Effects of forest biomass energy production on northern forest wildlife and forest sustainability

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- The annual probability of harvest can be described as a function of of forest type/region, basal area, and distance to the nearest improved road.
- Northern forests are predicted to increase in adult aboveground biomass in all intensified harvest regime scenarios. Forest biomass can represent a viable component of renewable energy policy in the Northeast, however, tradeoffs must be considered.

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Project Summary

Federal and state governments in the Northeast U.S. are actively engaged in assessing the potential role of forest biomass in meeting renewable energy goals. While current rates of timber harvest are generally sustainable, there is considerable pressure to increase the contribution of forest biomass for renewable energy. We estimated current harvest regimes for different forest types and regions across New York, Vermont, New Hampshire, and Maine using data from the Forest Inventory and Analysis Program. We implemented the harvest regimes in SORTIE-ND, an individual tree-based forest stand model, and simulated the effects of current harvest regimes and five additional harvest scenarios that varied by harvest frequency and intensity for 150 years. Forests were predicted to increase in adult aboveground biomass in all harvest scenarios in all forest type and region combinations, however, the magnitude of the growth varied dramatically (ranging between 3% and 120%). The variation in biomass growth can be largely explained by the disproportionately high harvest rates estimated for Maine as compared with the rest of the region. Despite steady biomass accumulation across the landscape, stands that exhibited older growth characteristics (defined as >=300 metric tons of biomass/hectare) were rare (8% or less of stands). Intensified harvest regimes had little effect on species composition, due to a predominance of partial harvesting that contributed to the prevalence of later successional species over time. Forest biomass can represent a viable component of renewable energy policy in the Northeast, however, tradeoffs between biomass stock and supply must be considered.

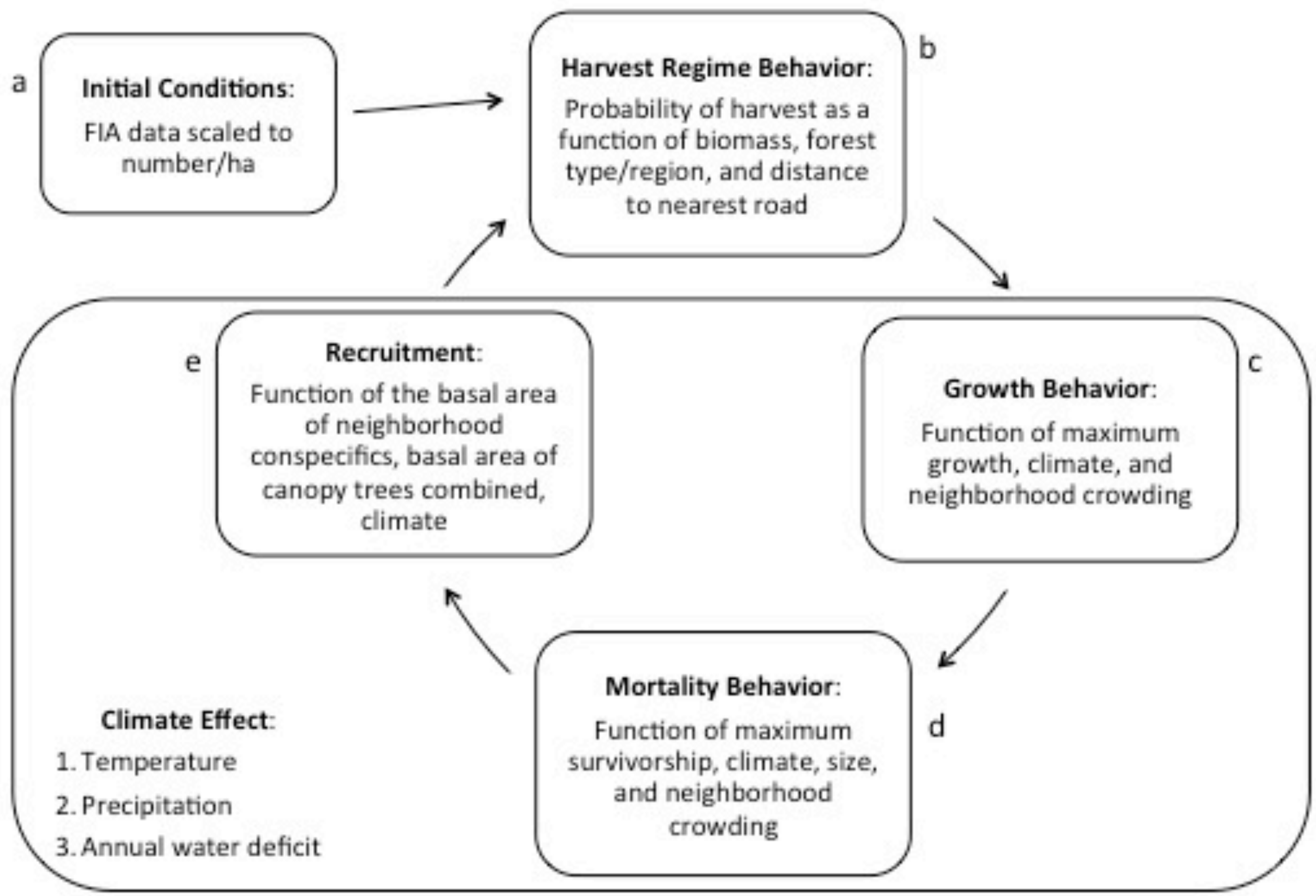
Background and Justification

- Harvesting is the number one source of tree mortality in forests of the northeastern United States.
- Recent calls for increasing the use of forest biomass as a feedstock for a renewable energy industry underscore the importance of examining the effects of intensifying rates of harvest on landscape-scale forest structure and composition.
- Many states are setting progressive renewable energy goals to increase energy independence and reduce carbon emissions.
- How would intensification of harvest affect biomass feedstock supply? Key issues include understanding the current harvest regime of the Northeast, the effect of such timber removals on forest structure and composition, and the long-term (e.g., 150 years) implications of increased harvest.

Methods

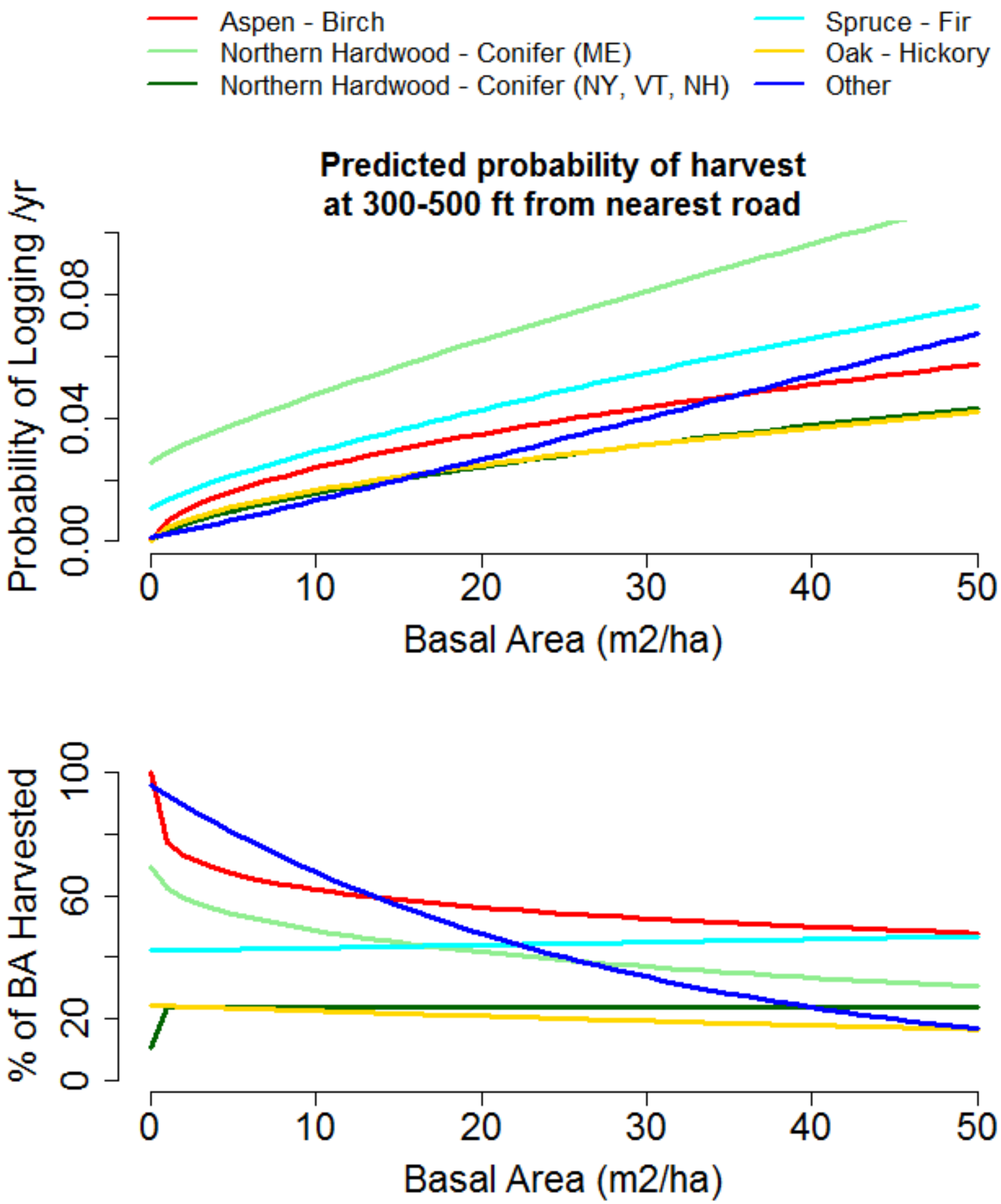
- The study area included all forest land in the states of New York, Vermont, New Hampshire, and Maine. The four-state landscape is approximately 71% forest land.
- We estimated current harvest regimes for different forest types and regions across New York, Vermont, New Hampshire, and Maine using data from the Forest Inventory and Analysis Program.
- We implemented the harvest regimes in SORTIE-ND, an individual tree-based forest stand model.
- We simulated the effects of current harvest regimes and five additional harvest scenarios that varied by harvest frequency and intensity for 150 years.
- The six harvest scenarios are: 1) current harvest regime, 2) current harvest regime plus a modest climate effect, 3) 50% increase in current harvest intensity, 4) 75% increase in the frequency of the current harvest regime, 5) 50% increase in current harvest intensity and 100% increase in current harvest frequency, 6) no harvest.

Methods



Simplification of the SORTIE-ND forest simulation model used to implement the six harvest regime scenarios.

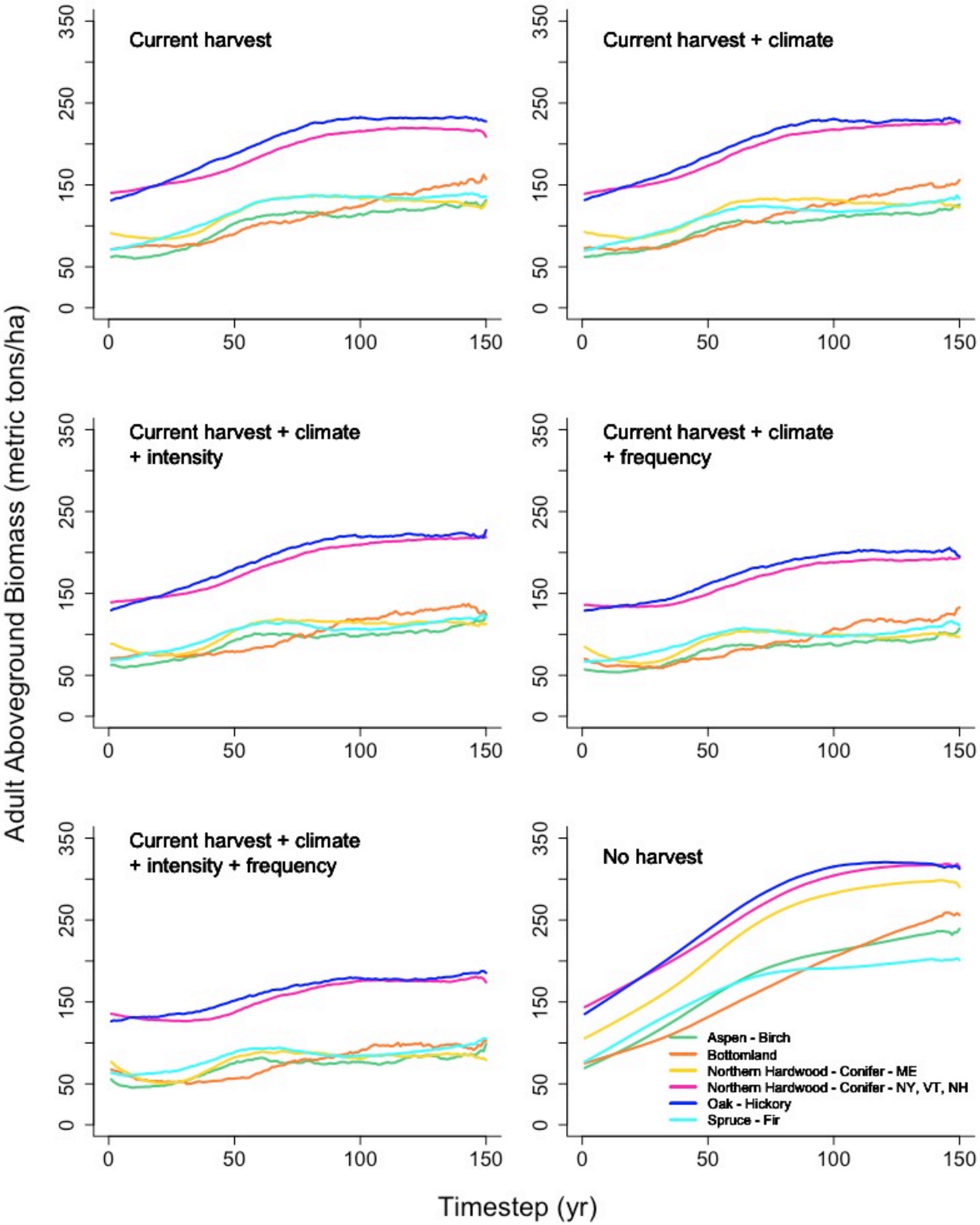
Results/Project outcomes



- The best statistical model for the harvest regime, defined by the lowest AIC value, described the annual probability of harvest as a function of forest type/region, total plot basal area, and distance to the nearest improved road.

(Left) Predicted frequency and intensity of logging as a function of total stand basal area, by forest type/region, shown at 300 – 500 feet from the nearest road.

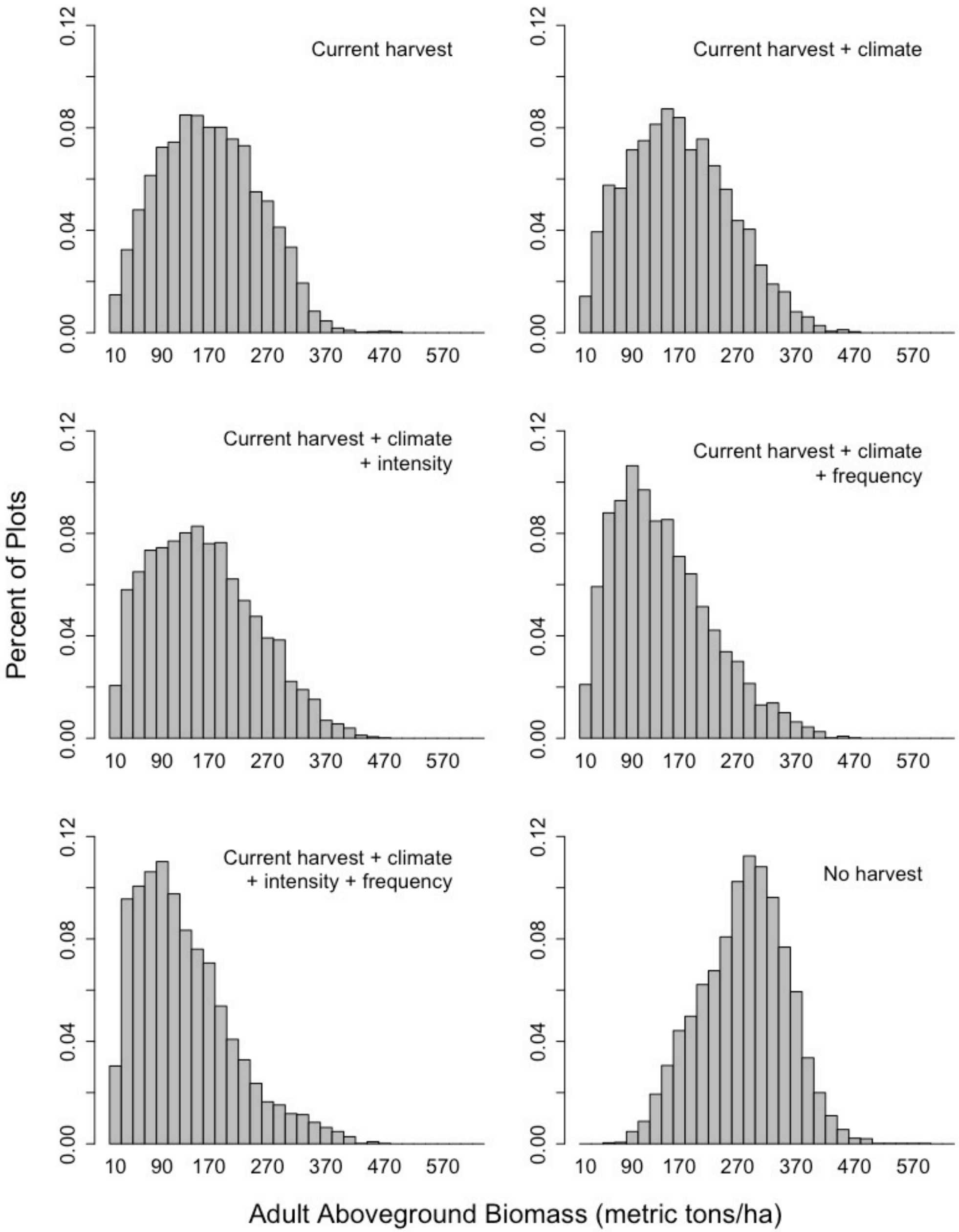
Results/Project outcomes



- All forest types/regions increased in biomass in all scenarios, but they differed in the total amount of biomass accumulated. Northern hardwood-conifer forests in Maine accumulated the least amount of biomass in every scenario that included harvest.

(Left) Adult aboveground biomass (metric tons/ha) by harvest scenario and forest type/region.

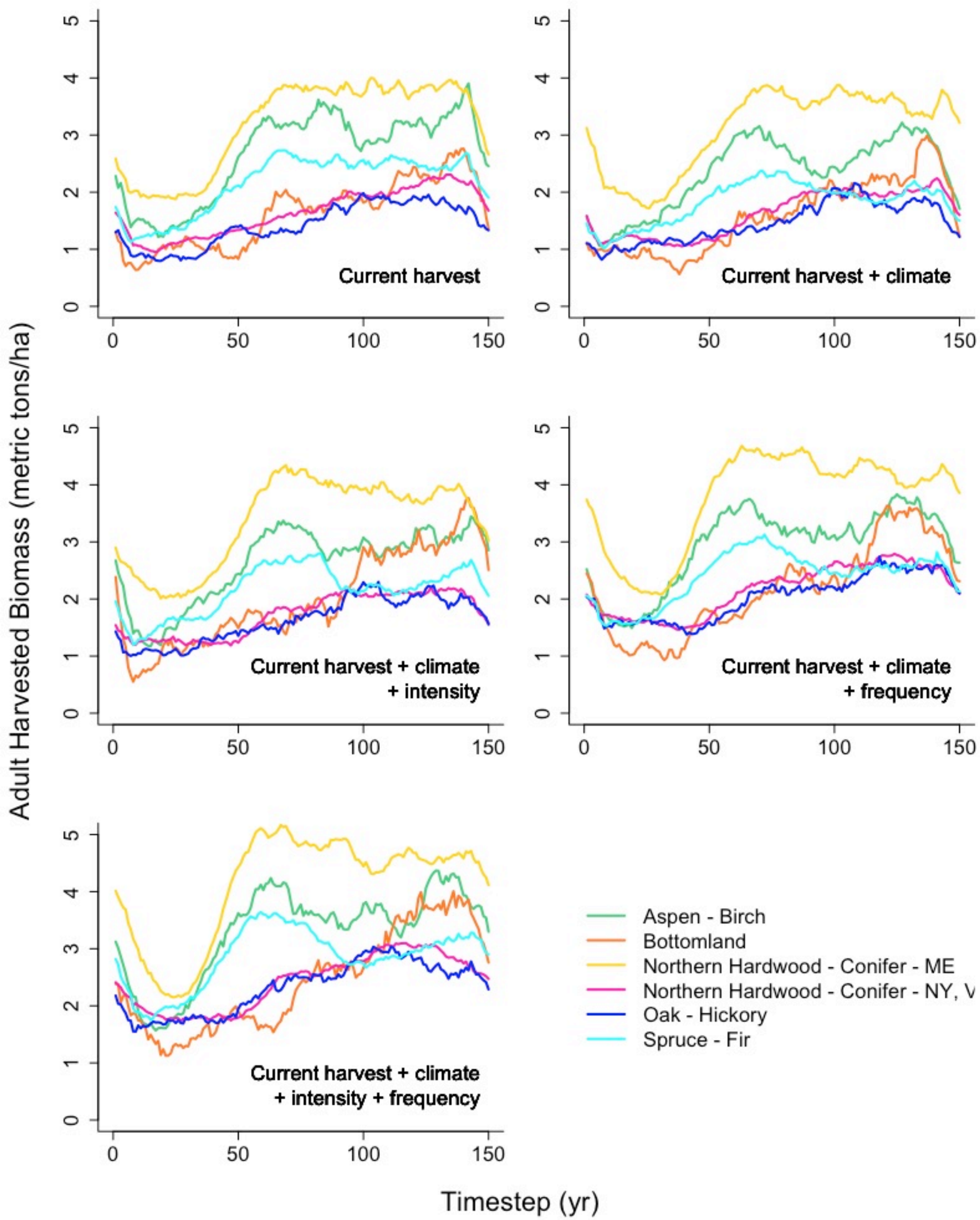
Results/Project outcomes



- In all harvest intensification scenarios, the proportion of stands in young forest shifted toward more mature stands over time. Despite the steady biomass accumulation, however, only 8% or less of stands exhibited characteristics of old growth forests (≥300 mt/ha) in the year 2147 landscape under any of the harvest regimes except the no harvest scenario.

(Left) Percent of plots in aboveground biomass classes in year 2147 for each harvest scenario.

Results/Project outcomes



- Harvest yields varied by the magnitude of logged biomass, but the pattern of yield was similar across all scenarios. Over the first 30 – 40 years, harvest yields declined before rising dramatically and eventually somewhat stabilizing in the last 50 years.

(Left) Amount of biomass harvested (15-year running averages) by forest type/region for each harvest scenario (excluding no harvest).

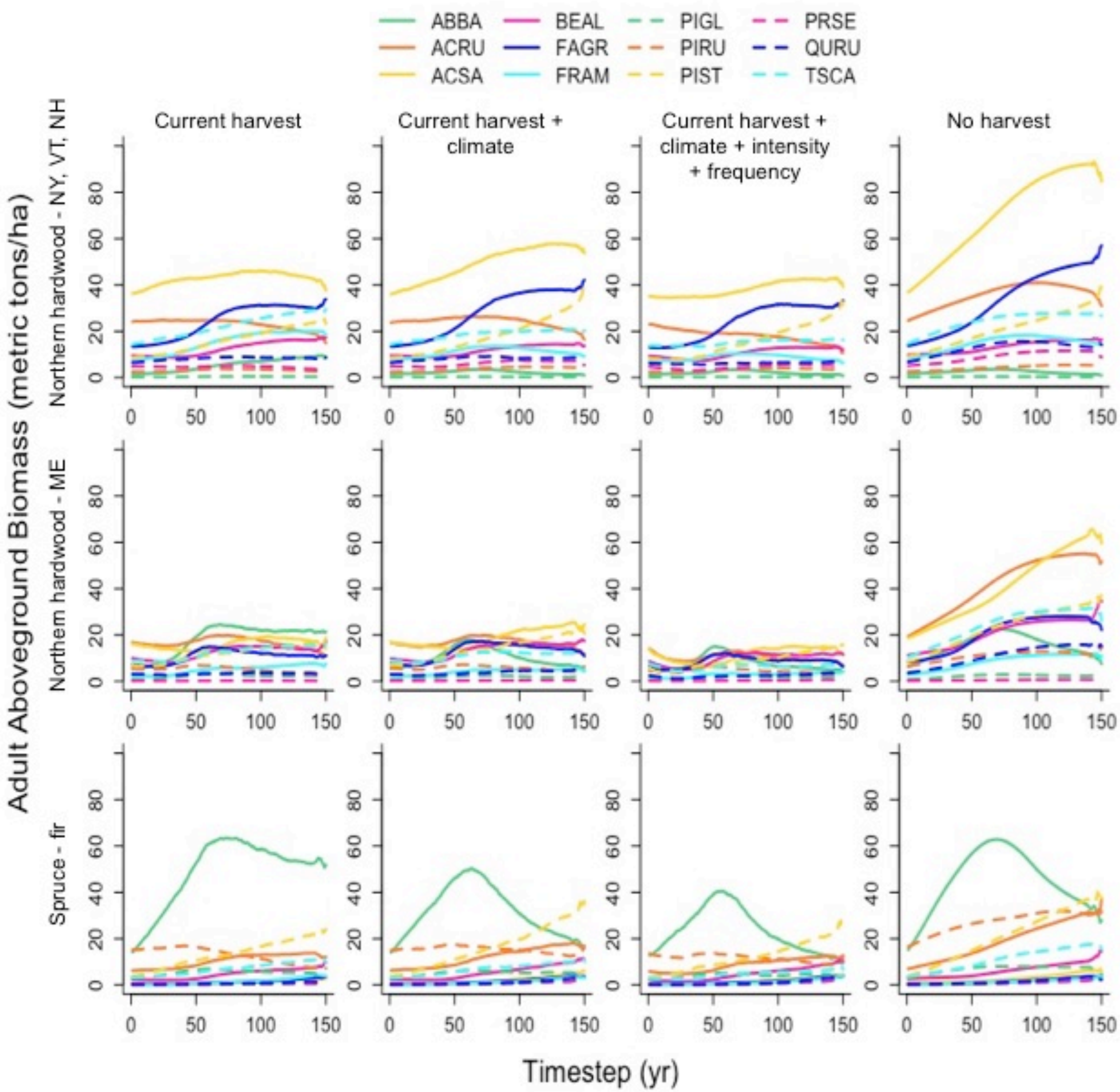
Results/Project outcomes

- While intensifying harvest had clear effects on both average stand biomass and the frequency distribution of stand biomass within a region or forest type, it had little effect on overall patterns of succession and stand development.

- One notable exception to this pattern emerged. Comparing the current harvest regime with the current harvest + climate regime isolates the effect of the projected climate change. Of the dominant species of these northern temperate forests, balsam fir was the most disproportionately affected by climate change.

See figure below.

Results/Project outcomes



(Left) Species development over 150 years across four harvest regimes (columns): current harvest regime, current harvest regime with climate effect, increased frequency and intensity of the current harvest regime with climate effect, and no harvest, and three forest types/regions (rows): northern hardwood forest-conifer - NY, VT, NH, northern hardwood-conifer – ME, and spruce-fir.

Implications and applications in the Northern Forest region

- Logging is the dominant source of disturbance in northeastern forests; therefore, understanding the effects of harvest and integrating harvest with natural disturbance is critical for assessing the future of these forests. Harvest regimes, like natural disturbance regimes, are predictable in terms of their frequency and intensity. We show that the northeastern forest harvest regime varies as a function of basal area, forest type/region, and distance to roads.
- In terms of stand development, beyond the climate effect decreasing balsam fir and eastern hemlock biomass, little difference was observed in species responses between harvest scenarios for forest types/regions that varied by frequency and intensity. We would expect shade-tolerant species to prevail in the no harvest scenarios, but not necessarily in intensively harvested scenarios. The response of late-successional species generally holds across all harvest regimes (albeit in different magnitudes) due to the pervasiveness of partial harvesting.
- While harvest regimes do capture some amount of resulting biomass variability across the landscape, large biomass classes for live trees and inputs to snags and downed woody debris are missing. These features are critical habitat for many species of Northern Forest wildlife.

Implications and applications in the Northern Forest region

- Within a landscape like the Northern Forest that contains limited protected lands and widespread partial harvesting, less intensive harvest regimes will result in more variability on working forest lands. As harvest regimes intensify, working forests will become less variable and the limited amount of protected lands will represent a greater proportion of the landscape in later successional stages and larger biomass classes.
- The intensified harvest scenarios immediately decline in aboveground biomass for about 25 years at which point biomass increases and eventually surpasses its initial values. From a climate standpoint, the next two decades are the most important for sequestering and storing carbon to stabilize the climate. Thus, despite biomass being greater after a century of recovery and growth, the initial decline may be detrimental.
- Our analysis indicates that in every harvest scenario average landscape biomass is expected to increase significantly over the next 150 years (ranging from 45% to 175% above current landscape averages), even in the most intensive harvest scenario. In contrast to studies predicting that the future strength of the carbon sink in eastern U.S. forests will decline, our results suggest that at least in terms of carbon storage in vegetation, the strength of the carbon sink could increase over 150 years.
- The potential contribution of forest bioenergy to meeting state renewable energy goals and reducing fossil fuel dependencies will vary broadly by state, renewable energy objectives, fossil fuel conservation technologies, forest landowner objectives, and other social and economic factors.

Future directions

- We are currently finalizing expert-derived regional wildlife models. We will use these biodiversity models to assess the tradeoffs between biomass harvest, carbon storage, biodiversity, and energy needs met utilizing a multi-criteria decision analysis framework.

List of products

- Peer-reviewed products:
  - Brown et al. *in review*. Timber harvest as the predominant disturbance regime in northeastern U.S. forests: effects of harvest intensification. Ecosphere.
  - Brown et al. *in preparation*. Forest biomass in the Northern Forest: tradeoffs between bioenergy and net carbon storage. Projected date: June 2017.
  - Brown et al. *in preparation*. Using an expert elicitation method to build regional biodiversity models. Projected date: June 2017.
  - Brown et al. *in preparation*. Using multi-criteria decision analysis to evaluate forest biomass energy alternatives in the Northern Forest, USA. Projected date: September 2017.

- Conference presentations:
  - Brown et al. 2016. Effects of forest biomass energy production on long-term Northern Forest structure and composition. Northeastern Natural History Conference, Northampton, MA.

- Dissertation:
  - Brown, M. L. *in preparation*. Effects of forest biomass energy production on Northern Forest wildlife and forest sustainability. Projected graduation date: October 2017.