Issue of Concern: Insect pests and forest diseases

Forest insect pests and pathogens are expected to increase in occurrence and inflict more damage within Northeastern forests as the climate continues to change. This increase will contribute to tree stress and mortality, difficult management scenarios for landowners and managers, and potentially dangerous recreation conditions. A variety of forest adaptation practices may be able to prevent or ameliorate the negative effects of this increase in forest pests and pathogens.

Climate Change Impacts

Insect and disease outbreaks have long influenced vegetation within Northeastern forests; prior to European settlement, native species including the spruce budworm and forest tent caterpillar periodically led to extensive defoliation. These species continue to impact forests in the Northeast, however, insect and disease outbreaks have recently occurred at an increasing frequency with the introduction and establishment of nonnative insects and disease agents. Forest pests and pathogens are generally expected to become more damaging as the climate changes, because they are able to adapt more rapidly to new climatic conditions, migrate more quickly to suitable habitat, and reproduce at faster rates than host tree species (Ryan and Vose 2012, Weed et al. 2013).

Some of the non-native insect pests of greatest concern within Northeastern forests include the *Lymantria dispar* (gypsy moth), the hemlock woolly-adelgid, the emerald ash borer, the Asian-longhorned beetle, and the southern pine-beetle. Outbreaks of the nonnative gypsy moth have caused mortality in oak forests across the Northeast since the early 1900s. Recent research has demonstrated that gypsy moth defoliation is contributing to oak mortality across nearly all diameter classes, with mortalities being highest among younger, smaller trees (Morin & Liebhold 2015). The range of the hemlock woolly adelgid is generally limited by cold winter temperatures with mortality occurring at temperatures below –20 °F (–29 °C), however, less severe winters may increase hemlock woolly adelgid survival and spread (Dukes et al. 2009, Paradis et al. 2008, Trotter & Talbot 2013). The emerald ash borer has expanded its range within Northeastern forests, but the impacts of climate change on emerald ash borer populations are uncertain and dependent on several dynamics. Extreme variations in temperature have been demonstrated to limit its fecundity and survival, but may also hinder our ability to control populations through introduction of parasitoids (Wetherington et al. 2017). Southern pine beetle has also been detected in Connecticut, Massachusetts, and Rhode Island (Dodds et al. 2018), and winter temperatures by 2040 are expected to be warm enough to allow the beetle species to exist across the entire northeastern United States (Lesk et al. 2017).

Research on the relationship between forest pests and diseases and climate change highlights the potential for increased tree stress and mortality due to interactions involving other stressors such as extreme heat and drought (Sturrock et al. 2011, Trotter & Talbot 2013, Weed et al. 2013). For instance, the already widespread fungal pathogen, Armillaria, could expand further or become more aggressive due to a longer active season, enhanced colonization under warmer and drier conditions, and increased stress on host trees (Dukes et al. 2009, Kliejunas 2011, Sturrock et al. 2011).

Within oak forests, insect pests such as gypsy moth, southern pine beetle, and winter moth are expected to cause more frequent and severe damage under climate change, and new pests present unknown risks:

- **Southern pine beetle (*Dendroctonus frontalis*):** Expansion of southern pine beetle populations into the Northeast has also been detected and is expected to increase (Lesk et al. 2017, Dodds et al. 2018). Climates suitable for southern pine beetle are predicted to reach 71% of the red pine (*Pinus resinosa*) and 48% of jack pine (*P. banksiana*) forest ranges that extend across more than 706,000 km^2 in the northeastern United States and northwards (Heuss et al. 2019).
- **Gypsy moth (*Lymantria dispar dispar*):** Defoliation due to gypsy moth may hinder oak regeneration by leading to increased mortality in young, small diameter oaks (Morin & Liebhold 2015).
- **Winter moth (*Operophtera brumata*):** Expansion of winter moth outbreaks (which have thus far been temperature limited) is expected as average winter temperatures increase and as hybridization with the bruce spanworm improves the winter moth's cold tolerance (Havill et al. 2016, Brinkman 2017, Andersen et al. 2019).

Adaptation Actions for Forests

Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Site Condition	Adaptation Approaches	Example Adaptation Actions
Active insect pest or disease outbreak	• Reduce the impact of biological stressors • Realign significantly disrupted ecosystems to meet expected future conditions	• Use pesticides or biological control methods to manage pest populations (e.g., gypsy moth, Asian longhorned beetle, or hemlock woolly adelgid) in heavily infested areas • Allow a transition in forest type by planting future-adapted species within a stand that is already declining or is expected to decline
Anticipated or nearby insect pest or disease outbreak	• Maintain or improve the ability of forests to resist pests and pathogens	• Restrict harvest and transportation of logs near stands already heavily infested with known pests or pathogens • Thin to reduce the density of a pest's host species in order to discourage

		infestation, based on the knowledge that species are especially susceptible to pests and pathogens at particular stocking levels ● Adjust rotation length to decrease the period of time that a stand is vulnerable to insect pests and pathogens, based on the knowledge that species are especially susceptible to pests and pathogens at particular ages
Low levels of diversity increase risk from pests and pathogens	● Maintain or improve the ability of forests to resist pests and pathogens ● Promptly revegetate sites after disturbance	● Create a diverse mix of forest or community types, age classes, and stand structures to reduce the availability of host species for pests and pathogens ● Maintain a variety of age classes of a given forest type across a larger landscape ● Plant species expected to be adapted to future conditions and resistant to insect pests or present pathogens

Adaptation Actions for Recreation

Additional actions are described in the [Adaptation Strategies and Approaches for Recreation].

Site Condition	Adaptation Approaches	Possible Adaptation Actions
Active or recent insect pest or disease outbreak	● Improve awareness of climate-exacerbated risks to public safety	● Identify hazard trees and initiate their removal

On-the-Ground Examples

- South Central Connecticut Regional Water Authority: Maltby Lakes Southern Pine Beetle Response
    - Managers conducted a clearcut in this forested watershed in response to a southern pine beetle infestation that threatened to expand northward into other forests. Silvicultural techniques and supplemental planting were used to support the establishment of future-adapted tree species.

- Saint Regis Mohawk Tribe: Forest Stand Improvements in Ash
  - In response to the threat of an emerald ash borer infestation 1.5 miles from this forested area, The Saint Regis Mohawk Tribe conducted stand improvement cuts on 500 acres to reduce the density of ash to 20% and increase overall species diversity.

Potential Monitoring Items

- Evidence of pest and disease outbreaks
- Survey of actively infected trees
- Tree mortality
- Aerial survey of forest damage

Additional Resources

- The Early Detection & Distribution Mapping System (EDDMaps) is an innovative web-based mapping tool which can be used to document the distribution of invasive species across the United States and help
identify leading edges of new infestations.

- The Northeastern Forest Health Atlas (NEFHA) hosted by the Forest Ecosystem Monitoring Cooperative. The NEFHA interface provides maps of forest damage collected from aerial surveys, as well as links to regional forest health research projects. NEFHA users can filter by damage agent, damage type, state, and year, as well as view graphs and tables.