# The changing North Woods and moose

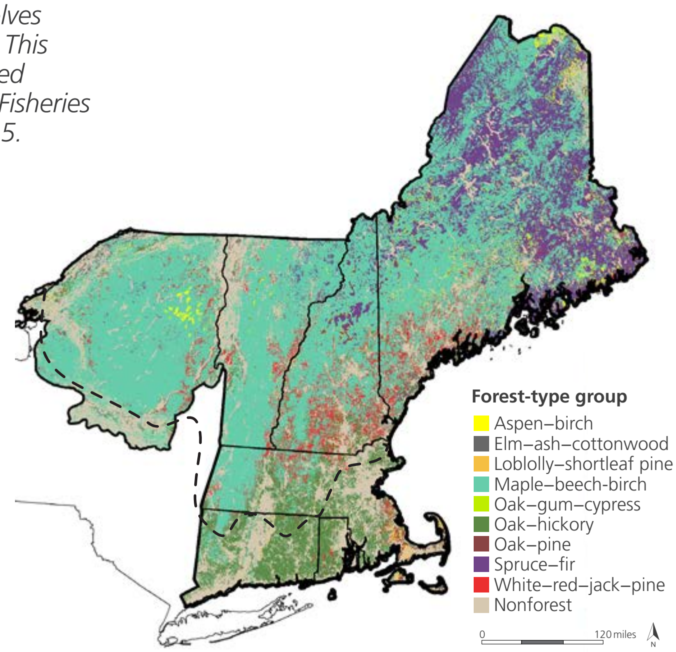
## Scenario planning to inform land and wildlife management

Science Synthesis Workshop
Westborough, MA
February 4-5, 2015

*A scenario planning exercise focused on climate change, land use, and moose in the Northeast U.S. is being undertaken by the Wildlife Conservation Society, North Atlantic Landscape Conservation Cooperative, Northeast Climate Science Center (U.S. Geological Survey), and the University of Maryland Center for Environmental Science. Phase 1 of the scenario planning process involves the identification of key features and drivers within the focus system. This newsletter summarizes the scientific state of knowledge and associated uncertainties from a workshop held at the Massachusetts Division of Fisheries and Wildlife headquarters in Westborough, MA on 4–5 February 2015.*

### Setting the stage: moose and land use in the North Woods

The North Woods stretch across the Northeastern U.S. and include portions of New York, New Hampshire, Vermont, Maine, Massachusetts, Connecticut, and Rhode Island. These forests include conifers (e.g., spruce, white pine, hemlock, balsam fir) and hardwoods (e.g., maple, beech, birch) and are largely privately owned. Moose populations occur throughout much of the North Woods, with the highest densities associated with industrial forest lands (3–4 individuals per square kilometer), and lower densities (≤1 individuals per square kilometer) where development and forest type make habitat less suitable. Industrial forestry occurs in portions of the forest (ME, northern NH and VT), and forest regeneration associated with extensive harvesting, particularly following the spruce budworm outbreak of the 1970s–80s, has stimulated a resurgence of moose populations in these areas.

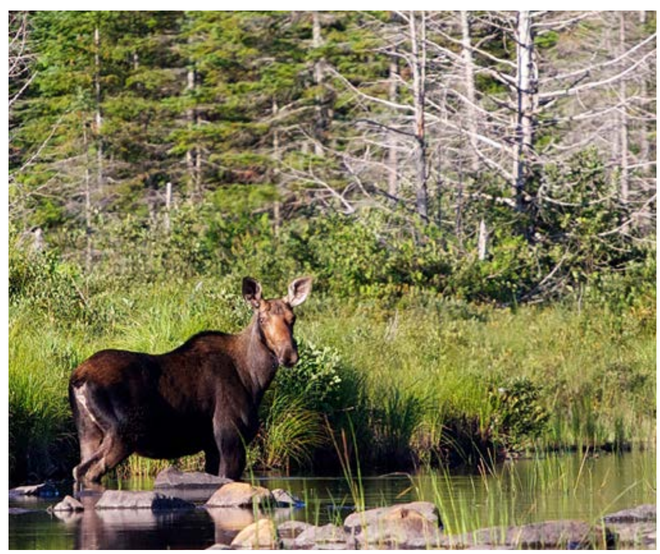



*Forest type in the North Woods is dominated by maple–beech–birch communities. Dotted black line represents southern edge of moose range. Source: USDA Forest Service FIA Program, Janowiak et al. (in prep), http://forestadaptation.org/new-england, Wattles and Destefano, 2011.*

### Moose in the North Woods of the United States

Moose are mobile, adaptable generalists. They prefer to forage on early successional forests, wetland plants, and winter conifer trees. Fat accumulation helps moose overwinter when low forage quality cannot meet their daily energy demands and they slowly loose weight. Moose seek out forested wetlands and mature forest stands to cope with elevated temperatures, and they develop thick winter coats to cope with cold winter weather. In the North Woods, black bears and coyotes may prey on calf moose during the first weeks of life. Hunting pressure is related to state regulations and landowner values.

Moose population increases have been attributed to changes in forestry practices (e.g., industrial forestry in ME) and increases in beaver populations that dam streams and subsequently convert closed canopy forests into marshy wetlands with young vegetation. Pests and parasites, including winter tick, brainworm and liver fluke are an increasingly critical issue for moose and can result in stress and death. Winter tick is related to moose density and snow cover in the fall, winter, and spring, and causes mortality through anemia, especially in the young. Moose brainworm are carried by white–tailed deer and lead to neurological damage and behavioral shifts. Less threatening is liver fluke, which is also associated with deer and linked to terrestrial snail density.



Mike Hoff, Flickr

*Within the North Woods of the eastern United States, moose populations are found in the states of New York, New Hampshire, Vermont, Maine, and Massachusetts.*

## Changing climate in the North Woods

The climate change projections for the North Woods include shorter, warmer winters, and drier summers punctuated by intense rainfall events. These changes will also result in a lengthening growing season and reduced snow cover. Increased inter-annual climate variability across seasons is a likely outcome of future conditions. There is a high degree of confidence that temperatures will increase, but projections about precipitation are more uncertain. Even less certain are projections about destructive wind storms and hurricanes, but greater frequency is suggested.

## Changing climate in the North Woods: impacts on moose

The implications of climate change in the North Woods are profound, with a variety of direct and indirect effects on a) forest and wetland habitats, and b) moose and their pests and parasites. Important to moose is the relative proportion and availability of habitat types that provide forage (browse) and cover for cooling (thermoregulation), and escaping deep snow at different times of the year. Questions about how climate change might affect the forest through insect outbreaks and wind damage, forest management responses and shifts in tree species distributions after disturbances are foremost. While these disturbances have the potential to enhance the availability of regeneration for browse, its distribution through space and time are uncertain. Greater frequency of heavy winter tick infestations are also a major concern. Warmer falls, extending the season for ticks to attach to moose; mild winters, enhancing the feeding ticks' chances of survival; and reduced spring snow cover, improving the survival of engorged females when they drop off moose, all exacerbate the impact of winter tick. Warming temperatures also have the potential to support the expansion of white-tailed deer, the primary host of brainworm, farther into the range of moose.

| Parameter | Change by 2100 | Confidence |
|---|---|---|
| Temperature | ↑5–8 ˚F (greatest in winter) | High |
| Precipitation | ↑10–14% (winter)<br>↓0–4% (summer) | Low |
| Snowfall | ↓8–10 days in Dec, Jan, Feb with snow cover (shift to rain) | Medium |
| Extreme temperatures | ↑10–15 days > 90 ˚F (by 2050) | High |
| Extreme precipitation | ↑5–25% more intense | Medium |
| Growing season length | ↑25–29 days longer (by 2050) | Low |

*Summary of projected changes for the North Woods of the Northeastern United States by 2100. Source: Alex Bryan, Northeast Climate Science Center.*


*Heavy infestation of winter ticks typically leads to severe hair loss and malnutrition in late winter, and may ultimately cause acute anemia and death of moose calves in late March–April.*

**Climate change drivers influencing moose populations in the North Woods of the Eastern United States**


**Snow cover** Winter ticks have higher survival rates when snow cover is reduced. Shorter spring retention of snow due to climate change results in more winter ticks and can lead to higher tick infestation rates on moose.

**Winter variability** Changes in snow depth, snow hardness and freezing rain due to climate change can influence moose feeding behavior and mobility, as well as susceptibility to predation.

**Winter severity** Wooly hemlock adelgid and spruce budworms have higher survival rates in shorter, milder winters due to climate change. As a forest disturbance agent, these pests have the potential to increase the availablity of hardwood forage but conifers are their primary hosts, with an overall impact of reducing forest types important for thermoregulation and winter browse.

**Cumulative heat stress** Successive days of higher than normal temperatures, particularly in spring, summer and fall, due to climate change can directly influence the condition of moose by shifting the amount of time spent foraging to a greater amount of time spent cooling in forest types without suitable browse. Moose in poor body condition may not be able to feed enough to build up fat reserves to survive overwintering.

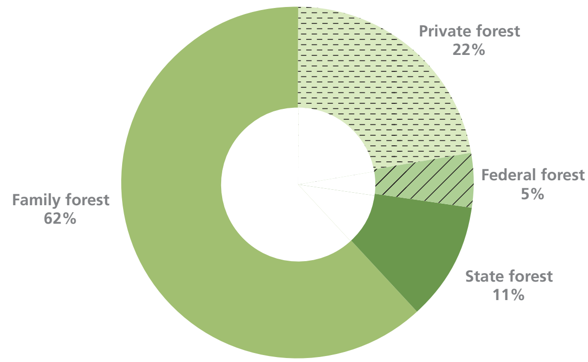
**Extreme weather events** The destruction of forest canopies due to high wind and/or intense rainfall events due to climate change can lead to patches of forest regeneration. Regenerating forests provide excellent food sources for moose.

## Changing forests in the North Woods

The mixed forests of the North Woods will be affected by climate change through changes in temperature, precipitation including snowfall/icing, intense weather events and infection rates of pests. Of equal or, maybe, greater importance is that much of the forest in the North Woods is in private land ownership, small family woodlots, and commercial timberlands. The forests of the North Woods are a mosaic of young, middle-aged, and mature forest stands with differing structure. Historical clear-cut timber harvest practices have given way to partial-cut harvesting, which in some areas is shifting the age-structure away from early successional forest ideal for moose browse.

Across the region, changes in forestry practices and the associated transportation infrastructure will affect both the forests and moose populations. Future land use patterns in the North Woods will be influenced by timber markets, carbon credits, and development pressure. Changes in land protection through the establishment of additional working forest conservation easements, protected areas and ecotourism could have large implications.

**Average distribution of forest ownerships across the New England States**




**Total area: 40.2 million forested acres**

*Forest ownership in the Northeastern United States is dominated by private land ownership, including industrial and non-industrial privately and family owned forests. Adapted from Shifley, S.R. et al. 2012.*

## Pulling it together: how will a changing climate and forest impact moose populations of the North Woods?

Following a thorough discussion of the drivers impacting moose populations within the North Woods, several small groups used the 2x2 matrix approach to explore the scenario development process by experimenting with preliminary scenario framings. For this initial effort, participants chose two drivers of moose populations for the quadrant axes—temperature increase and forest complexity, in the example shown here. The different groups worked together to create four divergent scenarios of future conditions, to begin considering the implications for moose in the North Woods within each of the quadrants.

Bill Dennison, UMCES

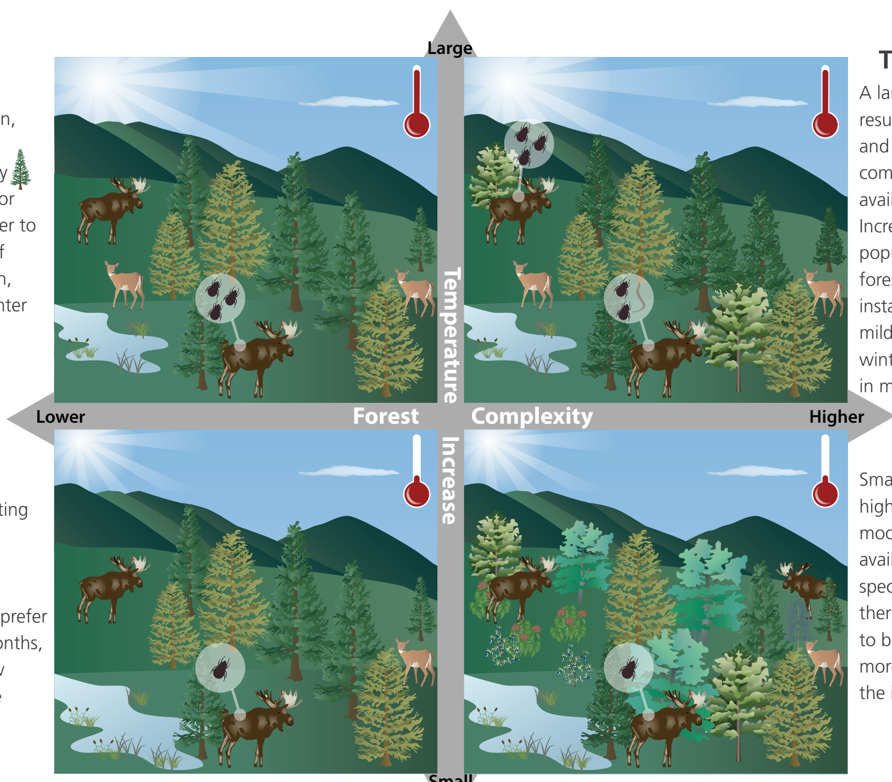
*Workshop participants work together to construct scenarios using the matrix approach at the February science synthesis workshop.*

### Bye bye moose

A large temperature increase results in a longer growing season, with increased forage vegetation available. Lower forest complexity decreases forest types available for moose populations seeking shelter to thermoregulate during periods of warmer temperatures. In addition, temperature increases during winter months allow for winter tick populations to remain active and impact moose health.

### Tick, tick, tick...boom

A large temperature increase results in a longer growing season, and when coupled with high forest complexity, allows for high availability of forage vegetation. Increases in white–tailed deer populations may occur with high forest complexity, leading larger instances of brainworms. Shorter, milder, winters allow for abundant winter tick populations, resulting in moose decline.




### Slow and steady

Smaller temperature increases favor moose populations by limiting winter tick and brainworm populations. Lower forest complexity may decrease the availability of browse, as moose prefer deciduous foliage in summer months, and if mobility is limited by snow depth during winter, may forage heavily on balsam fir for extended periods.

### Moose nirvana

Small temperature increases ,and high forest complexity favor moose populations. Higher availability of regenerating forest species for forage, and reduced thermoregulatory costs allow moose to be in better condition, develop more body fat, and better cope with the impact of high winter tick loads.

*A conceptual diagram depicting scenarios created during the science synthesis workshop using the quadrant approach. These four divergent scenarios detail potential changes in forest complexity and temperature increase, and how these factors may influence moose populations in the North Woods.*

## A vision for Phase II: Building and refining scenarios

Phase II of the scenario planning process aims to construct and refine scenarios of future change in the Northern Woods by seeking out and embracing uncertainties about the future. Building on momentum from the science synthesis workshop, next steps will work to expand/broaden the group to refine key drivers and variables of interest influencing moose populations in the North Woods, for developing scenario outlines and narratives, and evaluating the internal consistency and relevance.

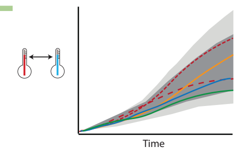
A webinar providing a more detailed summary of the outputs of the science synthesis will be scheduled in the next month. Moving into the spring, we hope to capitalize on both the NEAFWA meeting in Newport, RI on April 19–21 and the Northeast Moose Group meeting in Maine (May/June) by engaging moose managers to further develop, evaluate, and possibly start applying scenarios to moose and habitat management decisions. Additional meetings and/or conference calls may be scheduled throughout the spring and summer of 2015, depending on needs and progress made.

*Scenario planning is a comprehensive exercise that involves the development of scenarios that capture a range of plausible future conditions. The basic steps to the scenario planning can be broken down into the three phases as described.*

### Phase 1 Process and scoping

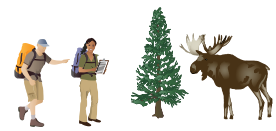
Assemble experts and stakeholders to define project outcomes, identify key drivers within the system, and develop a planning timeline.

### Phase 2 Building and refining scenarios



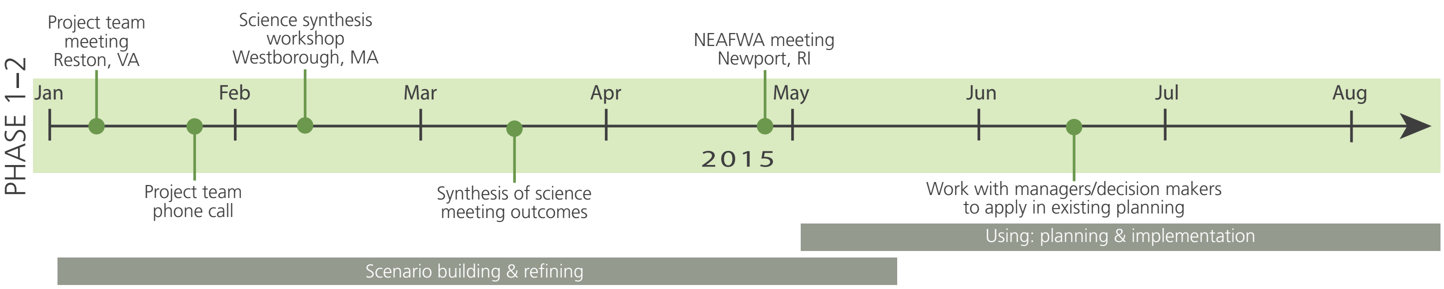

Identify, assess, and prioritize critical drivers within the system and explore, and evaluate scenarios.

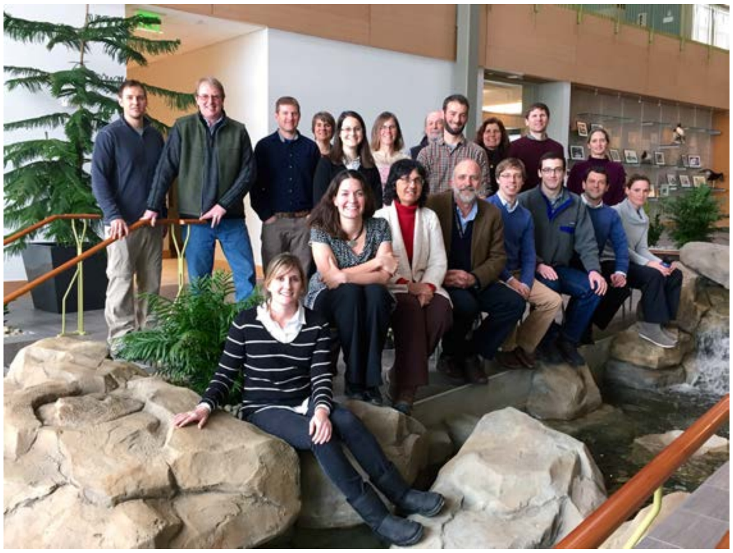
### Phase 3 Using scenarios



Evaluate potential implications of each scenario and identify and lay out action options to take now and under future conditions. Design monitoring and research to track changes and measure effectiveness.

## Project timeline



*Workshop participants at the science synthesis meeting in Westborough, Massachusetts.*

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**Cover image:** Nate Hughes, Flickr

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