Uneven-aged management may be an attractive method for meeting multiple social and economic objectives in spruce-fir forests, but existing guidelines were not developed to meet a broad suite of objectives and can even provide negative financial returns. This project uses a variety of quantitative tools to provide improved guidance.

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Project Summary

Uneven-aged or multi-cohort management represents one possible strategy for meeting a range of goals in spruce-fir forests, including goals related to aesthetics, wildlife habitat, emulation of desired disturbance scales and frequencies, and carbon sequestration. However, existing guidelines for spruce-fir management were developed without explicit attention to these objectives, and may even yield negative discounted financial returns.

We have extended and refined a previous analysis by Gove (1998), which explicitly addressed stand structural diversity. We used existing data along with a variety of quantitative methods to analyze uneven-aged spruce-fir management systems.

Key results include:
• Demonstration of improved performance on financial and ecological objectives when diameter distributions are specified using methods that are more flexible than the usual “q factor” approach
• Simple spreadsheet tools to allow foresters to calculate and compare aspects of different uneven-aged guidelines simply and quickly
• Development of simple tools for calculating the aboveground carbon in trees in unevenaged stands
• Optimization results that will support the development of revised guidance for multi-objective spruce-fir management
Background and Justification

The overall goal of this project is to improve uneven-aged management of spruce-fir forests in the NSRC region. Uneven-aged management has been suggested as an alternative for meeting multiple goals and objectives. These include:

- Esthetics
- Wildlife Habitat
- “Natural” Landscape Characteristics
- Carbon sequestration

However, existing guidelines and approaches for uneven-aged management are not economically efficient, even when purely financial objectives dominate. They have rarely been evaluated for their ability to meet non-financial objectives.
Background: Management for Whom?

The majority of forest land in the Northeast is held by small, non-industrial owners. Privacy, general appearance, and perceptions of conservation value (founded or not) are often associated with structurally complex, multi-aged stands for these owners.

Previous studies have identified two major options for achieving significant within-stand structural diversity over large spatial scales.

1. Allow a large portion of the landscape to reach very long rotation ages
   - Significant capital and opportunity costs
   - Probably not a feasible solution in the privately-owned forest matrix

2. Employ varied, diversity-driven silvicultural prescriptions
   - Economically preferable, especially on private land
   - Harvests can occur across a range of stand development stages.
   - Silvicultural methods remain poorly developed.
Background: What Did We Know?

The USFS had developed a standard set of silvicultural guidelines for uneven-aged management of spruce-fir (Frank and Bjorkbom 1973), based primarily on work at the Penobscot Experimental Forest in Maine. These guidelines use a “q ratio” approach which is simple but not very flexible.

Gove (1998) had already shown that the holding costs associated with large trees in the standard Frank-Bjorkbom guide gave a negative discounted return.

To be successful, forestry must pay... or at least not cost too much! Improved guidance is clearly needed, especially since attaining structural and ecological goals (such as increased carbon sequestration) may involve financial tradeoffs.
Methods

We employed a variety of quantitative approaches to explore and understand tradeoffs between management objectives. We also looked for opportunities to simplify the underlying calculations so they would be more accessible to foresters and other conservation professionals.

Our methods included:
- Simulation modeling
- Optimization
- Analysis of diameter distributions
  - “Size-biased” distribution theory
  - Implications for structure, biomass, and carbon
Results and Outcomes:
I. Simplified calculations for BDq management

• The “BDq” approach is a traditional approach to specify stand structures in uneven-aged management
  – B: stand basal area
  – D: maximum tree diameter
  – q: a parameter that determines the shape of the diameter distribution

• We developed simple tools (implementable in a spreadsheet) that streamline key calculations in this approach
Results and Outcomes:
II. Simplified calculations for forest carbon

- Carbon is an emerging concern
  - Tree carbon can be estimated from plot data
  - Calculations can be tedious
  - Simplifications would allow rapid comparison of management alternatives
- “Size biased” distribution theory provides insights for uneven-aged stands
- Under mild assumptions, the ratio of tree carbon to stand basal area (or TCBAR) is nearly constant in uneven-aged spruce-fir stands
Results and Outcomes:
III. Does Uneven-Aged Management Store More Carbon?

• The preceding result was used to compare alternative uneven-aged management guidelines, with balanced even-aged landscapes following regional 1605(b) curves from GCOLE
• GCOLE uses methods that give slightly lower standing carbon than those used to derive the TCBAR results, so the analysis privileges uneven-aged management
• How do the results stack up?

The curve on the left shows the typical development of tree carbon in even-aged spruce-fir stands in NY, VT, NH, and ME.

How would a mixed-age landscape of such stands compare to a landscape of uneven-aged stands?
Results and Outcomes:  
III., Continued.

- The results show that an uneven-aged stand has similar tree carbon density to a balanced landscape of even-aged stands with a rotation age of approximately 55-70 years.
- For uneven-aged stands to remain uneven-aged, recruitment of new trees must continue – so stocking cannot be too heavy. This limits the amount of carbon that can be stored.
- Work by Kenefic and Seymour at the PEF suggests the original Frank-Bjorkbom guide had stocking that was too high – a result borne out by our simulations.

As a result, the actual sustainable tree carbon storage in uneven-aged stands might be even lower – leading to an unfavorable comparison with even-aged management for potential carbon storage.
Results and Outcomes:
IV., Approaches for Optimal Management

• The existing Frank and Bjorkbom guide was intended as an initial “rough estimate” of a reasonable stocking level and stand structure
  – two main structures for two main objectives
  – subjectively determined
• Mathematical optimization can be based on local growth and yield information
• Results show the BDq method is insufficiently flexible to capture key objectives well
• Maximizing land expectation value (a measure of financial return) requires lower basal area than the F&B guide, but very few trees in the sawlog size classes
• Maximizing board foot production or board foot stocking requires stand distributions that do not conform to BDq
Implications and Applications

• Uneven-aged management is not a panacea for spruce-fir forests
  – Difficult to sustain high carbon densities and numbers of large trees
  – Easy to create stand structures with negative land expectation value

• Calculations associated with BDq approach can be simplified
  – facilitates comparison of management alternatives, different systems, different units of measurement
  – simple linkage between basal area and carbon
  – basal area/carbon link appears to hold well for other complex diameter distributions

• More flexible approaches to diameter distribution specification are needed
  – optimization results provide clear indication
  – can we simplify the communication and comparison of these results?
  – are practitioners prepared to contend with the math of more complex distributions?
Future Directions

• Finalize analysis of tradeoffs associated with growth and retention of large living trees and snags
  – entails significant long-term commitment of growing space to non-financial objectives
  – extremely difficult given the need to manage uneven-aged stands for (nearly) continuous regeneration and growth of smaller trees

• Intercomparison of BDq approach with other methods for specifying stand density/competition level
  – additive SDI
  – specific gravity-based mixed species relative density (Ducey and Knapp 2010)
List of Products

Peer-Reviewed Publications


List of Products, continued.

Presentations


Additional presentations of this NSRC-funded work are planned for NEMO 2010, ECANUSA 2010, and the NESAF 2011 spring meeting.
List of Products, continued.

Website

The project website can be found at:

http://ncasi.uml.edu/nemo/SpruceFir/sprucefir.htm

This website will be maintained, and will be expanded as peer-reviewed publications and additional presentations from this project are completed.