Effects of nonselective partial harvesting in Maine's working forests

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Partial harvesting in Maine creates a diverse set of forest stand conditions, and better understanding these conditions is critical to the future of Maine forests.

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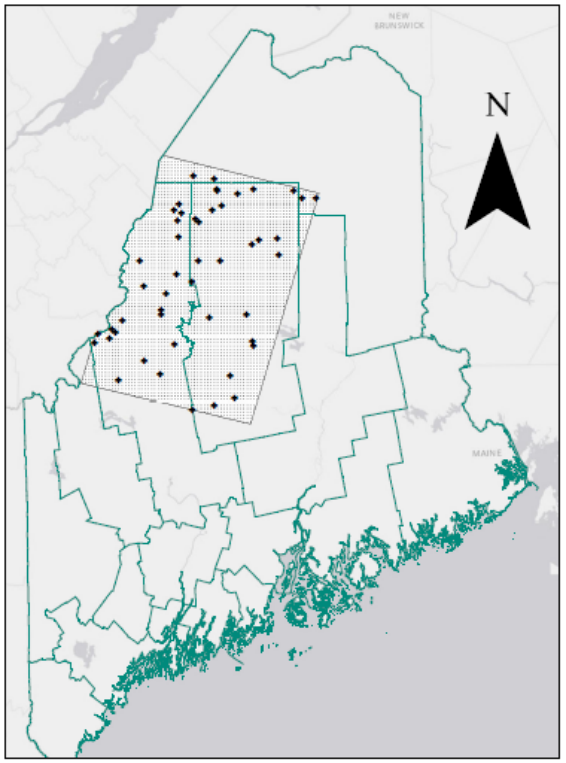
http://www.nsrcforest.org

Project Summary

- This research encompass three general areas of focus:
  - Post-harvest inventory measurement methods
  - Assess current stand characteristics focusing on overstory attributes
  - Assess current stand characteristics focusing on understory attributes
- Research was conducted in 50 selected stands across 4.08 million acres (1.65 million ha) in northern and central Maine; Landsat scene (Landsat Worldwide Reference System path 12, row 28



Project Summary

- Post-harvest inventory measurement methods
  - We compared efficiency and stand-level inventory estimates using horizontal point, fixed area and horizontal line sampling measurement (a total of 6 methods) methods in 16 partially harvested stands across northern and central Maine.
  - Some stand-level variables were sensitive to measurement method (e.g., volume, quadratic mean diameter and small stem density and basal area), while others were less sensitive (e.g., overall basal area and stem density).
  - Efficiency, defined as a combination of precision of volume estimates and measurement time, varied among measurement methods at lower stand basal area values but was similar at higher basal area, with the exception of the fixed area method.
  - Overall, horizontal line sampling proved to be a viable method in post-partial harvest stand conditions. Our results illustrate the trade-offs between precision and time costs involved in several measurement methods under a range of heterogeneous stand conditions.

Project Summary

- Assess current stand characteristics: Overstory
  - Objectives:
    - Assess residual stand and harvest attributes of partially harvested stands
    - Evaluate the within stand variability
  - Total of 50 stands sampled
  - Preliminary analyses completed
  - Preliminary results suggest that there is substantial variation among partially harvested stands. Complete results for this objective will be produced in forthcoming publications

Project Summary

- Assess current stand characteristics: Understory
  - Objectives:
    - Determine which residual stand and environmental variables were most important in influencing abundance of regeneration for selected species groups
    - Develop predictive models using the most influential variables to predict abundance of each species group
  - Total of 50 stands sampled
  - Preliminary analyses completed
  - Preliminary results suggest that there is substantial variation among partially harvested stands. Complete results for this objective will be produced in forthcoming publications.

Background and Justification

- Mechanized partial harvesting has become the dominant forest management tool across eastern Canadian and northeastern US forests over the past two decades
- At the same time, changes in timberland ownership patterns and general concern over the effects of silvicultural practices in naturally regenerated working forests have led to concern that such harvesting practices may be detrimental to long-term forest productivity and ecological values
- Despite these concerns, little has been done to quantify the effects of nonselective partial harvesting on Maine's current and future forest, and consequently we are currently unable to adequately describe the current state of Maine's forests and provide the information needed to make meaningful projections of future forest conditions

Methods

- Post-harvest inventory measurement methods
  - Inventory plots were placed on a systematic grid in each of 16 stands
  - The order of measurement was randomly varied from plot to plot
  - Horizontal point sampling methods were conducted at each plot
  - Horizontal line sampling at every third plot
  - Fixed area at every fifth plot

Methods

- Assess current stand characteristics: overstory
  - At each sampling point, overstory tree and harvest data were collected using horizontal line sampling
  - For each live “in” tree, species and DBH was recorded. On a subsample of trees, height and height to crown base to the nearest 0.3 m (1 foot) were measured. We recorded the source of the damage (natural, logging, or unknown), the type of damage (open wound, crack or seam, and broken bole), the location of the damage, and the severity of damage
  - Harvest attributes were assessed at the plot level. In order to develop an estimate of the percent of stand area that had been completely or partially harvested, we assigned one of three harvest status conditions along each overstory sampling line

Methods

- Assess current stand characteristics: understory
  - At each sampling point, understory tree data were collected using circular fixed radius sampling plots of 1/385 acre; (6 ft) radius
  - For all stems of tree species <2" diameter at breast height (DBH) rooted within the plot, species, height class (0.3-0.9 m; 0.9-1.8 m; >1.8 m; 1-3 ft; 3-6 ft; >6ft), and number were recorded
  - Visual estimates of the percent *Rubus* cover within the radius plot.
  - Harvest attributes were assessed at the plot (unharvested= no tree removal, complete removal= removal of all overstory trees (i.e., trials and landings), and partial removal= removal of some but not all overstory stems)

Results/Project outcomes

- Post-harvest inventory measurement methods
  - Some stand-level variables were sensitive to measurement method (e.g., volume, quadratic mean diameter and small stem density and basal area), while others were less sensitive (e.g., overall basal area and stem density)

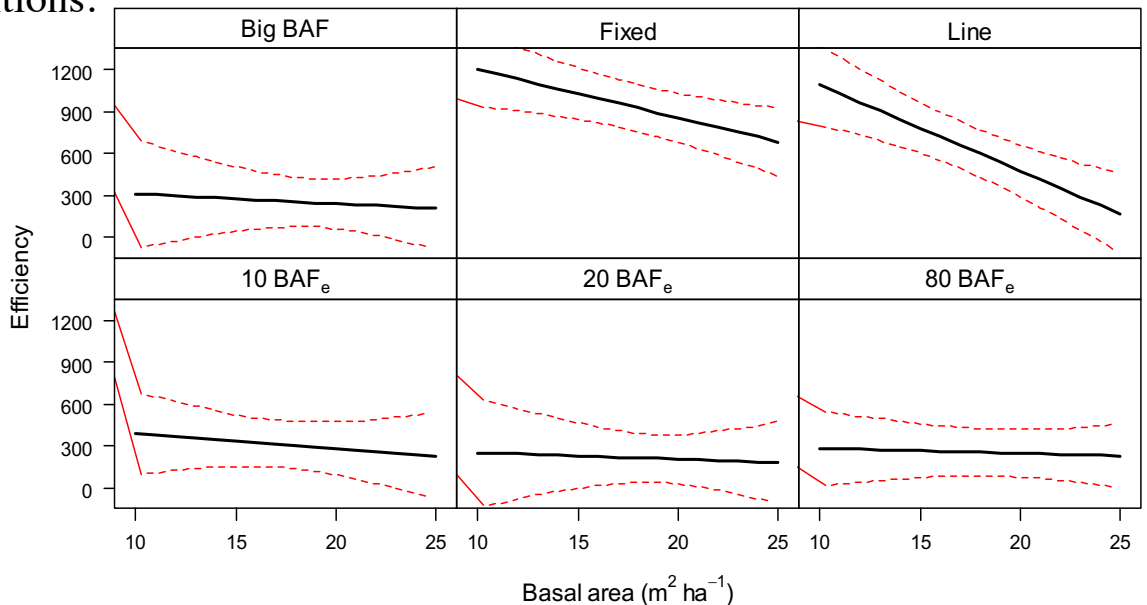
Table 1. Stand level least square estimates (mean ± SE) by measurement method for 16 partially harvested stands in northern and central Maine. Different letters among methods indicate statistically significant differences at $p \leq 0.05$.

	10 BAF_e	**20 BAF_e**	**80 BAF_e**	**Big BAF**	**Fixed**	**Line**
Basal area (m^2 ha^{-1})	17.33[a] (1.48)	18.64[a] (1.50)	18.86[a] (1.48)	*	17.97[a] (1.48)	17.44[a] (1.48)
Basal area <12.7cm (Percent of total)	20.15[ab] (2.52)	20.81[ab] (2.54)	15.82[a] (2.52)	*	20.94[b] (2.52)	20.39[ab] (2.52)
QMD (cm)	15.15[a] (0.86)	15.10[a] (0.88)	17.97[b] (0.86)	*	15.23[a] (0.86)	15.39[a] (0.86)
Basal area CV (Percent)	57.21[a] (7.23)	63.47[a] (7.41)	115.67[b] (7.23)	*	48.25[a] (7.23)	59.61[a] (7.23)
Stems (Number ha^{-1})	990.44[a] (96.37)	1071.22[a] (97.37)	943.20[a] (96.37)	*	1037.01[a] (96.37)	987.63[a] (96.37)
Stems <12.7 cm (Percent of total)	64.81[a] (4.03)	65.93[a] (4.10)	49.15[b] (4.03)	*	65.35[a] (4.03)	64.10[a] (4.03)
Volume (m^3 ha^{-1})	112.41[ab] (10.69)	119.72[ab] (10.80)	125.97[b] (10.69)	125.73[b] (10.80)	86.32[c] (10.69)	98.83[ac] (10.69)

* Values derived from 20 BAF_e

Results/Project outcomes

- Post-harvest inventory measurement methods
  - Efficiency, defined as a combination of precision of volume estimates and measurement time, varied among measurement methods at lower stand basal area values but was similar at higher basal area, with the exception of the fixed area method. Overall, horizontal line sampling proved to be a viable method in post-partial harvest stand conditions. Our results illustrate the trade-offs between precision and time costs involved in several measurement methods under a range of heterogeneous stand conditions.

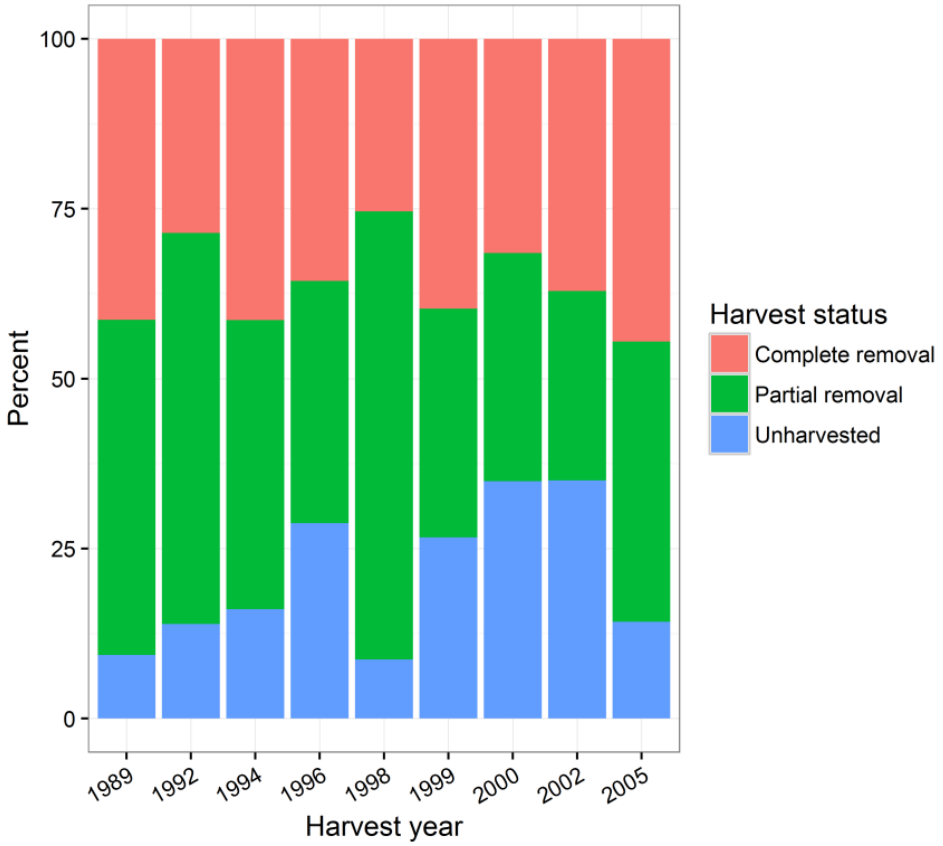


Results/Project outcomes

- Assess current stand characteristics: overstory
  - Partial harvesting in Maine appears to have changed over time, with an increase in complete overstory removal and an apparent increased emphasis on hardwood removals
  - With nearly one-third of stand area in trails, landings, and similar conditions on average, for some period of time these areas are taken out of the production of wood fiber
  - Post-harvest stand composition was related to the residual basal area, percent of noncommercial basal area and density, residual stand density, quadratic mean diameter (QMD), size of the harvest, and percent of the stand with partial overstory removal
  - The year of harvest was related to residual stem density, QMD, size of the harvest, and percent of the stand with partial and complete overstory removal
  - Whether a stand had been partially harvested more than once within the period of interest influenced the percent of stand area with complete overstory removal
- Analyses are continuing and a publication detailing the results is in preparation

Results/Project outcomes

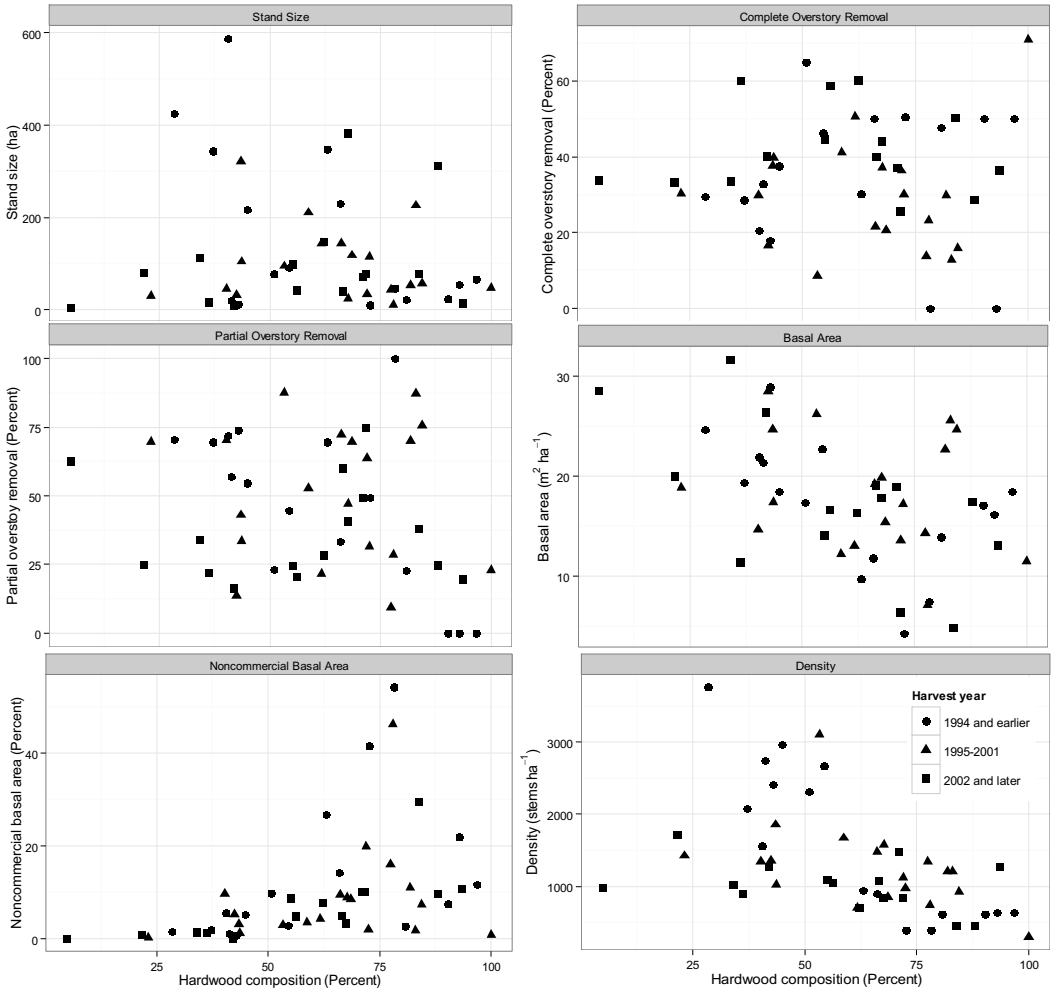
- Assess current stand characteristics: overstory



Percentage of stand area in each harvest status by harvest year

Results/Project outcomes

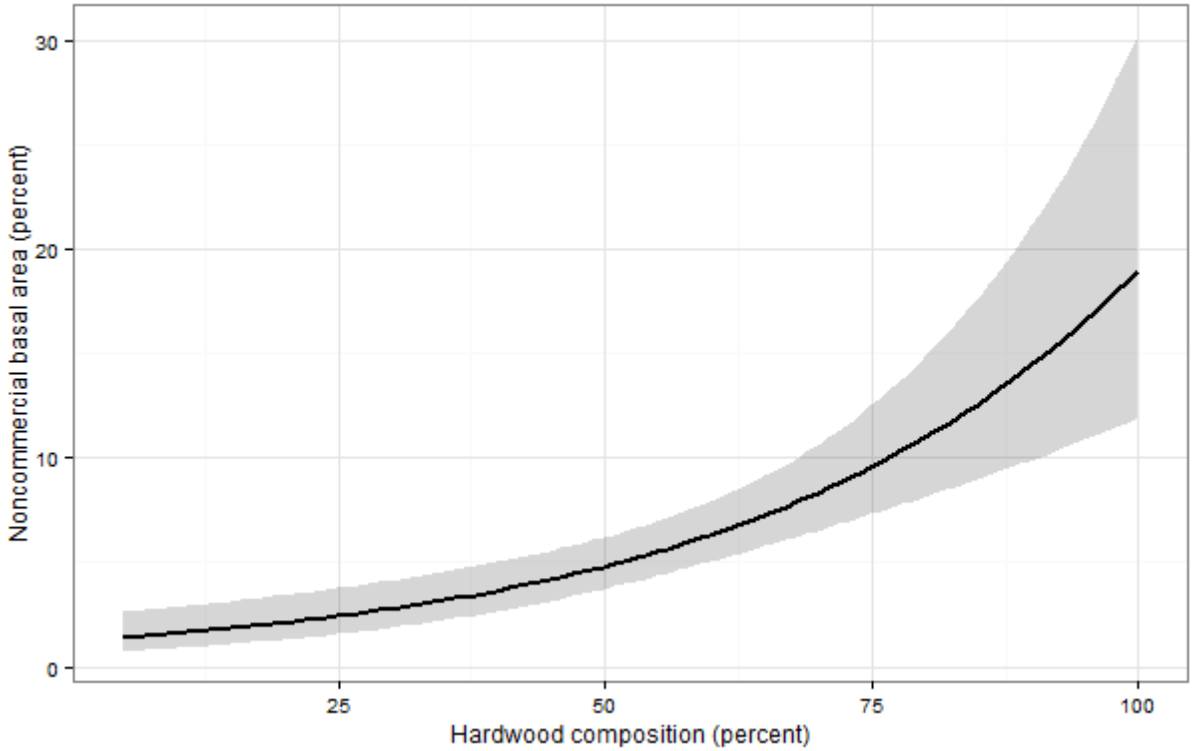
- Assess current stand characteristics: overstory



XY plots of raw data, illustrating relationships between the selected variables on the y axis and hardwood composition (x axis) and harvest year (symbols). Note that harvest years have been grouped into three periods.

Results/Project outcomes

- Assess current stand characteristics: overstory



Predicted percent noncommercial basal area by stand hardwood composition. Shading represents 95% confidence interval.

Results/Project outcomes

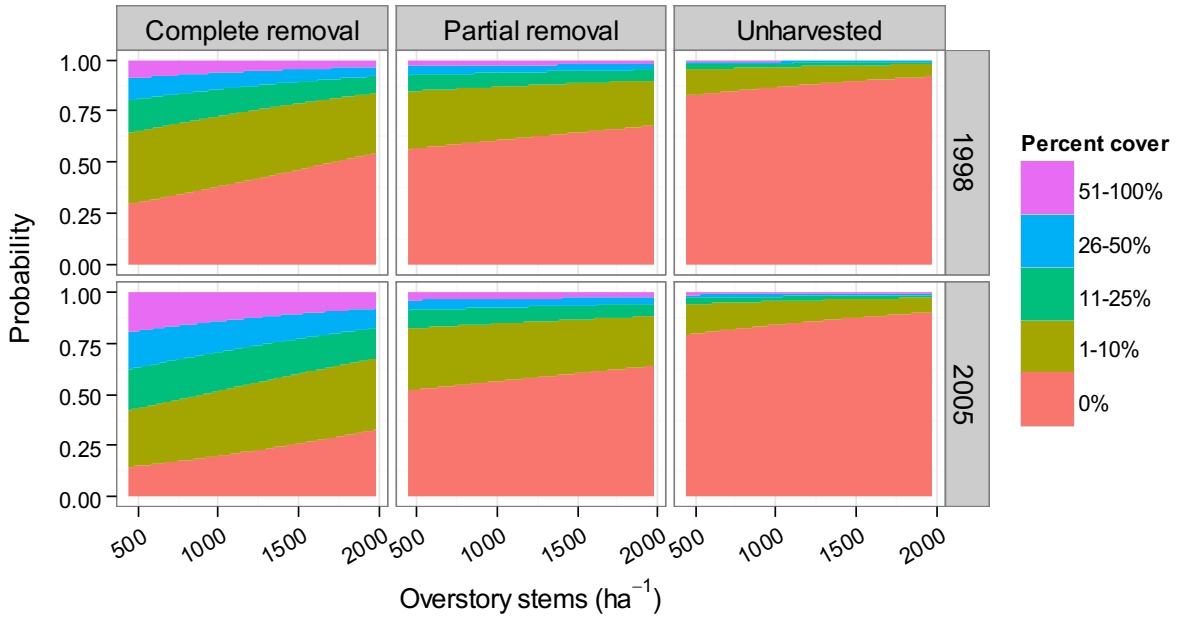
- Assess current stand characteristics: understory
  - Contrary to expectations, we found that shade tolerant hardwood species dominated regeneration stem counts
  - With the exception of the intermediate shade tolerant group, all other species groups and *Rubus* cover were affected by variables related to partial harvesting attributes
  - Areas of complete removal were significantly different than other sub-stand areas with increased abundance of shade intolerant species and *Rubus* cover. While only shade intolerant species abundance was explicitly influenced by harvest status, all species groups combined, shade tolerant hardwoods, and shade tolerant softwoods were influenced by overstory density, which was related to harvesting intensity
  - *Rubus* cover and density of shade tolerant hardwoods were more abundant in recent harvest years

Results/Project outcomes

- Assess current stand characteristics: understory
  - Shade tolerant hardwoods, all species groups combined, tolerant softwood, intolerant species and *Rubus* cover were related to overstory tree density
  - Growing season mean annual precipitation ratio was the most frequent environmental variable in the mixed models, influencing the abundance of all species groups combined, intermediate shade tolerant, and shade tolerant hardwood species groups, as well as *Rubus* cover
- Analyses are continuing and a publication detailing the results is in preparation

Results/Project outcomes

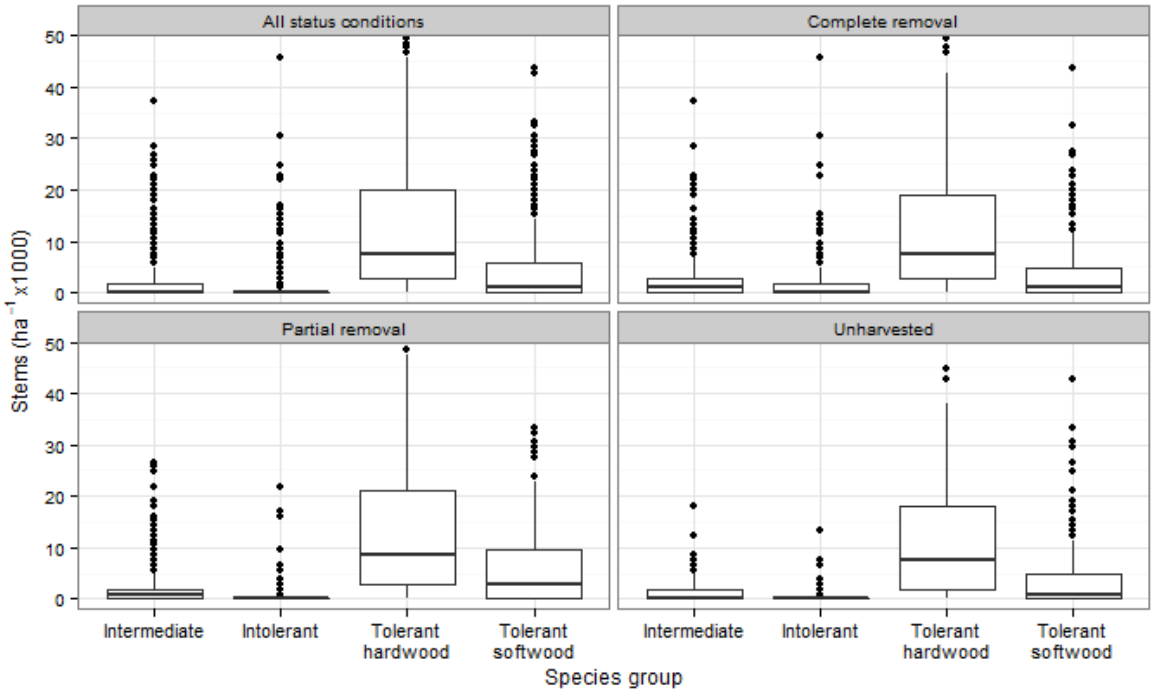
- Assess current stand characteristics: understory



Predicted probability of *Rubus* cover groups illustrating the effects of harvest status, harvest year, and overstory density (25th to 75th percentile). Growing season mean annual precipitation ratio held at median value.

Results/Project outcomes

- Assess current stand characteristics: understory



Boxplots of regeneration density occurrences by species group for each of the harvest status conditions and all status conditions. Note extreme data (>50,000 stems ha^{-1}) not shown.

Implications and applications in the Northern Forest region

- Post-harvest inventory measurement methods
  - Poor forest inventory can contribute to suboptimal forest management decisions, resulting in significant financial losses (Borders et al. 2008). With this in mind, forest inventories need to be designed and conducted to optimize a balance of relevant quality data while minimizing costs. Due to the inherent variability in forested systems and the subjective nature of balancing competing values, there is no single approach that predictably serves both purposes across a range of stand conditions.
  - With the increasing pressures on forests to supply a range of goods and services to a growing global population with a decreasing forestland base, being able to accurately, precisely and efficiently sample forest conditions is critical
  - This study reinforces this notion for post-harvest forest inventories and demonstrates that horizontal line sampling is a viable method that may be well suited to highly variable forest conditions.

Implications and applications in the Northern Forest region

- Assess current stand characteristics
  - Partial harvesting in Maine appears to be a diverse set of forest operations and these appear to have changed over time
  - While it is useful to talk about partially harvested "stands," our results indicated that sub-stand conditions (unharvested and complete and partial overstory removal) were important in regeneration patterns. Thus, it is likely that partially harvested stands will experience a persistent divergence of within stand regeneration patterns
  - Partial harvesting will likely complicate the ability to accurately predict growth and yield at the stand and landscape levels, as partial harvesting creates conditions that may be relatively novel in these forest types
  - For Maine and the Acadian forest region in general, it is critical that we better understand the stand and landscape level effects of this type of harvesting practices in terms of wood supply, recreation value, wildlife habitat, and overall ecological integrity
  - Because so little is known about the silvicultural outcomes associated with this range of partial harvesting practices, this study is a crucial first step in developing an understanding of how these practices have influenced current conditions in partially harvested stands on Maine's industrial forest lands

Future directions

- Further research is needed to examine underutilized approaches such as horizontal line sampling and sector sampling. In particular, we need a better understanding of the balance between accuracy, precision and cost under a wide range of stand conditions, particularly in heterogeneous forest conditions like partially harvested stands
- The future of forestry in Maine depends on better understanding the current forest conditions, how those conditions may develop over time and how silviculture can be used to create and maintain options that meet landowner goals and social objectives

List of products

- Awards
  - The Primary Investigator (Rice) was awarded the Maine Economic Improvement Fund (MEIF) Doctoral Dissertation Fellowship Award by the University of Maine Graduate School based in part on the significance of this research on partial harvesting to the state of Maine.
- Publications
  - Rice B, Weiskittel AR and Wagner RG. 2014. Efficiency of alternative forest inventory methods in partially harvested stands. DOI: 10.1007/s10342-013-0756-4. European Journal of Forest Research. 133:261-272.
  - Weiskittel AR, B Rice, J Wilson and RG Wagner. 2012. Improved sampling methods and growth & yield models for partially harvested stands. In Roth, B.E. (Ed.) Cooperative Forestry Research Unit: 2011 Annual Report. University of Maine. Orono, ME. pp. 37-39
- Presentations and Posters
  - Rice B, RG Wagner and AR Weiskittel. Nonselective partial harvesting in Maine. Eastern CANUSA Forest Science Conference, Durham, New Hampshire, November 2, 2012.
  - Rice B, RG Wagner and AR Weiskittel. Natural regeneration following partial harvesting in Maine, Society of American Foresters National Convention. Spokane, WA, October 25, 2012.
  - Rice B, AR Weiskittel, and RG Wagner. Horizontal line sampling- just interesting or is it feasible? Southern Mensurationists 2012 Meeting. Jacksonville, FL. October 9, 2012.
  - Rice B, RG Wagner and AR Weiskittel. Forest inventory methods in Maine's partially harvested stands. Northeastern Mensurationist Organization (NEMO) 2012 Meeting. State College, PA. October 1, 2012.