategy #2: Identify potential threats and vulnerabilities specific to your properties

Find out if local forests and your woodland are at risk for:

- Warmer temperatures over time
- Exotic pests (e.g., hemlock woolly adelgid, emerald ash borer)
- Drought and/or wildfire
- Extreme wind and ice storm events
- Exotic and invasive plants and pests
- Reduced snow and winter length
- Impacts of extreme rainfall events on access points and logging and recreation trails
- Deer browsing
- Sea level rise
- Altered rainfall and snowfall patterns

## Strategy #3: Share your experiences with others

Changing weather and precipitation patterns will impact woodlands across New England. The notion of taking action on climate change may seem overwhelming. By sharing your experiences, you can encourage fellow landowners to take action that makes sense.

- Share what you are doing about climate change with your neighbors, landowner groups, and local land trusts.

## Step 2: Plan for Change

An important step to deal with climate change is to plan for good forest stewardship of your woodlot. Incorporating elements of climate change adaptation (i.e. addressing risks and opportunities) into your existing management plan can help ensure that your forests remain healthy.

### Strategy #1: Gather and catalogue basic property information

Planning for climate change at a parcel level requires a familiarity of your woodland, as well as a way to catalogue changes and management actions over time.

- Get to know your property by walking it often at different times of year.

- Work with a public or private forester to develop or adapt a forest management plan. Your plan should help you identify and understand the natural resources on your property. If you already have a forest management plan, the plan likely contains appropriate information to begin planning for climate change.

### Strategy #2: Establish goals and objectives for each parcel or group of parcels

Think about your woodland and identify:

- Short and long-term goals for your property and how climate change may affect your goals. These goals can address a number of topics including forest health, wildlife habitat, recreational use, water and air quality, timber production, carbon storage/sequestration, and human health. You may have addressed at least some of these topics in your forest management plan.

### Strategy #3: Identify areas where climate change may impact your property

Identifying areas that are particularly vulnerable or resilient to climate change can help you identify and prioritize management activities.

- Forest areas vulnerable to climate change because they are dominated by or contain:
  - Trees that are targets for pests including hemlock woolly adelgid, emerald ash borer, and Asian longhorn beetle (e.g., Eastern hemlock, ash, maple).
  - Trees that are likely not favored by warming weather (e.g., American beech, Eastern hemlock, balsam fir, red and black spruce).
  - Many exotic trees and plants.
  - Shallow and well-drained soil that are at high risk for drought or wildfire.
  - Hill tops, forest edges, riparian buffers, and areas with rocky and shallow soil that are at risk of damage during high winds.
  - A single tree species and/or same sizes or ages of tree.
  - Trees preferred by deer or lacking vigorous natural regeneration due to deer browsing.
  - Unique features including vernal pools, cold-water streams, and climate change-sensitive plants and animals.

- ❑ Undersized stream crossings that may be prone to flooding or causing aquatic habitat fragmentation.
- ❑ Access points (e.g., trails, roads, parking lots) that are inaccessible or vulnerable to damage during prolonged wet conditions.
- ❑ Low-lying coastal areas that may be at risk to storm surge and sea level rise.
- ❑ Some trees and habitats that may thrive under changing conditions, creating opportunities to establish healthy, native habitat. Forest areas that might not be very vulnerable to climate change include:
  - ❑ Trees likely favored by warming weather including white pine, oak, and hickory.
  - ❑ Habitat areas that may be used by southern species as their ranges shift northward.
  - ❑ Deep, moderately well-drained soils, which are drought and flood resistant.
  - ❑ Northern slopes or forest areas along the ocean, where summertime temperatures may remain cooler than other areas.

### Step 3: Apply Key Strategies

Tweaking existing management strategies can provide practical and cost-effective ways to minimize changes associated with climate change and help ensure that your woodlands continue to provide benefits for you and future generations.

#### Forest Health

Climate change will likely affect the composition of New England's woodlands over the next generation. You can help maintain a healthy woodlot by applying appropriate management strategies.

#### Strategy #1: Maintain native plants and trees

Invasive plants are expected to thrive in a changing climate, allowing them to quickly spread and outcompete native forest plants and animals. To help reduce the spread of invasive plants and pests:

- ❑ Learn about existing and emerging threats of invasive plants and insects in your area.
- ❑ Know how to reduce the risk of pest introduction and transport during timber harvests, road or trail construction, and/or creation or expansion of recreation trails.
- ❑ Develop a simple monitoring program for invasive plants and pests such as knowing which forest stands have invasives and do what degree (e.g. absent, some, a lot). It may be sufficient to focus on invasive "hot spots" which include roads, trail, and disturbed areas.
- ❑ Control invasives at the early stages of infestation.
- ❑ In areas where invasive plants are abundant, consider how timber harvesting may expand existing populations of invasives. After timber harvests, additional action may be needed to prevent invasives from interfering with regeneration of native species.
- ❑ In areas with existing invasive forest plants or pests, consider participation in efforts to use biological controls to manage these species.
- ❑ In areas of high deer density, use appropriate silviculture, tree shelters, exclusion pens, or other means to ensure the establishment and survival of saplings of native trees.

#### Strategy #2: Minimize negative impacts of disturbance events

The frequency and intensity of forest disturbances is predicted to increase with climate change, resulting in a decline of habitat and amenity values, changing recreational opportunities, and financial loss. To minimize the negative impacts of disturbance events:

- ❑ Be on the look out for invasive plants and pests after disturbances such as ice storms or wind damage.
- ❑ Consider the vulnerability of softwoods and other shallow-rooted trees, forest edges, ridgelines, and riparian buffers to disturbance events when planning timber harvests, recreational trails, or access points.
- ❑ Consider harvesting trees and stands most vulnerable to disturbance sooner rather than later. This may help create more diverse stands with a variety of tree of different ages and sizes.
- ❑ Encourage growth of native trees that are predicted to thrive in new weather conditions through appropriate silviculture and planting (with appropriate follow-up to ensure survival).
- ❑ Understand the range of potential options for managing major disturbance events including pest infestations, wildfire threats, exotic plants threats, and major windthrow. Depending on your goals and objectives for your woods, actions can include allowing stands to naturally transition,

conducting salvage harvesting after a disturbance, or preemptively harvesting the most vulnerable trees and stands to reduce potential damage and establish a more resilient forest.

### Strategy #3: Maintain a range of trees, sizes, and age classes

Managing for a range of native species, trees sizes, and age classes is a strategy for avoiding “putting all your eggs in one basket.” Maintaining a diversity of trees can reduce the risks of wide-spread damage and mortality across large areas. It may or may not be a successful strategy for an individual woodlot. Sustainable forest management is a valuable tool for creating a diversity of native forest and habitat types. Some tips for conducting sustainable timber management include:

- ❑ Create a combination of mature trees, young trees, and seedlings. For example, you might restrict timber harvesting in areas that are difficult to access or have high ecological value (e.g., riparian areas, uncommon habitats). In easily accessible areas, more frequent cutting may be appropriate to realize timber value before it’s lost to catastrophic events, minimize risk of disturbance to mature stands, and promote the establishment of young, vigorous trees.
- ❑ Retain healthy and well-formed trees in your woods. Individual trees with full crowns, good root systems, and minimal stem damage are better equipped to survive and adapt to climate change events.
- ❑ Diversify the existing mix of trees to minimize pest impacts. Timber harvesting can create canopy openings to help establish seedlings and saplings of native trees that are projected to benefit from climate change.
- ❑ Work with respected credentialed professionals to plan and carry out harvest operations. Use appropriate BMPs as needed to minimize unwanted impacts of timber harvesting. Key BMPs include:
  - ❑ Construct and maintain woods road, trails, and landing locations to minimize ground disturbance and reduce water flow to protect soil productivity and reduce erosion.
  - ❑ Track changing soil and weather conditions during harvests and suspend harvest operations when soils become saturated and vulnerable to damage.
  - ❑ Maintain a well-constructed system of access points, roads, and skid roads to enable quick responses to

changing forest conditions.

- ❑ Check with your local state forestry agency for more information on forestry BMPs.

### Strategy #4: Enhance populations of climate change beneficiaries

Some trees and plants may thrive under changing conditions. Increasing the presence and distribution of these species can establish healthy habitat.

- ❑ Use harvest methods such as shelterwood cuts, thinning, and crop tree release to favor more well-adapted trees. Oaks, hickory and white pine are well suited for the warmer temperatures and precipitation patterns expected under climate change and are highly valued for forest products.
- ❑ Consider under planting oak seedlings.

### Wildlife Habitat

The range of some wildlife will shift due to climate change. Keeping forests healthy will provide habitat for existing and new animals in the area and maintain a diversity of wildlife and associated habitats.

### Strategy #1: Maintain and restore native forest habitats

Taking steps to maintain healthy woodlands and restore degraded habitat can improve the health of the forest and make substantive improvements to wildlife habitat over the long term.

- ❑ Maintain and restore healthy forests:
  - ❑ Control invasive plants and pests at the early stages of infestation.
  - ❑ Plant native trees and plants in areas where natural regeneration is not adequate.
  - ❑ In areas of high deer density, ensure the establishment and survival of saplings of native trees by using tree shelters, exclusion pens, or other methods.
  - ❑ When harvesting timber follow BMPs to protect soils.
- ❑ Maintain and restore water quality:
  - ❑ Manage buffer areas along streams and wetlands to slow down storm water, prevent sediment and other chemicals from entering water bodies, and provide shade to keep water cool.

- ❑ Avoid and/or minimize the number of trails and roads crossing streams.
- ❑ Minimize the placement of trails or roads in wetlands and near water bodies.
- ❑ Design stream crossings to withstand extreme rainfall events.
- ❑ When harvesting timber, follow BMPs to protect water quality).

### Strategy #2: Maintain woodland refugia

North-facing slopes, end-of-peninsula coastal areas, cold-water streams, and mountain tops may be less affected by climate change than other sites. These areas may serve as legacy sites for plants and animals vulnerable to changes in weather and climate.

- ❑ Minimize disturbance of these naturally resilient areas to protect microclimate and habitat.
- ❑ Maintain spruce-fir forest and cedar swamps to conserve plants and wildlife limited to these areas.
- ❑ Maintain buffers around vernal pools, streams, lakes, and rivers to provide shade and protect water quality. Follow local regulations and guidelines.
- ❑ Retain some areas of mostly closed-canopy forest conditions to protect understory micro-climates for northern understory plants.

### Strategy #3: Maintain forest habitat connectivity and woodland block size

Plants and animals will need to move across landscapes as habitats shift. Maintain connectivity among parcels can facilitate movement of plants and animals.

- ❑ Keep your woodland healthy and well-managed.
- ❑ Know how your woodland contributes to habitat connectivity and woodland block size at the landscape scale.
- ❑ Retain areas of mid-age or older forest for plants and animals that require mature forest.
- ❑ Manage wooded buffers along streams and rivers to maintain travel corridors. Follow state and local regulations and guidelines, and consult with wildlife and other professionals to determine the size and density of these buffers.

- ❑ In developed areas, consider converting clearings and old fields to forest to increase the forest area in your county.
- ❑ Consider placing an easement on your forest land to restrict future development.

## Water Quality

Well managed forests help maintain clean water and aquatic wildlife habitat while contributing to flood control.

### Strategy #1: Minimize disturbance to water bodies and wetlands

Vegetated stream banks keep rivers, lakes, and streams cool, clean, and healthy. Well-designed bridges and culverts can significantly reduce the risk of sedimentation and habitat degradation.

- ❑ Minimize the placement of trails or roads in wetlands and near water bodies.
- ❑ Avoid and/or minimize the number of trails and roads crossing streams.
- ❑ Create buffers along streams and wetlands to slow down storm water, prevent sediment and other chemicals from entering water bodies, and provide shade to keep water cool.
- ❑ Use temporary bridges instead of culverts or permanent bridges to reduce risk of failure during storm events.
- ❑ Plan for extreme rainfall events when designing stream crossings, roads, and trails.
- ❑ Apply water quality BMPs when harvesting timber or improving trails and stream crossings.
- ❑ Reforest shorelines that currently lack trees.

### Strategy #2: Maintain watershed health

Heavily forested watersheds are much less vulnerable to extreme rainfall events that can cause significant flooding and erosion that degrades water quality and aquatic wildlife.

- ❑ Keep your woodland healthy and well-managed.
- ❑ Avoid disturbing the hydrology and water storage capacity of wetlands and vernal pools.
- ❑ Consider placing an easement on your woodland to restrict future development.

- ❑ In highly developed watersheds, consider restoring unforested areas to forest, especially along streams and rivers.

## Recreation

Private woodland can provide important recreational opportunities that allow people to connect with nature. If you have trails on your property, consider applying the following strategies.

### Strategy #1: Create a low-impact recreational trail system

Trail-based recreation is highly vulnerable to climate change. Decreases in snow depth and duration, as well as increases in extreme precipitation events, may degrade trail quality and become a significant sediment source to water bodies.

- ❑ Clearly communicate the permitted recreational uses.
- ❑ Work with local clubs (e.g. snowmobile, ATV, hiking) to routinely evaluate the condition of trails and stream crossings and identify areas needing improvement or maintenance.
- ❑ Relocate, re-route, or improve trails in routinely wet or degraded areas to avoid rutting and erosion. Close trails when they are very wet and muddy to avoid damage to trails.
- ❑ Design and construct stream crossings capable of withstanding extreme rainfall events.

### Strategy #2: Monitor and repair trails after large storms

Large storms can damage bridges, steps, and other trail structures and as well as trees creating unsafe conditions for recreational users.

- ❑ Work with volunteers from local recreational clubs to identify and communicate trail hazards and closures after storms.
- ❑ Enlist trained volunteers to remove hazards such as broken tree limbs and repair damage to stream crossings and other trail infrastructure.
- ❑ Include routine monitoring and repairs into your trail building and maintenance program, if you have one.

### Strategy #3: Encourage deer management

As winters warm and the depth and duration of snow cover decrease, deer herd size and density may increase. This can

damage vegetation, reduce forest regeneration, and increase the incidence of ticks and Lyme disease.

- ❑ Provide hunting opportunities to keep deer populations in check.
- ❑ In areas with high deer density, use tree tubes, deer repellent, deer exclosures, tall fencing, or other methods to protect seedlings and saplings and regenerate the forest.

## Maintain or Increase Carbon Storage

Forests are one of the most important sinks of global carbon. Late-successional stands (>100 years old) often contain twice as much carbon as young stands. Many stands in the region are young enough to double carbon storage if managed to mature or late-successional condition.

### Strategy #1: Grow and retain trees on site

Healthy forests generally store ten to twenty times more carbon than non-forested sites.

- ❑ Retain forest cover and avoid converting forest to other uses.
- ❑ Foster regeneration of native seedlings and saplings.
- ❑ Protect stands of old forests with adequate regeneration.
- ❑ When harvesting timber, consider using the following strategies:
  - ❑ Apply silvicultural techniques designed to grow vigorous trees of all sizes.
  - ❑ Retain standing dead trees (e.g., snags, wildlife trees) and dead wood on the forest floor to retain carbon stocks and nutrients on site.
  - ❑ Retain large, old trees singly or in patches.

### Strategy #2: Minimize stand damage when harvesting timber

Excessive damage to soils and standing trees will release carbon dioxide and other greenhouse gases into the atmosphere. Protecting soils and residual trees in stands where timber is harvested can reduce carbon dioxide and other greenhouse gas emissions, as well as enhance the future value of your woods.

- ❑ Conduct logging operations on frozen or dry ground to minimize soil disturbance.
- ❑ Avoid timber harvests during wet weather unless soil conditions allow a minimal risk of rutting.

- ❑ Use directional felling, forwarders, bumper trees and/or other techniques to minimize damage to residual trees during timber harvesting.

### Strategy #3. Utilize trees in products that reduce greenhouse gas emissions

As trees grow, they remove and store carbon from the atmosphere. After trees are harvested they can continue to provide carbon storage for decades in the form of buildings and furniture. Wood fiber used in composites such as a particle board and strand-panels also sequester carbon.

- ❑ Grow trees for harvest to sawlog size that can be used in long-lived wood products such as lumber and wood composites (e.g., plywood, strand board).
- ❑ Market low-grade timber into its greatest carbon sequestration potential. This may be pallets, pulp, or wood for heating.

## Human Health and Safety

Climate change increases the frequency of catastrophic forest disturbances that can make trails unsafe or create the possibility of wildfire.

### Strategy #1: Manage wildfire risk appropriately

Increased frequency of early spring and late summer drought can contribute to wildfire risk. Key practices for reducing wildfire risk on your properties can include:

- ❑ Learn about the FireWise program.
- ❑ Create a defensible space around your home by reducing potential fuel sources near structures.
- ❑ Manage fuel loads to reduce fire risk in woods where wildfires could pose a human health risk in local communities.
- ❑ Recognize that areas that are dominated by trees associated with fire (e.g., pitch pine, red pine, jack pine, big-tooth aspen) or have widespread evidence of fire (e.g., fire scars, charcoal in the soils, historic record) are at risk of burning in the future.

### Strategy #2: Maintain safe trails

With recent changes in weather patterns, extreme rainfall and storms have become more common, often creating trail hazards.

- ❑ Close trails when numerous hazard trees are near trails or unsafe stream crossings are present.
- ❑ Re-route trails away from forest areas with catastrophic impacts (e.g., wind throw, major pest outbreaks).

## Step 4: Monitor and Adjust

Experts agree that over the next fifty years, changing weather patterns will bring significant changes to forests. We can predict the types of changes we can expect, but we cannot precisely predict the timing of these changes or how quickly they will occur. Monitoring for signs of local climate impacts is complicated because not all changes in your woods may be attributable to climate change. By monitoring your woodlands, you can assess the current condition of your woodlot and identify potential stressors (that may or may not be related to climate change), adjust management actions to achieve your goals. Monitoring can be costly, so consider selecting simple, low-cost methods that can provide the information necessary to help maintain your forest.

### Strategy 1: Have simple and effective ways to monitor forest health

- ❑ Look for signs of stress and decline in canopy trees. Trees predicted to decline in New England over the next 100 years may include sugar maple, red maple, black cherry, balsam fir, red spruce, yellow birch, paper birch, quaking aspen, eastern hemlock, American beech, and white ash. Depending on your goals you may consider harvesting declining trees in order to realize timber value before the quality of wood products suffers or allow the stand to naturally transition over time.
- ❑ Develop a simple monitoring program for invasive species:
  - ❑ Focus on invasive plants and/or pests with a confirmed presence in the region that target species present at your site.
  - ❑ Focus monitoring in invasive “hot spots”, such as roads, trails, and parking lots. Pay particular attention after large disturbances such as ice storms and wind damage, timber harvesting, and road or trail construction.
  - ❑ Simple, categorical assessments of abundance (single plant, scattered plants, patches, or dense growth) and whether native tree growth is effected can help identify and prioritize management responses.

- ❑ Assess forest regeneration (i.e., seedlings and saplings) to understand whether your woods have the capacity to rapidly recover from catastrophic disturbance or timber harvesting.
- ❑ Assess whether deer impacts on seedlings, saplings, and other plants are affecting regeneration or degrading forest habitats.
- ❑ Track seasonal, local fire risk if you have forest types prone to wildfire.

### Strategy 2: Have an efficient monitoring system for infrastructure

Wood yards, woods roads, and skid trails provide important timber access and potential recreational opportunities. Climate change can have a negative impact on these benefits by impeding access, damaging trails, creating dangerous conditions, and reducing recreational opportunities.

- ❑ Monitor woods roads, skid trails, wood yards/landings, and access points for hazard trees and areas where rutting and/or erosion are problematic.

### Strategy 3: Periodically incorporate the results of your monitoring and adjust management strategies to respond to existing and emerging threats

Monitoring is the best way to gauge the current condition of your woodland, as well as recognize existing and emerging threats. This information can be used to adjust and improve your plans and strategies and help maintain a healthy and viable woods.

- ❑ Continue to learn about climate change and how your properties may be affected. See Step 1 for specific strategies.
- ❑ Talk with natural resource professionals. Public foresters, conservation agency staff, as well as consultants, private foresters, and loggers in your area can help you understand risks and opportunities posed by climate change, and choose management strategies that work best for you.
- ❑ Periodically update management goals and plans to include new information and opportunities. See Step 2 for specific strategies.
- ❑ Periodically revisit your management plans to ensure these strategies include current and emerging threats and opportunities for your woodland. New strategies may

emerge as scientific knowledge and practical expertise develops. See Step 3 for specific strategies.

- ❑ Continue to monitor your property to determine whether impacts of changing weather and climate are occurring on your parcel and whether you are making the adjustments necessary to reduce impacts. See Step 4 for specific strategies.

## Summary

Experts agree that climate change will change our forests. The notion of taking action on climate change can be overwhelming. However, we believe you will find there are simple ways, perhaps some you are already doing to effectively shape and sustain your woodlands. The four steps outlined in this workbook (prepare for change, plan for change, apply key strategies, and monitor and adjust) are intended to help you understand the impacts of climate change on your woods and apply tangible actions, both small and large, to make your land more resilient to changes in weather and climate.

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## Increasing the Resiliency of Forests in New England: Resource Guide for Private Woodland Owners

### Introduction

The Weather-Wise Worksheet for Woodland Owners outlines four steps (prepare for change, plan for change, apply key strategies, and monitor and adjust) to help make your lands and community more resilient to changes in weather and climate. This resource guide provides background information to help you implement the strategies identified in the worksheet. Although we worked to make this guide complete, you also may find other useful resources for taking action on climate change.

### Step 1: Prepare for Change

#### Strategy #1: Increase your knowledge about climate change

#### National Information

##### **Climate Change Impacts in the United States: Frequently Asked Questions about Climate Change (2014)**

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Appendix 4: Frequently Asked Questions. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, T.C. Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 790-820.

<http://nca2014.globalchange.gov/report/appendices/faqs>

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#### Regional Information

##### **Climate Change in the Northeast (2014)**

Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz. 2014. Ch. 16: Northeast. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 371-395.

<http://nca2014.globalchange.gov/report/regions/northeast>

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##### **Maine's Climate Future: An Initial Assessment (2009)**

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[http://climatechange.umaine.edu/files/Maines\\_Climate\\_Future.pdf](http://climatechange.umaine.edu/files/Maines_Climate_Future.pdf)

## **Climate Change in Northern New Hampshire: Past, Present, and Future (2014)**

Wake, C., E. Burakowski, P. Wilkinson, K. Hayhoe, A. Stoner, C. Keeley, J. LaBranche Climate Solutions New England, Sustainability institute, University of New Hampshire, Durham, NH

[http://climatesolutionsne.org/sites/climatesolutionsne.org/files/unhsi-csne-northernnh\\_climateassessment\\_june\\_4\\_2014.pdf](http://climatesolutionsne.org/sites/climatesolutionsne.org/files/unhsi-csne-northernnh_climateassessment_june_4_2014.pdf)

## **Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State. (2011)**

Rosenzweig, C., W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, and P. Grabhorn (Eds.) 2001. Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State. Synthesis Report. New York State Energy Research and Development Authority (NYSERDA), Albany, New York.

<http://www.nyserdera.ny.gov/climaid>

## **Considering Vermont's Future in a Changing Climate: The First Vermont Climate Assessment (2014)**

Galford, Gillian L., Ann Hoogenboom, Sam Carlson, Sarah Ford, Julie Nash, Elizabeth Palchak, Sarah Pears, Kristin Underwood, and Daniel V. Baker, Eds, 2014: Considering Vermont's Future in a Changing Climate: The First Vermont Climate Assessment. Gund Institute for Ecological Economics, 219 pp.

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## **Strategy #2: Identify potential threats and vulnerabilities specific to your properties**

### **Climate Change Impacts in the United States: Forests (2014)**

Joyce, L. A., S. W. Running, D. D. Breshears, V. H. Dale, R. W. Malmshiemer, R. N. Sampson, B. Sohngen, and C. W. Wood-all, 2014: Ch. 7: Forests. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 175-194.

[http://nca2014.globalchange.gov/system/files\\_force/downloads/low/NCA3\\_Full\\_Report\\_07\\_Forestry\\_LowRes.pdf?download=1](http://nca2014.globalchange.gov/system/files_force/downloads/low/NCA3_Full_Report_07_Forestry_LowRes.pdf?download=1)

### **Forest Threat Facts: Climate Variability, Climate Change, and Severe Weather (2014)**

USDA, Forest Service, The Eastern Forest Environmental Threat Assessment Center • Asheville, Raleigh, and Research Triangle, NC

[http://www.forestthreats.org/products/fact-sheets/EFETAC\\_climate\\_factsheet\\_2013.pdf](http://www.forestthreats.org/products/fact-sheets/EFETAC_climate_factsheet_2013.pdf)

## **Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada (2012)**

Rustad, L., J. Campbell, J. Dukes, T. Huntington, K. Fallon Lambert, J. Mohan, N. Rodenhouse. 2012. Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada. USDA Forest Service, Northern Research Station General Technical Report NRS-99: 56pp.

[http://www.nrs.fs.fed.us/pubs/gtr/gtr\\_nrs99.pdf](http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs99.pdf)

### **National Climate Change Viewer**

An online climate projections viewer shows temperature and precipitation trends at the county level.

[http://www.usgs.gov/climate\\_landuse/clu\\_rd/apps/nccv\\_viewer.asp](http://www.usgs.gov/climate_landuse/clu_rd/apps/nccv_viewer.asp)

### **Strategy #3: Share your experiences with others**

Most states have organizations that provide information for woodland owners through trainings, workshops, newsletters, and state-wide and local meetings.

#### **Small Woodland Owners Association of Maine**

<http://www.swoam.org/>

#### **Vermont Woodlands Association**

<http://www.vermontwoodlands.org/>

#### **New Hampshire Timberland Owners Association**

<http://www.nhtoa.org/index.html>

#### **New York Forest Owners Association**

<http://nyfoa.org/>

## **Step 2: Plan for Change**

### **Strategy #1: Establish goals and objectives for each parcel or group of parcels**

#### **Good Forestry in the Granite State: Chapter 1.2 Setting Objectives (2010)**

Bennett, K.P. editor. 2010. Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire (second edition). University of New Hampshire Cooperative Extension, Durham, N.H.

<http://extension.unh.edu/goodforestry/assets/docs/GoodForestry2010FINALreducedsizeSECURE.pdf>

## Seven questions that can help forest landowners clarify their goals (2013)

Peterson, G. Michigan State University Extension, East Lansing, MI

### Article:

[http://msue.anr.msu.edu/news/seven\\_questions\\_that\\_can\\_help\\_forest\\_landowners\\_clarify\\_their\\_goals](http://msue.anr.msu.edu/news/seven_questions_that_can_help_forest_landowners_clarify_their_goals)

### Worksheet:

[http://msue.anr.msu.edu/uploads/files/Greening/Forestry\\_goal\\_worksheet.docx](http://msue.anr.msu.edu/uploads/files/Greening/Forestry_goal_worksheet.docx)

## Strategy #2: Gather and catalogue basic property information

### Managing Your Woodlands: A Template for Your Plans for the Future (2011)

American Tree Farm System, Forest Stewardship Program, Natural Resources Conservation Service, Washington, D.C., 32pp.

### Guide:

[https://www.treefarmssystem.org/stuff/contentmgr/files/1/811656e8116af1c86571cbbf51851fac/files/guide\\_for\\_landowners\\_for\\_the\\_joint\\_management\\_plan\\_template.21feb11.pdf](https://www.treefarmssystem.org/stuff/contentmgr/files/1/811656e8116af1c86571cbbf51851fac/files/guide_for_landowners_for_the_joint_management_plan_template.21feb11.pdf)

### Template:

[https://www.treefarmssystem.org/stuff/contentmgr/files/1/811656e8116af1c86571cbbf51851fac/files/managing\\_your\\_woodlands\\_national\\_atfs\\_fs\\_nracs\\_joint\\_management\\_plan\\_template.21feb11.doc](https://www.treefarmssystem.org/stuff/contentmgr/files/1/811656e8116af1c86571cbbf51851fac/files/managing_your_woodlands_national_atfs_fs_nracs_joint_management_plan_template.21feb11.doc)

## Strategy #3: Identify areas where climate change may impact your property

### LANDFIRE

A free mapping tool that provides over 20 geo-spatial layers (e.g. vegetation, fuel, fire risk, disturbance, etc.), to create vegetation maps to identify areas that are vulnerable to wildfire or declines in productivity.

<http://www.landfire.gov/index.php>.

### Web Soil Survey

A free online tool that provides soil data and information produced by the National Cooperative Soil Survey. The site is updated and maintained online as the single authoritative source of soil survey information. Soil surveys can be used to identify areas at risk to drought or flooding.

<http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>

## The Vulnerabilities of Fish and Wildlife Habitats in the Northeast to Climate Change (2012)

Manomet Center for Conservation Sciences and National Wildlife Federation. 2012.

A report to the Northeastern Association of Fish and Wildlife Agencies and the North Atlantic Landscape Conservation Cooperative. Manomet, MA

[http://static.rcngrants.org/sites/default/files/final\\_reports/RCN%202009-01%20Final%20Report%20-%20THE%20VULNERABILITIES%20OF%20FISH%20AND%20WILDLIFE%20HABITATS%20IN%20THE%20NORTHEAST%20TO%20CLIMATE%20CHANGE.pdf](http://static.rcngrants.org/sites/default/files/final_reports/RCN%202009-01%20Final%20Report%20-%20THE%20VULNERABILITIES%20OF%20FISH%20AND%20WILDLIFE%20HABITATS%20IN%20THE%20NORTHEAST%20TO%20CLIMATE%20CHANGE.pdf)

### Climate Change Adaptation for Forestry in New England (2013)

Wilkerson, E., Grund, S., Walberg, E., 2013. Climate Change Adaptation for Forestry in New England. Manomet Center for Conservation Sciences, Plymouth, MA

[https://www.manomet.org/sites/default/files/publications\\_and\\_tools/Forestry\\_fact\\_sheet%205-13.pdf](https://www.manomet.org/sites/default/files/publications_and_tools/Forestry_fact_sheet%205-13.pdf)

### Climate Change and Massachusetts Fish and Wildlife: Volume 2 Habitat and Species Vulnerability (2010)

Manomet Center for Conservation Sciences and Massachusetts Division of Fisheries and Wildlife. Boston, MA

<http://www.mass.gov/eea/docs/dfg/dfw/habitat/cwcs/climate-change-quick-ref-habitat-types.pdf>

### Change and Biodiversity in Maine: Vulnerability of Habitats and Priority Species. (2013)

Whitman, A., A. Cutko, P. deMaynadier, S. Walker, B. Vickery, S. Stockwell, and R. Houston. 2013. Manomet Center for Conservation Sciences (in collaboration with Maine Beginning with Habitat Climate Change Working Group) Report SEI-2013-03. 96 pp. Brunswick, Maine

### Summary Report

[https://www.manomet.org/sites/default/files/publications\\_and\\_tools/BwHSummary\\_021914.pdf](https://www.manomet.org/sites/default/files/publications_and_tools/BwHSummary_021914.pdf)

### Full Report

[https://www.manomet.org/sites/default/files/publications\\_and\\_tools/2013%20BwH%20Vulnerability%20Report%20CS5v7\\_0.pdf](https://www.manomet.org/sites/default/files/publications_and_tools/2013%20BwH%20Vulnerability%20Report%20CS5v7_0.pdf)

### Ecosystems and Wildlife: New Hampshire Climate Change Adaptation Plan (2013)

New Hampshire Fish and Game Department, Durham, NH

Executive Summary: [http://www.wildlife.state.nh.us/Wildlife/Wildlife\\_Plan/climate\\_change/Eco\\_Wildlife\\_CC\\_Adapt\\_Plan\\_Intro.pdf](http://www.wildlife.state.nh.us/Wildlife/Wildlife_Plan/climate_change/Eco_Wildlife_CC_Adapt_Plan_Intro.pdf)

### Full Report

[http://www.wildlife.state.nh.us/Wildlife/Wildlife\\_Plan/climate\\_change/Eco\\_Wildlife\\_CC\\_Adapt\\_Plan.pdf](http://www.wildlife.state.nh.us/Wildlife/Wildlife_Plan/climate_change/Eco_Wildlife_CC_Adapt_Plan.pdf)

## Assessing the Vulnerability of Key Habitats in New York: A Foundation for Climate Adaptation Planning (2013)

Hilke, C. and Galbraith, H. 2013. National Wildlife Federation, Northeast Regional Center. Montpelier, VT.

[http://www.nwf.org/~media/content/specialty%20programs/Climate-smart-conservation/Adaptation-Reports/Assessing\\_the\\_Vulnerability\\_of\\_Key\\_Habitats\\_of\\_NY.pdf](http://www.nwf.org/~media/content/specialty%20programs/Climate-smart-conservation/Adaptation-Reports/Assessing_the_Vulnerability_of_Key_Habitats_of_NY.pdf)

## Vermont Agency of Natural Resources Climate Change Adaptation Framework (2013)

Chapter 3.3 Upland Forests, Tetra Tech, Inc. Montpelier, VT

[http://www.anr.state.vt.us/anr/climatechange/Pubs/2013.0610.vtanr.NR\\_CC\\_Adaptation\\_Framework\\_Report.pdf](http://www.anr.state.vt.us/anr/climatechange/Pubs/2013.0610.vtanr.NR_CC_Adaptation_Framework_Report.pdf)

## Step 3: Apply Key Strategies

### FOREST HEALTH

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#### Strategy #1: Maintain native plants and trees

Invasive Plants Field and Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands (2005). Huebner, C.; Olson, C.; Smith, H. USDA Forest Service, State and Private Forestry, Northeastern Area

[http://www.na.fs.fed.us/pubs/misc/ip/ip\\_field\\_guide.pdf](http://www.na.fs.fed.us/pubs/misc/ip/ip_field_guide.pdf)

#### Responses of insect pests, pathogens, and invasive plant species to climate change in forests of northeastern North America: What can we predict? (2009)

Dukes, J.S., Et al., 2009. Canadian Journal of Forest Research. 39: 231-248.

[http://harvardforest.fas.harvard.edu/sites/harvardforest.fas.harvard.edu/files/publications/pdfs/Dukes\\_CanadianJForestResearch\\_2009.pdf](http://harvardforest.fas.harvard.edu/sites/harvardforest.fas.harvard.edu/files/publications/pdfs/Dukes_CanadianJForestResearch_2009.pdf)

#### Websites for Invasive Plant and Pests Species:

US Forest Service Northeastern Area website maintains current information about invasive plants and pests threatening forests in New England.

Invasive plants

[http://www.na.fs.fed.us/fhp/invasive\\_plants/](http://www.na.fs.fed.us/fhp/invasive_plants/)

Invasive insects

<http://www.na.fs.fed.us/fhp/id/index.shtm>

US Forest Service Top Ten Invasive Plants in New England

[http://www.na.fs.fed.us/fhp/invasive\\_plants/top\\_ten\\_invasives/index.shtm](http://www.na.fs.fed.us/fhp/invasive_plants/top_ten_invasives/index.shtm)

Invasive Plant Atlas of New England (IPANE)

[http://www.eddmaps.org/ipane/volunteers/training\\_materials/2006\\_basic\\_10\\_species.pdf](http://www.eddmaps.org/ipane/volunteers/training_materials/2006_basic_10_species.pdf)

## Emerald Ash Borer

A clearinghouse of information of the Emerald Ash Borer is available at <http://www.emeraldashborer.info>.

#### Emerald Ash Borer Pest Alert (2008)

McCullough, D. and Katovich, S. USDA Forest Service, Northeastern Area, State & Private Forestry, Newtown Square, PA

[http://na.fs.fed.us/spfo/pubs/pest\\_al/eab/eab.pdf](http://na.fs.fed.us/spfo/pubs/pest_al/eab/eab.pdf)

#### Emerald Ash Borer: A guide to identification and comparison to similar species. (2008)

Parsons, G.L. Michigan State University, East Lansing, MI

[http://www.emeraldashborer.info/files/eab\\_id\\_guide.pdf](http://www.emeraldashborer.info/files/eab_id_guide.pdf)

## Asian Longhorned Beetle

Asian Longhorned Beetle - A New Introduction (2008)

USDA Forest Service, State and Private Forestry, Northeastern Area; Animal and Plant Health Inspection Service, Pest Alert NA-PR-01-99. Newtown Square, PA

[http://www.na.fs.fed.us/pubs/palerts/alb/alb\\_pa.pdf](http://www.na.fs.fed.us/pubs/palerts/alb/alb_pa.pdf)

#### Asian Longhorned Beetle and its Host Trees (2012)

Parker, B., Skinner, M., Dodds, K., Bohne, M. United States, Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry, Newtown Square; NA-PR-05-12

<http://na.fs.fed.us/pubs/alb/alb-and-host-trees-09-12-2012-screen.pdf>

#### Hemlock Woolly Adelgid

The USFS Northeastern area maintains a clearinghouse of information about the Hemlock Woolly Adelgid: <http://www.na.fs.fed.us/fhp/hwa/>

#### Hemlock Woolly Adelgid (Pest Alert) (2005)

US Forest Service, Northeastern Area, State and Private Forestry, 11 Campus Blvd, Suite 200, Newtown Square, PA 19073, NA-PR-09-05

[http://na.fs.fed.us/spfo/pubs/pest\\_al/hemlock/hwa05.htm](http://na.fs.fed.us/spfo/pubs/pest_al/hemlock/hwa05.htm)

#### Eastern Hemlock Forests: Guidelines to Minimize the Impacts of Hemlock Woolly Adelgid (2004)

Ward, J.S.; Montgomery, M.E.; Cheah, C.A.S.-J.; Onken, B.P.; Cowles, R.S. NA-TP-03-04. U.S. Department of Agriculture, Forest Service, Northeastern Area State & Private Forestry, Morgantown, WV. 27 p.

[http://na.fs.fed.us/pubs/tps/eastern\\_hemlock/eastern\\_hemlock.pdf](http://na.fs.fed.us/pubs/tps/eastern_hemlock/eastern_hemlock.pdf) (PDF)

## Strategy #2: Minimize negative impacts of disturbance events

### ICE STORMS

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#### Ice Resistant Tree Populations (2009)

University of New Hampshire Cooperative Extension, Durham, NH

[http://extension.unh.edu/resources/files/Resource000987\\_Rep1123.pdf](http://extension.unh.edu/resources/files/Resource000987_Rep1123.pdf)

#### Trees and Ice Storms: the Development of Ice Storm-Resistant Urban Tree Populations (2006)

Hauer, R.J., J.O. Dawson, and L.P. Werner. 2006. Joint Publication 06-1, College of Natural Resources, University of Wisconsin-Stevens Point, and the Department of Natural Resources and Environmental Sciences and the Office of Continuing Education, University of Illinois at Urbana-Champaign. 20pp.

<http://www.vtfpr.org/protection/documents/TreesandIceStorm.pdf>

#### Ice Storm Response: helping Landscape Tree Recover from Ice Storms (2008)

USDA Forest Service, Northeastern Area State and Private Forestry, Durham, NH

<http://www.vtfpr.org/protection/documents/HelpTreesRecover.pdf>

#### Recovery of Stands Damaged by Ice Storms: Advice for Landowners and Foresters (2014)

Vermont Forest Health Newsletter, January 2014, Vermont Department of Forests, Parks, and Recreation.

<http://www.vtfpr.org/protection/documents/IceDamage2014.pdf>

### WIND DAMAGE

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#### Managing Storm Damaged Woods

Klase, W. University of Wisconsin Cooperative Extension, Rhinelander, WI

<http://dnr.wi.gov/topic/ForestLandowners/documents/ManagingStormDamagedWoods.pdf>

#### How to Evaluate and Manage Storm-Damage Forest Areas (2001)

Barry, P.J., C. Doggett, R.L. Anderson, K.M. Swain. 2001. US Forest Service, Southern Region, Asheville, NC

[http://www.fs.fed.us/r8/foresthealth/pubs/storm\\_damage/contents.html](http://www.fs.fed.us/r8/foresthealth/pubs/storm_damage/contents.html)

## Strategy #3: Maintain a range of trees, sizes, and age classes

Northeastern Forest Regeneration Handbook: A Guide for Forest Owners, Harvesting Practitioners, and Public Officials (2013)

Ward, J.S.; Worthley, T.E.; Smallidge, P.J.; Bennett, K.E.

[http://www.na.fs.fed.us/stewardship/pubs/NE\\_forest\\_regeneration\\_handbook\\_revision\\_130829\\_desktop.pdf](http://www.na.fs.fed.us/stewardship/pubs/NE_forest_regeneration_handbook_revision_130829_desktop.pdf)

#### Brief Overview of Timber Management Practices and Principles

Mike Leonard, Consulting Forester, North Quabbin Forestry, Petersham, Massachusetts

<http://northquabbinforestry.com/forestry-practice/>

## Strategy #4: Enhance populations of climate change beneficiaries

#### Perspectives on the Ecology and Silviculture of Oak-Dominated Forests in the Central and Eastern States (1993)

Johnson, P.S. USDA Forest Service, General Technical Report NC-153, St. Paul, MN, 28 p.

[http://www.nrs.fs.fed.us/pubs/gtr/gtr\\_nc153.pdf](http://www.nrs.fs.fed.us/pubs/gtr/gtr_nc153.pdf)

#### Silvicultural Guide for White Pine in the Northeast (1978).

Lancaster, K.F., and W.B. Leak. 1978. A USDA For. Serv. Gen. Tech. Rep. NE-41. 13 p.

[http://www.fs.fed.us/ne/newtown\\_square/publications/technical\\_reports/pdfs/scanned/gtr41.pdf](http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/scanned/gtr41.pdf)

### WILDLIFE HABITAT

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## Strategy #1: Maintain and restore native forest habitats

#### Good Forestry in the Granite State: Chapter 6 Wildlife Habitat (2010)

Bennett, K.P. editor. 2010. Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire (second edition). University of New Hampshire Cooperative Extension, Durham, N.H.

<http://extension.unh.edu/goodforestry/assets/docs/GoodForestry2010FINALreducedsizeSECURE.pdf>

#### Focus Species Forestry: A Guide to Integrating Timber and Biodiversity Management in Maine (2007)

Bryan, R. Published by Maine Audubon, in cooperation with Maine Department of Conservation, Professional Logging Contractors of Maine, Master Logger Program, Small Woodland Owners Association of Maine, Falmouth, ME

<http://maineaudubon.org/wp-content/uploads/2012/08/MEAud-FocusSpeciesForestry.pdf>

### **Landowner's Guide to Wildlife Habitat: Forest Management for the New England Region (2005)**

DeGraaf, R.M., M. Yamasaki, W.B. Leak, and A.M. Lester. University Press of New England

<http://www.upne.com/1584654678.html>

### **Forester's Guide to Managing Wildlife Habitats in Maine (1999)**

Elliott, C.A. University of Maine Cooperative Extension, Orono, Maine

<http://www.upperstjohnriver.com/BFM.pdf>

## **Strategy #2: Maintain woodland refugia**

### **Good Forestry in the Granite State: Chapter 7 Sensitive Areas (2010)**

Bennett, K.P. editor. 2010. Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire (second edition). University of New Hampshire Cooperative Extension, Durham, N.H.

<http://extension.unh.edu/goodforestry/assets/docs/GoodForestry2010FINALreducedsizeSECURE.pdf>

### **Forestry Habitat Management Guidelines for Vernal Pool Wildlife (2004)**

Calhoun, A. J. K. and P. deMaynadier. MCA Technical Paper No. 6, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York.

<http://www.umaine.edu/vernalpools/MunicipalGuideResources/Forestry%20Habitat%20Management%20Guidelines%20for%20Vernal%20Pool%20Wildl.pdf>

## **Strategy #3: Maintain forest habitat connectivity and woodland block size**

### **Resilient Sites for Species Conservation in the Northeast and Mid-Atlantic Region (2011)**

Anderson, M.G., M. Clark, and A. Olivero Sheldon. The Nature Conservancy, Eastern Conservation Science. 122pp.

[http://rcngrants.org/sites/default/files/final\\_reports/Resilient-Sites-for-Species-Conservation%281%29.pdf](http://rcngrants.org/sites/default/files/final_reports/Resilient-Sites-for-Species-Conservation%281%29.pdf)

### **Focus Species Forestry: A Guide to Integrating Timber and Biodiversity Management in Maine (2007)**

Bryan, R. Published by Maine Audubon, in cooperation with Maine Department of Conservation, Professional Logging Contractors of Maine, Master Logger Program, Small Woodland Owners Association of Maine, Falmouth, ME

<http://maineaudubon.org/wp-content/uploads/2012/08/MEAud-FocusSpeciesForestry.pdf>

### **Conservation Easements: An Introduction for Maine Landowners (2002)**

Maine Coast Heritage Trust, Topsham, ME

[http://www.mltn.org/documents/conservation\\_easement.pdf](http://www.mltn.org/documents/conservation_easement.pdf)

### **Conservation Options: A Guide for Maine Landowners (2003)**

Published by Maine Coast Heritage Trust, in cooperation with Land Trust Alliance, Topsham, ME

<http://www.mltn.org/documents/mchtconsoptions.pdf>

## **WATER QUALITY**

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### **Strategy #1: Minimize disturbance to water bodies and wetlands**

Massachusetts Forestry Best Management Practices Manual (2013) Catanzaro, P., J. Fish, D. Kittredge., MA Department of Conservation and Recreation Service, Forestry Program,

<https://masswoods.net/sites/masswoods.net/files/pdf-doc-ppt/MA-Forestry-BMP-Manual.pdf>

### **Best Management Practices for Forestry: Protecting Maine's Water Quality (2004)**

Maine Department of Conservation, Maine Forest Service, Augusta, ME

[http://www.maine.gov/dacf/mfs/publications/handbooks\\_guides/bmp\\_manual/bmp\\_manual.pdf](http://www.maine.gov/dacf/mfs/publications/handbooks_guides/bmp_manual/bmp_manual.pdf)

Best Management Practices for Forestry: Protecting New Hampshire's Water Quality (2005)

University of New Hampshire Cooperative Extension,

[https://extension.unh.edu/resources/files/Resource000248\\_Rep267.pdf](https://extension.unh.edu/resources/files/Resource000248_Rep267.pdf)

### **Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont (2009)**

Vermont Department of Forests, Parks, and Recreation, Waterbury, VT

<http://www.vtfrp.org/watershed/documents/Amp2009pdf.pdf>

### **New York State Forestry Best Management Plans for Water Quality (2007)**

New York State Forestry, Albany, NY

<http://www2.dnr.cornell.edu/ext/info/pubs/Harvesting/BMP%20Field%20Guide.pdf>

### **Silvicultural Activities and Wetlands (2014)**

Department of Environmental Conservation, Watershed Management Division, Vermont Wetlands Program, Montpelier, VT

[http://www.watershedmanagement.vt.gov/wetlands/docs/2014\\_Silviculture\\_Guidance.pdf](http://www.watershedmanagement.vt.gov/wetlands/docs/2014_Silviculture_Guidance.pdf)

## Strategy #2: Maintain watershed health

### Water, Climate Change and Forests (2010)

Furniss, M.J.; B.P. Staab, S. Hazelhurst, C. Clifton, F. Cathrine, K.B. Roby, B.L. Ilhadrt, E.B. Larry, A.H. Todd, L.M. Reid, S.J. Hines, K.A. Bennett, C.H. Luce, P.J. Edwards. General Technical Report, PNW-GTR-812. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 75 p

[http://www.fs.fed.us/pnw/pubs/pnw\\_gtr812.pdf](http://www.fs.fed.us/pnw/pubs/pnw_gtr812.pdf)

### i-tree Hydro

A free program, developed by the US Forest Service, that models water flow and changes in water quality based on the amount of tree cover and impervious service within a watershed.

<http://www.itreetools.org/hydro/>

## RECREATION

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### Strategy #1: Create a low-impact recreational trail system

#### Lightly on the Land: The SCA Trail Building and Maintenance Manual (2006)

Birkby, B. and The Student Conservation Association, 2nd Edition, Mountaineers Books, 304 pp.

<http://www.mountaineersbooks.org/Lightly-on-the-Land-P286.aspx>

#### Best Maintenance Practices: Maine Motorized Trail Construction and Maintenance Manual (2011)

Maine Department of Conservation, Bureau of Parks & Lands, Off-Road Vehicle Division, Augusta, ME

[http://www.maine.gov/dacf/parks/trail\\_activities/atv/docs/motorized-trailBMP-handbook.pdf](http://www.maine.gov/dacf/parks/trail_activities/atv/docs/motorized-trailBMP-handbook.pdf)

#### Trail Solutions: IMBA's Guide to building Sweet Single Track (2004)

International Mountain Bicycling Association, Boulder, CO, 272 pp.

<https://www.imba.com/catalog/book-trail-solutions>

### Strategy 2: Monitor and repair trails after large storms

#### A Recreation Trail Scorecard for evaluating trails in northern New England (2009)

Wilkerson, E. and A. Whitman, Natural Capital Science Note, Manomet Center for Conservation Sciences, Brunswick, ME

Protocol

[https://www.manomet.org/sites/default/files/publications\\_and\\_tools/trailassessment\\_ncnote12.2009.pdf](https://www.manomet.org/sites/default/files/publications_and_tools/trailassessment_ncnote12.2009.pdf)

User guide

[https://www.manomet.org/sites/default/files/publications\\_and\\_tools/trailassessmentprotocol\\_userguide12.2009.pdf](https://www.manomet.org/sites/default/files/publications_and_tools/trailassessmentprotocol_userguide12.2009.pdf)

### Strategy #3: Encourage deer management

#### Impacts of white-tailed deer overabundance in forest ecosystems: An overview. (2008)

Rawinski, T.J. Northeastern Area State and Private Forestry, Forest Service, U.S. Department of Agriculture

[http://www.na.fs.fed.us/fhp/special\\_interests/white\\_tailed\\_deer.pdf](http://www.na.fs.fed.us/fhp/special_interests/white_tailed_deer.pdf)

#### White-trailed Deer in Northeastern Forests: Understanding and Assessing Impacts (2014)

Rawinski, T.J. 2014. US Forest Service, Northeastern Area State and Private Forestry, Newtown Square, PA.

<http://www.town.east-hampton.ny.us/DocumentsPDF/DeerManagement/UnderstandingDeerImpacts.pdf>

## MAINTAIN OR INCREASE CARBON STORAGE

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### Strategy #1: Grow and retain trees on site

#### Climate Change, Carbon, and the Forests of the Northeast (2007)

Perschel, R.T., A.M. Evans and M.J. Summers. Forest Guild, Santa Fe, NM

[http://www.forestguild.org/publications/research/2007/ForestGuild\\_climate\\_carbon\\_forests.pdf](http://www.forestguild.org/publications/research/2007/ForestGuild_climate_carbon_forests.pdf)

#### The Role of Forests in Carbon Cycles, Sequestration, and Storage (2003)

Percy, K.E., R. Jandl, J.P. Hall, and M. Lavigne. The Global Network for Forest Science Cooperation, Newsletter No.1

<http://iufro.boku.ac.at/iufro/taskforce/hptfcs.htm>

### Strategy #2: Minimize stand damage when harvesting timber

#### Forest Biomass Retention and Harvesting Guidelines for the Northeast (2010)

Forest Guild Biomass Working Group, Forest Guild, Santa Fe, NM.

[http://www.forestguild.org/publications/research/2010/FG\\_Biomass\\_Guidelines\\_NE.pdf](http://www.forestguild.org/publications/research/2010/FG_Biomass_Guidelines_NE.pdf)

### Strategy #3. Utilize trees in products that reduce greenhouse gas emissions

## **Managing Forests because Carbon Matters: Integrating Energy, Products, and Land Management Policy (2011).**

Malmshheimer, R.W., J.L. Bowyer, J.S. Fried, E. Gee, R.L. Izlar, R.A. Miner, I.A. Munn, E. Oneil, and W.C. Stewart. *Journal of Forestry*: 109(7S):S7–S50.

<http://www.safnet.org/documents/JOFSupplement.pdf>

## **HUMAN HEALTH AND SAFETY**

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### **Strategy #1: Manage wildfire risk appropriately**

#### **Firewise Communities**

NFPA's Wildland Fire Operations Division and Firewise Communities Program, Quincy, MA

[www.firewise.org](http://www.firewise.org)

### **Strategy #2: Maintain safe trails**

#### **How to Recognize and Reduce Tree Hazards in Recreation Sites (1986)**

Robbins, K. United States Department of Agriculture, Forest Service, Northeastern Area, NA-FR-31

<http://na.fs.fed.us/spfo/pubs/hazardtrees/recreation/index.htm>

#### **How to Recognize Hazardous Defects in Trees (2012)**

Albers, J., Bedker, P., MacKenzie, M., O'Brien, J., Pokorny, J., USDA, United States Forest Service, Northeastern Area, State and Private Forestry, NA-FR-01-96

[http://www.na.fs.fed.us/spfo/pubs/howtos/ht\\_haz/ht\\_haz\\_low\\_res.pdf](http://www.na.fs.fed.us/spfo/pubs/howtos/ht_haz/ht_haz_low_res.pdf)

#### **Lyme disease: What you need to know.**

US Department of Health and Human Services, Centers for Disease Control and Prevention, Publication: CS226008-A, Fort Collins, CO

<http://www.cdc.gov/lyme/resources/brochure/lymediseasebrochure.pdf>

#### **Ticks and Lyme Disease: How to prevent tick bites when hiking or camping**

US Department of Health and Human Services, Centers for Disease Control and Prevention, Publication: CS232422, Fort Collins, CO

[http://www.cdc.gov/lyme/resources/toolkit/factsheets/10\\_508\\_Lyme%20disease\\_HikersCampers\\_FACTSheet.pdf](http://www.cdc.gov/lyme/resources/toolkit/factsheets/10_508_Lyme%20disease_HikersCampers_FACTSheet.pdf)

## **Step 4: Monitor and Adjust**

### **Strategy 1: Have simple and effective ways to monitor forest health**

## **I-Tree Tools**

I-tree is a suite of free tools developed by the US Forest Service to help map forest resources and monitor changes over time. There are a variety of tools that can measure canopy cover, track changes over time, and model potential future scenarios.

<https://www.itreetools.org/>

## **A Climate Change Adaptation Monitoring Plan and Application for Private Landowners and Land Trusts: A case study at the Allen-Whitney Forest (2014)**

Whitman, A., E. Wilkerson, and S. Balch, Manomet Center for Conservation Sciences, Brunswick, ME

Monitoring programs are typically designed for conducting scientific research making the level of effort required to collect the data beyond the capacity of most land trusts and small landowners. Programs designed for volunteer monitors can be adapted for use by local land trusts.

## **Appalachian Trail Conservancy Invasive Species Monitoring Program Monitoring Guide**

<http://www.appalachiantrail.org/docs/default-document-library/atc-invasive-exotic-plant-monitoring-datasheet-guide.doc>

## **Data Sheet**

<http://www.appalachiantrail.org/docs/default-document-library/atc-invasive-exotic-plant-monitoring-datasheet.doc>

## **Invasive Plant Atlas of New England (IPANE)**

Training materials and forms are available on the IPANE website: [http://www.eddmaps.org/ipane/volunteers/training\\_materials/training.htm](http://www.eddmaps.org/ipane/volunteers/training_materials/training.htm)

## **Strategy 2: Have an efficient monitoring system for infrastructure**

## **A Recreation Trail Scorecard for evaluating trails in northern New England (2009)**

Wilkerson, E. and A. Whitman, Natural Capital Science Note, Manomet Center for Conservation Sciences, Brunswick, ME

### **Protocol**

[https://www.manomet.org/sites/default/files/publications\\_and\\_tools/trailassessment\\_ncnote12.2009.pdf](https://www.manomet.org/sites/default/files/publications_and_tools/trailassessment_ncnote12.2009.pdf)

### **User guide**

[https://www.manomet.org/sites/default/files/publications\\_and\\_tools/trailassessmentprotocol\\_userguide12.2009.pdf](https://www.manomet.org/sites/default/files/publications_and_tools/trailassessmentprotocol_userguide12.2009.pdf)

## **Maine Stream Crossing Manual (2012)**

Abbot, A. Gulf of Maine Coastal Program, U.S. Fish and Wildlife Service, Falmouth ME

[http://www.fws.gov/northeast/mainefisheries/pdf/MaineStreamCrossingSurveyManual\\_2012.pdf](http://www.fws.gov/northeast/mainefisheries/pdf/MaineStreamCrossingSurveyManual_2012.pdf)

## **Best Management Practice (BMP) Manual –Field Guide: Monitoring, Implementation, and Effectiveness for Protection of Water Resources (2007)**

Welsch D., R. Ryder R., T. Post : U.S. Department of Agriculture, Forest Service, NA-FR-02-06, 129 pp.

[http://na.fs.fed.us/pubs/misc/bmp/06/bmp\\_field\\_guide\\_lr.pdf](http://na.fs.fed.us/pubs/misc/bmp/06/bmp_field_guide_lr.pdf)

## **Strategy 3: Periodically incorporate the results of your monitoring and adjust management strategies to respond to existing and emerging threats**

### **Adaptive Management for Land Trusts**

Land Trust Alliance, Washington, D.C.

<http://www.landtrustalliance.org/climate-change-toolkit/plan/uncertainty/adaptive-management>

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