Principles and Applications of Ecological Silviculture

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21st Century Context for Ecological Silviculture

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Ecological Silviculture

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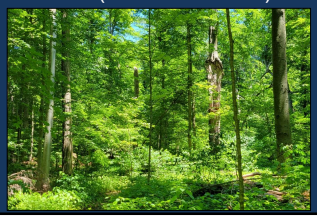
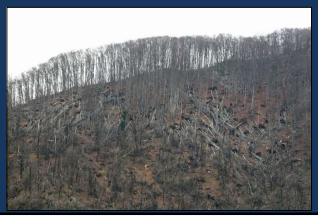
Ecological Silviculture Defined

Management approach that applies an understanding of the structure, function, and dynamics of natural forest ecosystems to achieve integrated environmental, economic, and social outcomes (Palik et al. 2020)





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Ecological vs. Timber-Focused Silviculture

Ecological silviculture still includes removal of trees to produce forest products; however, guiding principles are different from timber-focused model

Ecological Forestry	Timber-Focused Forestry
Maintains ecosystems and their array of structures, functions (processes), and biota	Maintains a subset of ecosystem structures, functions, and biota consistent with economic goals
Uses natural stand development models, including effects of disturbances, as the basis for silvicultural prescriptions	Based on agronomic models, e.g., plant spacing, weeding, fertilization, as the bases for silvicultural prescriptions
Values complexity and heterogeneity of ecosystem attributes	Values simplicity and homogeneity of structure and composition
Emphasizes ecosystem diversity and resilience to reduce major disruption risks	Emphasizes optimizing growth of crop species to reduce risks

Palik et al. (2020)

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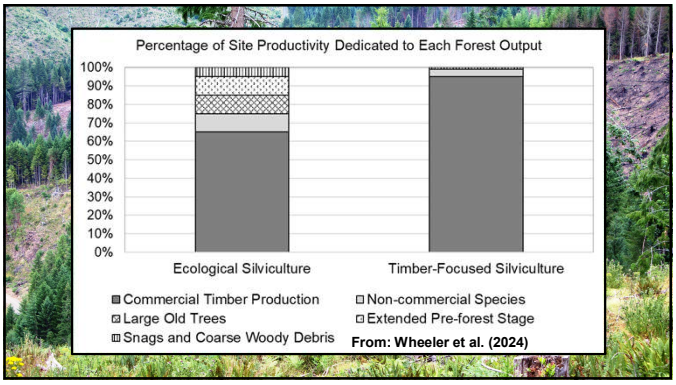

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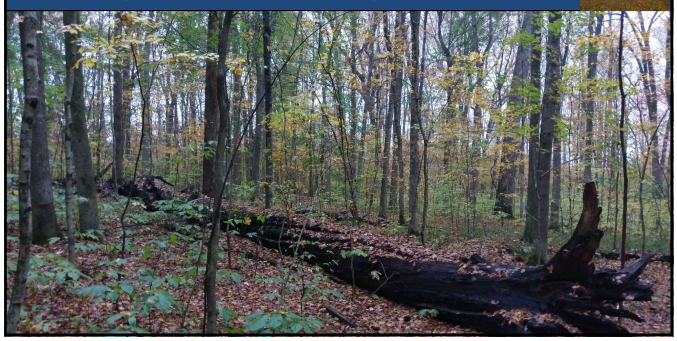
Operating principles of ecological silviculture



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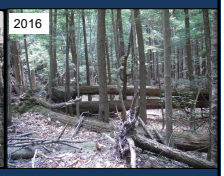
Operating principles of ecological silviculture

1. *Continuity*-provision for continuity in forest structure, function, and biota between pre- and post-harvest ecosystems during regeneration harvests



Emphasize what is left behind over what is removed

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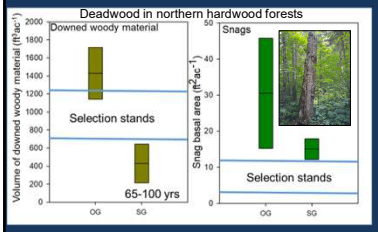
Continuity of deadwood legacies

Retention and creation of deadwood



If there's an opportunity to create more deadwood in your forest, do it! (Be a morticulturist).

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Leaving trees to die

Not all cavity trees provide the same benefits, especially human created ones

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Operating principles of ecological silviculture

Principle	Commodity productivity	Biodiversity conservation	Global change resilience/adaptation
1) Continuity	• Opportunities for natural regeneration of a range of species • Larger high-value products*	• Life boating of species requiring mature forest conditions • Greater diversity of food/energy sources from canopy species • Large snags/deadwood for saproxylic and cavity nesting species	• Options for regeneration in face of uncertainty • Amelioration of harsh environmental conditions ◦ regeneration safe sites (shaded understory, decomposed wood) • Conservation of genetic diversity

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Operating principles of ecological silviculture

2. *Complexity/diversity*-create and maintain structural complexity and species diversity at multiple spatial scales through silvicultural treatments

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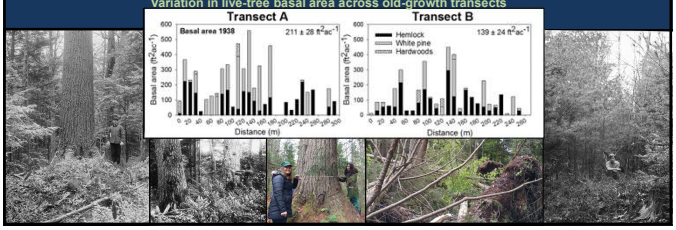
Operating principles of ecological forestry

We tend to overemphasize "pristine" cathedral-like groves when characterizing natural forests

- Tremendous spatial variability within and across stands resulting from disturbance and edaphic factors

Variation in live-tree basal area across old-growth transects



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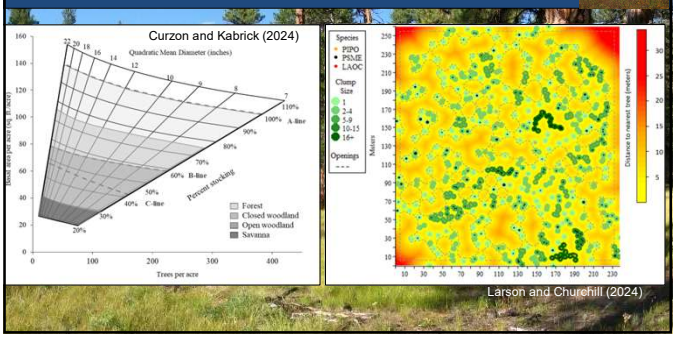
Variability in density and spatial pattern



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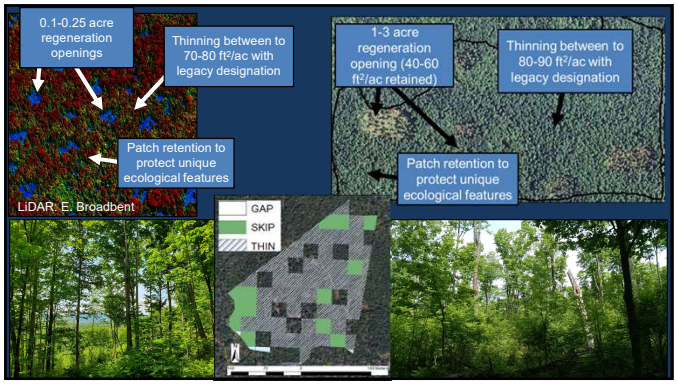

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Operating principles of ecological silviculture

Principle	Commodity productivity	Biodiversity conservation	Global change resilience/adaptation
2) Complexity/ Diversity	• Opportunities for multiple entries (outputs) • Diverse product mix • High-quality products (resulting from natural pruning, training) • Multiple opportunities for natural regeneration of desired species	• Diversity of habitat niches ◦ tree size classes ◦ deadwood decay classes ◦ live-tree spatial conditions ◦ tree, shrub, understory species	• Reduced vulnerability to disturbance ◦ spatial variability in fuels ◦ heterogeneity in wind risk (diverse heights) ◦ heterogeneity in potential host species (insects/disease) ◦ heterogeneity of tree sizes (host preferences, stress tolerance) • Multiple Recovery and developmental pathways ◦ diversity of seed sources ◦ advance regeneration • High levels of onsite mitigation potential (carbon storage)

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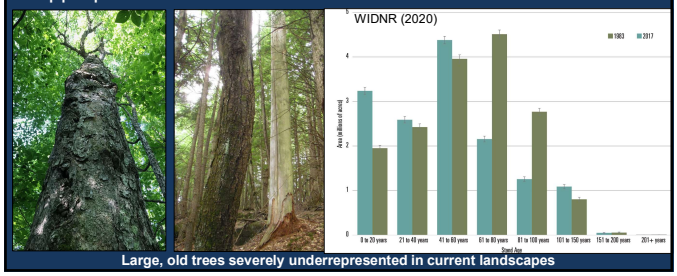
Operating principles of ecological silviculture

3. Timing-apply silvicultural interventions at ecologically appropriate time intervals



Large, old trees severely underrepresented in current landscapes

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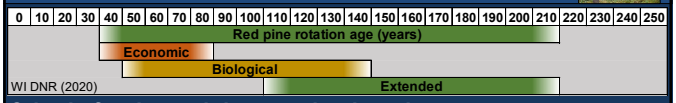
Extended Rotation Systems



Criteria for determining rotation length

- **Economic**-rotation age based on maximum net present value
  - Based primarily on discount rate
- **Biological**-rotation age based on peak mean annual increment (maximum sustained yield)
  - Often determined from normal yield tables
- **Extended**-rotation age that exceeds biological rotation age
  - Determined based on ecological and economic objectives

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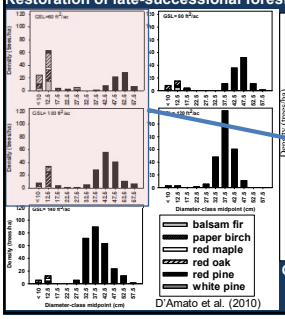
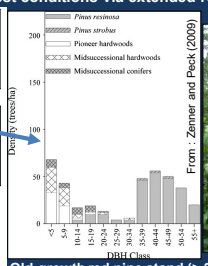
Extended rotation systems

Restoration of late-successional forest conditions via extended rotations in red pine



D'Amato et al. (2010)



From : Zenner and Peck (2009)

Old-growth red pine stand (> 300 years old), Itasca, MN

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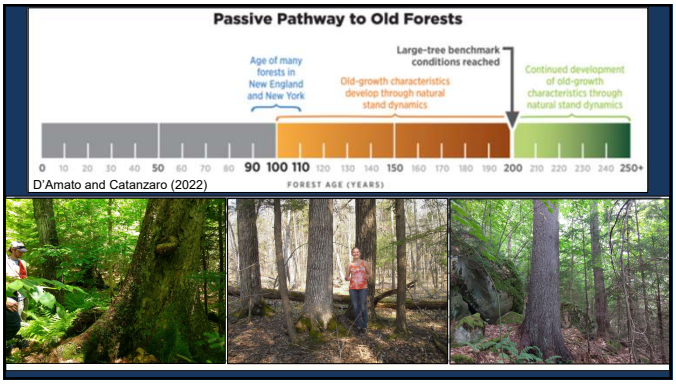
Passive Pathway to Old Forests



D'Amato and Catanzaro (2022)

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Operating principles of ecological silviculture

Principle	Commodity productivity	Biodiversity conservation	Global change resilience/adaptation
3) Timing	• Higher-value products • Multiple entries (outputs) • Seed source over extended periods • Multiple species and lifespans (diversity of products/harvests over time)	• Opportunity for multiple life cycles for species with slower development • Habitats for large tree specialists (live and dead trees)	• Long-term maintenance of options for adaptation from current overstory species • Long-term amelioration of extremes in understory conditions • Reduced likelihood for compounding influence of harvesting with other stressors/disturbance • Accumulation of large onsite carbon stores

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Operating principles of ecological silviculture

4. *Context*-plan and implement silvicultural interventions in the context of how these actions accumulate to influence landscape structure and function

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Operating principles of ecological silviculture

Principle	Commodity productivity	Biodiversity conservation	Global change resilience/adaptation
4) Context	• Diverse portfolio of products and potential harvest entries • Lower risk from changing market conditions	• Connectivity across landscapes and habitat gradients (e.g., riparian to upland, travel corridors) • Refugia at multiple scales • Diversity of structures/composition at landscape-scale	• Reduced risk from landscape-scale stressors (drought) and disturbance (insects, fire, wind) • Greater options for adaptation potential at broad scales • Greater range of regeneration conditions for new species due to localized and landscape-scale heterogeneity in structure

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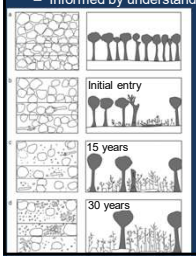
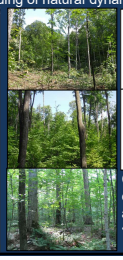
Ecological silvicultural systems

Ecological silvicultural system-long-term sequence of treatments for restoring, maintaining, and enhancing compositional diversity, ecological complexity, and heterogeneity

- Informed by understanding of natural dynamics and processes for a given community





Initial: canopy gaps (0.1-0.5 ac) across 10-20% of stand to initiate cohort with placement where possible focused on cull and advance regeneration; in-gap retention and deadwood creation; crown thinning across remainder (60-70ft^2/ac stand wide)

Years 15 and 30: continued creation of canopy gaps and deadwood legacies in areas previously receiving crown thinning treatments (continuous cover irregular shelterwood) or expansion of initial gaps using expanding gap irregular shelterwood (10-20% of area in each entry)

Creates mosaic of structural and compositional conditions found in natural systems with opportunity for adaptive decisions

- Multiple entries require economic value to carry future treatments and pose risk to damaging legacy elements

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Conclusions

- Ecological silviculture at its core is about working *with* versus *against* a site and ecological system (i.e., localize things to your spot on the map)
- Increasing frequency and severity of disturbance requires greater emphasis on thoughtful, proactive and adaptive (vs reactive) ecological silvicultural strategies
- Although based on "natural" systems, principles and outcomes of ecological silviculture provide useful building blocks for prescriptions that address novel challenges and objectives

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