Spatial and structural characteristics of old-growth red spruce-northern hardwood mixedwood forests in New York and New Hampshire

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Introduction

Historical selective removal of red spruce, along with a range of biotic and abiotic stressors, has significantly impacted the composition and structure of mixedwood stands in the transition zone between spruce-fir and northern hardwoods forests. This land-use legacy, in concurrence with the difficulty of regenerating shade-tolerant red spruce, has made managing mixedwoods in the northeastern US uniquely challenging. Key knowledge gaps regarding the spatiotemporal recruitment dynamics of these forests, particularly the red spruce component, limits our ability to develop effective silvicultural strategies for restoring this regionally important forest system.

Figure 1. Red spruce-northern hardwoods canopy at Township 40, NY.

Research Objectives

- Reconstruct spatiotemporal recruitment dynamics to identify critical recruitment limitations of red spruce
- Elucidate natural development pathways using reconstructed canopy disturbance histories
- Inform ecological silvicultural systems to restore and maintain these forests

Field Methods

- Nine 0.25-ha plots total established in old-growth mixedwood forests in New York (Figure 1) and New Hampshire (Figure 2)
- Plots in Township 40 were located in the west-central Adirondack Park, and plots in New Hampshire were in the Bowl Research Natural Area
- All stems ≥10 cm DBH were mapped and sampled for dendroecological reconstructions through extraction of increment cores

Figure 2. Field technician retrieving increment cores from an American beech at The Bowl Research Natural Area, NH.

Age Structure

- Reconstructions of recruitment dynamics at Township 40 indicate consistent, decadal recruitment of red spruce over the past 3 centuries (Figure 3)
- The oldest spruce (6.1%) recruited into the stand from 1700–1730
- Over half of all living trees (57.5%) recruited into the stand from 1930–1970

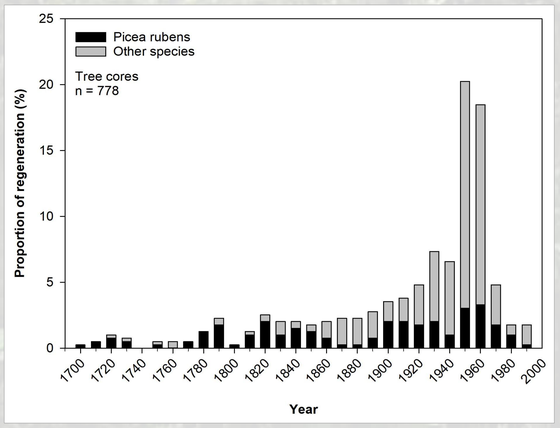


Figure 3. Age distributions of red spruce and all other species within 10-year age classes at Township 40, NY

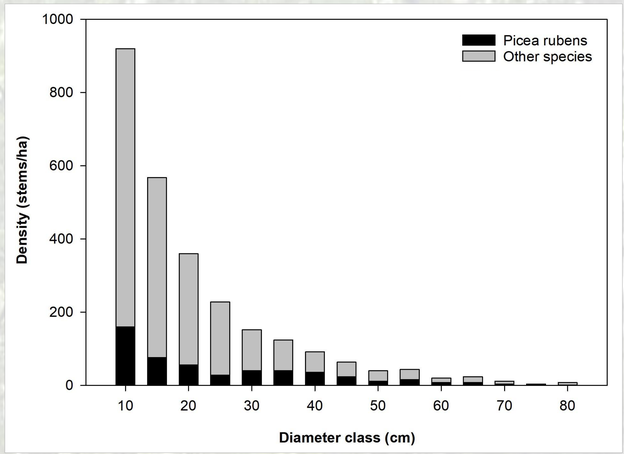


Figure 4. Diameter distributions of red spruce and other species, including red maple, American beech, yellow birch, and sugar maple, within 5-cm diameter classes at Township 40, NY.

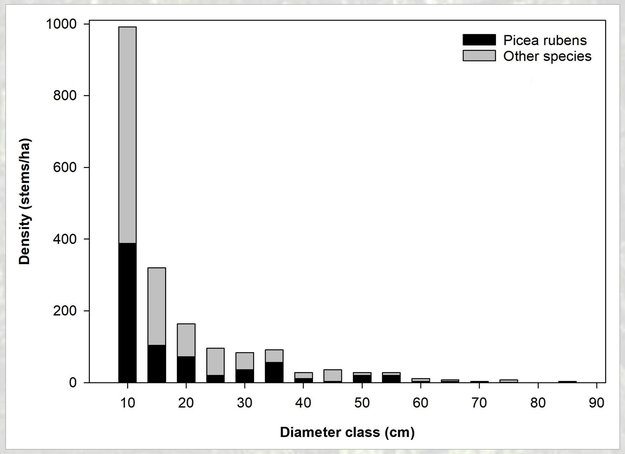


Figure 5. Diameter distributions of red spruce and other species, including yellow birch, American beech, striped maple, and sugar maple within 5-cm diameter classes at The Bowl Research Natural Area, NH.

Spatial Analysis

- Spatial patterns of tree locations were analyzed using pairwise correlation function of species for all stems, living and dead pooled (Figure 6)
- Spatially random arrangements of trees at all plots in Township 40
- Clustering observed within first 0.5 m at the lower elevation plot in The Bowl, but no significant clustering observed in the middle and high elevation plots
- Ongoing work will include analyzing spatial patterns of different age groups, and reconstructing the canopy disturbance histories at both sites

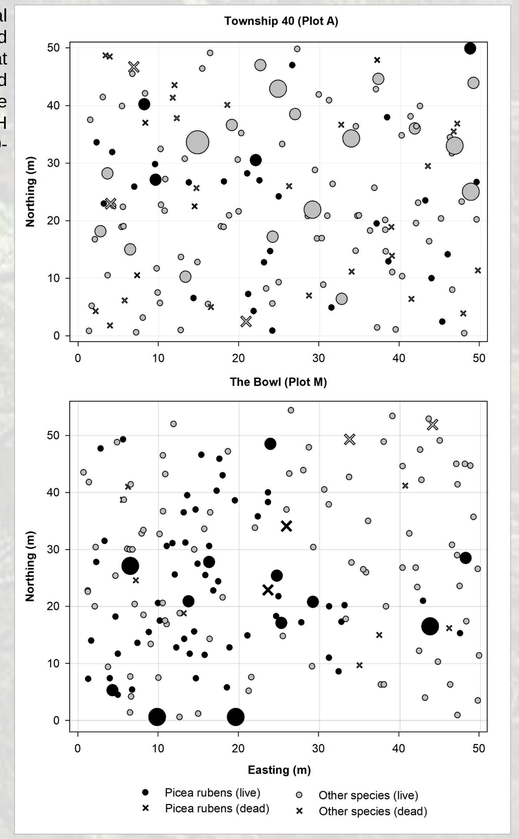
Structural Characteristics

- Diameter distributions for each site followed negative exponential forms, as confirmed through regression analyses (Figures 4 and 5)
- Red spruce importance value (IV) ranged from 14.7–26.8% at Township 40 and from 16.6–55.3% at The Bowl (Table 1)
- Greater variation of live tree densities and snag densities between sites
- Smaller variation of basal area, red spruce and total sapling densities, and coarse woody material between sites

Table 1. Mean values of structural characteristics by site (SE = ± standard error). Live trees density, snag density, and basal area calculated for stems ≥10 cm DBH. Saplings classified as stems <10 cm DBH.

Characteristic	Township 40	The Bowl
Red spruce IV (%)	22.5 (2.1)	37.1 (11.2)
Live tree density (stems/ha)	443 (26)	636 (34)
Basal area (m^2/ha)	23.7 (1.2)	28.2 (5.3)
Snag density (stems/ha)	237 (31)	111 (46)
Red spruce saplings (stems/ha)	758 (107)	742 (74)
Total saplings (stems/ha)	1529 (148)	1733 (276)
Coarse woody material (m^3/ha)	91.7 (14.9)	99.1 (32.5)

Figure 6 (right). Spatial arrangements of living and dead stems ≥10 cm DBH at Township 40 (Plot A) and The Bowl (Plot M). Icon size corresponds to four DBH classes, 20-39, 40-59, 60-79, and 80+ cm..



Acknowledgements

Thanks to Tony D'Amato and everyone in the Silviculture & Applied Forest Ecology Lab at UVM. Thanks to Colby Bosley-Smith, Tom Casper, Maegan Aldous, and Luther Millison for their hard work in the field and lab. Thanks to Steve Langdon of the Shingle Shanty Preserve & Research Station for his guidance and support. Funding was provided by the USDA Forest Service Northern Research Station and UVM Rubenstein School of Environment and Natural Resources.