



Natural Resource Network

Connecting Research, Teaching and Outreach

The 6th Eastern Old Growth Forest Conference

***Moving Toward Sustainable Forestry:
Lessons From Old Growth Forests***

**September 23-26, 2004
Geneva Point Center, Moultonborough, NH**

Recommended Citation:

Bennett, Karen P., technical coordinator. 2005. Moving Toward Sustainable Forestry: Lessons from Old Growth Forests. University of New Hampshire Cooperative Extension Natural Resource Network Report



UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

UNH Cooperative Extension
131 Main Street, 214 Nesmith Hall, Durham, NH 03824



The 6th Eastern Old Growth Forest Conference *Moving Toward Sustainable Forestry: Lessons From Old Growth Forests*

September 23-26, 2004

Geneva Point Center, Moultonborough, NH

2004 Event Sponsors

*Adirondack Council
Appalachian Mountain Club
Audubon Society of NH
Bear-Paw Regional Greenways
Center for Woodland Education
Eastern Native Tree Society
Forest Stewardship Guild
Forest Watch
Friends of the Sandwich Range
Hancock Land Company
Lakes Region Conservation Trust
Manomet Bird Observatory
New England Forestry Foundation
New England Wildflower Society
New Hampshire Fish & Game
NH Division of Forest & Lands
NH Charitable Foundation
Northeast Wilderness Trust
Northern Woodlands Magazine
Society for the Protection of NH
Forests
Society of American Foresters
The 500 Year Forest Foundation
The Nature Conservancy
The Sweet Water Trust
The Wildlands Project
The Wilderness Society
University of New Hampshire
UNH Office of Sustainability
UNH Cooperative Extension
USDA Forest Service- Northeastern
Research Station
USDA Forest Service- Northeastern
Area State & Private
White Mountain National Forest
Wonalancet Outdoor Club*



September 2004 brought beautiful fall weather and 200 conservationists, land managers, and old growth enthusiasts to the shores of Lake Winnepesaukee in Moultonborough NH for the 6th Eastern Old Growth Conference.

The conference was dedicated to furthering the scientific understanding and conservation of old growth forests in the eastern US and Canada and promoting sound forest management, informed by an understanding of old growth forest dynamics. The conference featured scientific research that emerged since the prior conference of 2000 and provided a forum for discussing the identification, protection and use of old growth forests on a working landscape. Specifically, conference objectives were: 1) to disseminate information to conservation groups and the forest products industry about old growth forests; 2) to explore the dynamics of old growth forest ecosystems in a way that can inform sustainable forestry practices; and 3) to provide a forum for discussing the ways in which the land conservation community can partner with the forest products industry in conserving forest lands.

These proceedings were prepared as a supplement to the conference. Papers submitted were not peer reviewed or edited. They were compiled by Karen P. Bennett, Extension Professor and Specialist in Forest Resources. Readers are encouraged to contact authors directly for more information or for clarifications. The papers appear in order of the conference schedule and a table of contents and the concurrent workshop schedule is included as an aid to finding papers of specific interest. Conference organizers are indebted to the authors.

Copies are available on the following website <http://ceinfo.unh.edu/Forestry/Forestry.htm> or for \$5 each from UNH Cooperative Extension, 211 Nesmith Hall, Durham, NH 02824.

Conference Committee

Karen Bennett	Jim DiStefano
Kathie Fife	Chris Kane
Tom Lee, Ph.D.	Bill Leak
Evelyn MacKinnon	Frank Mitchell
Jim Northup	Rick Van de Poll, Ph.D.

Conference Advisors

Charles Cogbill	Lee Frelich, Ph.D.
Don Leopold, Ph.D	Robert Leverett
William Martin, Ph.D.	David Stahle, Ph.D.
Tom Wessels	

Table of Contents

- 1 Lobbying For Stewardship, Conservation and Old Growth, Opening Remarks**
William H. Martin, University of Kentucky
- 2 Late-Successional Retention and Restoration on the Appalachian Mountain Club's Katahdin Iron Works Property in Maine, Opening Remarks**
David Publicover, Appalachian Mountain Club
- 5 September 24 Concurrent Sessions Schedule**
- 6 Managing For Old-Growth Structure in Northern Hardwood Forests**
William S. Keeton, University of Vermont
- 12 What Management Does Old Growth Need?** Stephen Fay, White Mountain National Forest
- 14 Does Age Matter? Evidence of Vigorously Growing, Ancient Oaks in the Eastern US.**
Neil Pederson, Ed Cook, H. Myvonwynn Hopton, Gordon Jacoby, Columbia University
- 17 The Ancient Cross Timbers Consortium**
David W. Stahle and R. Daniel Griffin, University of Arkansas
- 19 Strategies for Locating New Stands of Old Growth Forest**
Robert T. Leverett, Eastern Native Tree Society
- 22 Earthworms as Ecosystem Engineers in North American Forests**
Lee E. Frelich, Cindy M. Hale, Andy Holdsworth, and Peter B. Reich University of Minnesota
- 24 The Disturbance History of Northern Maine Old-Growth Forests**
Alan S. White, Shawn Fraver, Erika L. Rowland, and Unna Chokkalingam, University of Maine
- 26 Insect Biodiversity in Managed and Old-Growth Forests**
Donald S. Chandler, University of New Hampshire
- 28 Adaptive Forest Management & Ecological Forestry**
Ehrhard Frost, Full Circle Forestry
- 31 Estimating the Capital Recovery Costs of Managing for Old Growth Forests**
Chris B. Ledoux, Northeast Research Station, USDA Forest Service
- 32 Does Size Matter?** Ellen Snyder, Ibis Wildlife Consulting
- 34 Birds in Managed and Old-growth Forests of Northern Maine**
John M. Hagan, Manomet Center for Conservation Sciences
- 36 Nitrogen Retention in Eastern Old-Growth Forests: Early Warnings of Nitrogen Saturation** Christine Goodale, Cornell University, Ithaca, NY 14853
- 39 Effects of Old-Growth Riparian Forests on Adirondack Stream Systems** William Keeton, University of Vermont & Clifford Kraft, Dana Warren, & Andrew Millward, Cornell University

- 44 **Can Old Growth Be Protected Within Working Forests? Can Working Forest Easements Protect Old Growth?** Charles R. Niebling, Society for the Protection of NH Forest
- 47 **Using Conservation Easements to Protect Old Growth Forests**
Nancy P. Smith, Executive Director, Sweet Water Trust
- 49 **Distribution, Composition, and Age Structure of Black Gum Swamps in New Hampshire-** Dan Sperduto, NH Division of Forests and Lands, NH Natural Heritage
- 50 **A Private Landowner Perspective on Old Growth Forests**
Ted Harris, The 500 Year Foundation
- 52 **Empirical Dynamics: A Process Definition of Eastern Old Growth**
Charles V. Cogbill, Private Consultant
- 54 **Identification & Conservation of Mt. Sunapee State Park's East Bowl Old Growth Forest**
Lionel Chute, NH Division of Forests and Lands, NH Natural Heritage Bureau
- 55 **From Gravel Bars to Old Growth: Primary Succession in the Zoar Valley Canyon, NY.**
Thomas P. Diggins, Youngstown State University
- 57 **The Importance of Coarse Woody Material in Fostering Fungal Development**
Rick Van de Poll, Ph.D., Ecosystem Management
- 60 **Biodiversity Significance of Old-growth, Late-successional, and Economically Mature Forest** John M. Hagan and Andrew A. Whitman, Manomet Center for Conservation Sciences
- 62 **Bats and Small Mammals in Old Growth Habitats in the White Mountains**
Mariko Yamasaki, USDA Forest Service, Northeastern Research Station
- 64 **Using Remote Sensing to Identify and Map Old Growth**
Sam Stoddard, UNH Cooperative Extension.
- 65 **Aerial Canopy Signatures of Old Growth Forest**
Chris Kane, Society for the Protection of New Hampshire Forests
- 66 **Finding Rich Mesic Forest: A Remote Sensing and Geographic Information Systems Approach** (master's thesis draft) Pete Ingraham, Society for the Protection of NH Forests
- 68 **A Comparison of Floristic Diversity in Old-Growth versus 100 Year-Old Hardwood Forests of the White Mountains** Leslie M. Teeling-Adams, Ph.D.
- 71 **Ecological Economics and Long-Term Investments in Forest Management: Presentation Summary** Spencer Phillips, The Wilderness Society
- 76 **Trees of Mystery Closing Remarks** Sy Montgomery, writer
- 78 **Poster Abstracts**

Managing For Old-Growth Structure in Northern Hardwood Forests

William S. Keeton, Assistant Professor of Forest Ecology and Forestry, Rubenstein School of Environment and Natural Resources, University of Vermont, 343 Aiken Center, Burlington, VT 05405

Introduction

Recent research on sustainable forestry in the northern hardwood region of the United States and Canada has focused on “structure” (Keeton 2004) or “disturbance-based” (Seymour et al. 2002) silvicultural approaches. This includes managing for late-successional forests, which are vastly under-represented relative to the historic range of variability for this region (Mladenoff and Pastor 1993, Cogbill 2000, Lorimer 2001). An untested hypothesis is that silvicultural practices can accelerate rates of late-successional forest stand development (Franklin et al. 2002), promote desired structural characteristics, and enhance associated ecosystem functions more than conventional systems. I am testing this hypothesis using an approach, termed “Structural Complexity Enhancement (SCE), that promotes old-growth characteristics (Tyrrell and Crow 1994b, McGee et al. 1999) while also providing opportunities for timber harvest (Table 1). SCE is compared against two conventional uneven-aged systems advocated regionally for sustainable forestry (Mladenoff and Pastor 1993, Nyland 1998).

Table 1. Structural objectives and the corresponding silvicultural techniques used to promote those attributes in Structural Complexity Enhancement

Structural Objective	Silvicultural Technique
Multi-layered canopy	<ul style="list-style-type: none"> • Single tree selection using a target diameter distribution • Release advanced regeneration • Establish new cohort
Elevated large snag densities	<ul style="list-style-type: none"> • Girdling of selected medium to large sized, low vigor trees
Elevated downed woody debris densities and volume	<ul style="list-style-type: none"> • Felling and leaving, or • Pulling over and leaving
Variable horizontal density	<ul style="list-style-type: none"> • Harvest trees clustered around “release trees” • Variable density marking
Re-allocation of basal area to larger diameter classes	<ul style="list-style-type: none"> • Rotated sigmoid diameter distribution • High target basal area (34 m²/ha.) • Maximum target tree size set at 90 cm dbh
Accelerated growth in largest trees	<ul style="list-style-type: none"> • Full and partial crown release of largest, healthiest trees

The objectives of SCE include multi-layered canopies, elevated large snag and downed coarse woody debris (CWD) densities, variable horizontal density, and re-allocation of basal area to larger diameter classes. The later objective is achieved, in part, using an unconventional marking guide based on a rotated sigmoid target diameter distribution. Rotated sigmoid diameter distributions have been widely discussed in the theoretical literature (O'Hara 1998), but their silvicultural utility has not been field tested. Sigmoidal form is one of several possible distributions in eastern old-growth forests (Leak 1996 and 2002, Goodburn and Lorimer 1999). These vary with disturbance history, species composition, and competitive dynamics. The distribution offers advantages for late-successional structural management because it allocates more growing space and basal area to larger trees. If the rotated sigmoid distribution proves sustainable in terms of recruitment, growth, and yield, it would suggest that silviculturalists have greater flexibility in managing stand structure, biodiversity, and other ecosystem functions in the northern forest region than previously recognized.

Methods

The study is replicated at two mature, multi-aged, northern hardwood forests in Vermont. There are three experimental manipulations. The first two are conventional uneven-aged systems (single-tree selection and group-selection) modified to increase post-harvest structural retention and to represent best available practices. Prescriptions are based on a target residual basal area of 18.4 m²/ha, max. diameter of 60 cm, and q-factor of 1.3. Group-selection cutting patches are each approximately 0.05 ha in size. The third treatment is Structural Complexity Enhancement (SCE). The marking guide is based on a rotated sigmoid target diameter distribution applied as a non-constant q-factor. The marking guide is also derived from a target basal area (34 m²/ha.) and maximum diameter at breast height (90 cm) indicative of old-growth structure. Accelerated growth in larger trees is promoted through full (4 or 3-sided) and partial (2-sided) crown release. Prescriptions for enhancing snag and downed woody debris volume and density are based on pre-harvest CWD volume and literature-derived targets. On one SCE unit at each of the two study area, downed logs are created by pulling trees over, rather than felling, to create pits and exposed root wads.

Each of the first two treatments (uneven-aged) is replicated twice; the third (SCE) is replicated four times. Two un-manipulated control units are located at each of the two study areas. Treatment units are 2 ha in size and separated by 50 meter (min.) buffers. Experimental manipulations (i.e. logging) were conducted on frozen ground in winter 2003. Sample data were collected from five 0.1 ha permanent sampling plots established in each treatment unit. Forest structure data, including leaf area index (LAI), detailed measurements of individual trees, and coarse woody debris (CWD) densities and volumes, have been collected over two years pretreatment and two years post-treatment. A before/after/control statistical approach was used to analyze sample data. Fifty year simulations of stand development were run in NE-TWIGS, comparing alternate treatments and no treatment scenarios.

Results

Residual stand structure

Post-harvest basal area, relative density, canopy closure, and LAI were significantly ($\alpha = 0.05$) higher under SCE. Canopy closure was most variable across group-selection units. There were significant differences ($P < 0.001$) in LAI responses among treatments. Single-tree and group selection cuts reduced LAI by 19.8 and 29.9% respectively. LAI reductions were lowest in SCE units (9.4%), indicating high retention of vertical complexity. LAI was significantly more spatially variable for both SCE ($P = 0.031$) and group-selection ($P = 0.010$) compared to single tree selection; within-treatment variance was not significantly different between SCE and group-selection units ($P = 0.296$). These results are indicative of the high degree of horizontal structural variability expected for both group-selection and SCE, achieved in the later through variable density marking and clustered harvesting around crown-release trees. SCE shifted residual diameter distributions to a form statistically indistinguishable from the target rotated sigmoid form. Continued reallocations of basal area and stem density into larger size classes, yielding a rotated sigmoid distribution spanning a full range of diameter classes, are thus likely over time.

Crown release and vertical development

Marking guides were used to crown release 45 dominant trees per ha. on average in SCE units. When combined with the average pre-treatment number (20 per ha) of large trees (> 50 cm dbh), this exceeds our future target of 55 large trees per ha. The excess provides a “margin of safety” to accommodate canopy mortality. Crown release is likely to accelerate growth rates in the affected dominant trees by 50% or more based on previous modeling (e.g. Singer and Lorimer 1997). Crown release also resulted in spatial aggregations of harvested trees, creating canopy openings and variable tree densities. Elevated light availability associated with this effect is likely to promote vertical differentiation of the canopy through release and regeneration effects.

Coarse woody debris enhancement

SCE prescriptions resulted in substantially elevated densities of both downed coarse woody debris and standing snags. The structural complexity enhancement treatments increased coarse woody debris (> 30 cm dbh) densities, on average, by 10 boles/ha for snags and 12 boles/ha for downed logs. Snags were created primarily by girdling diseased, dying, or poorly formed trees. Pulling trees over was successful in most cases at creating large exposed root wads and pits. There were statistically significant differences ($P = 0.002$) between treatments with respect to downed CWD recruitment. Post-harvest CWD (logs > 10 cm diameter) volumes were 140% higher on average than pre-harvest levels in SCE units; mean CWD volume increased 30% in conventional uneven-aged units.

Projected stand development

Stand development projections suggest that total basal area under SCE will, on average, approach 34 m²/ha after 50 years of development. This is >50 % higher than the mean for the conventional uneven-aged units. However, this difference is an artifact of the higher residual basal area left by SCE. The projections showed no significant differences in absolute growth rates between treatment scenarios. However, when projected development is normalized against the null scenario (development expected with no treatment), the simulations indicate that conventional systems increase cumulative basal area increment (CBAI) more, at least at the stand level. Both SCE ($P < 0.05$) and conventional treatments ($P < 0.01$) are projected to significantly

accelerate tree growth rates above that expected with no treatment based on NE-TWIGS modeling. SCE is projected to significantly enhance rates of large tree recruitment over no treatment scenarios. There will be an average of 17 more large trees (> 50 cm dbh) per ha than there would have been without treatment after 50 years in SCE units. There will be 29 fewer large trees/ha on average in the conventional units than would have developed in the absence of timber harvesting.

Discussion

Silvicultural techniques can be used effectively to promote old-growth structural characteristics in northern hardwood and mixed northern hardwood-conifer forests. Both the uneven-aged and structural complexity enhancement (SCE) systems tested maintain high levels of post-harvest structure and canopy cover. However, SCE maintains, enhances, or accelerates develop of CWD, canopy layering, overstory biomass, large tree recruitment, and other structural attributes to a greater degree. The higher levels of structural retention associated with SCE are indicative of lower intensity, minimal impact forestry practices.

Both SCE and conventional uneven-aged treatments will result in accelerated tree growth rates according to NE-TWIGS projections. Since the conventional treatments had significantly lower residual basal areas, this result is consistent with previous research on growth responses to stocking density in northern hardwoods (Leak et al. 1987). However, an important effect of SCE is the promotion of large tree recruitment, whereas this process is impaired under conventional treatments that include maximum diameter limits. Projected basal area is also higher after 50 years of development under SCE due to greater post-harvest structural retention.

SCE resulted in significantly elevated CWD densities and volumes. However, it remains uncertain whether this effect will persist until natural recruitment rates increase, or, alternatively, whether CWD enhancement in mature stands has only transient or short-term management applications. Most of the newly added CWD is un-decayed. It is likely than decay class distributions will shift over time towards well-decayed material. As time passes, this will render silviculturally enhanced CWD increasing available as habitat and as a nutrient source (Gore and Patterson 1985, Tyrrell and Crow 1994a).

Table 2. Potential applications of SCE as an approach to incorporating old-growth structure into managed forests

Application	# Entries	Late-Successional Structural Development
Old-growth promotion	One or possibly two entries	High
Riparian management	Single or multiple	Moderate to high
Timber emphasis	Multiple	Low to moderate

SCE has a variety of useful applications, ranging from restoration to low intensity timber management. However, the degree of implementation and the number of stand entries will vary

by application (Table 2). Forest managers have the flexibility to manage for a wide range of structural characteristics and associated ecosystem functions. Uneven-aged systems provide some but not all of these or provide them to a more limited extent. Maximum diameter limits significantly retard the potential for large tree (live and dead) recruitment based on the results. Stand development is thus continuously truncated by multiple uneven-aged cutting entries. The results show that SCE's marking guide can be used to successfully achieve a rotated sigmoid diameter distribution. Unconventional prescriptive diameter distributions, such as the rotated sigmoid, combined with higher levels of residual basal area, very large (or no) maximum diameters, and crown release are alternatives for retaining high levels of post-harvest structure and for promoting accelerated stand development.

Acknowledgements

This research was supported by grants from the USDA CSREES National Research Initiative, the Vermont Monitoring Cooperative, the Northeastern States Research Cooperative, and the USDA McIntire-Stennis Forest Research Program.

Literature Cited

Cogbill, C.V. 2000. Vegetation of the presettlement forests of northern New England and New York. *Rhodora* 102:250-276.

Franklin, J.F., T.A. Spies, R. Van Pelt, A. Carey, D. Thornburgh, D.R. Berg, D. Lindenmayer, M. Harmon, W.S. Keeton, D.C. Shaw, K. Bible, and J. Chen. 2002. Disturbances and the structural development of natural forest ecosystems with some implications for silviculture. *Forest Ecology and Management* 155:399-423.

Goodburn, J.M. and C.G. Lorimer 1999. Population structure in old-growth and managed northern hardwoods: an examination of the balanced diameter distribution concept. *Forest Ecology and Management* 118: 11-29.

Gore, J.A. and W.A. Patterson. 1985. Mass of downed wood in northern hardwood forests in New Hampshire: potential effects of forest management. *Canadian Journal of Forest Research* 16:335-339.

Keeton, W.S. 2004. Managing for old-growth structure in northern hardwood forests. In: C.E. Peterson (ed.). *Balancing ecosystem values: innovative experiments for sustainable forestry*. USDA Forest Service General Technical Report, Pacific Northwest Research Station (In Press).

Leak, W.B. 1996. Long-term structural change in uneven-aged northern hardwoods. *Forest Science* 42:160-165.

Leak, W.B. 2002. Origin of sigmoid diameter distributions. USDA Forest Service Research Paper NE-718.

Leak, W.B., D.S. Solomon, and P.S. DeBald. 1987. *Silvicultural guide for northern hardwood types in the Northeast (revised)*. USDA Forest Service Research Paper NE-603. 36 pp.

Lorimer, C.G. 2001. Historical and ecological roles of disturbance in eastern North American forests: 9,000 years of change. *Wildlife Society Bulletin* 29:425-439.

McGee, G.G., D.J. Leopold, and R.D. Nyland. 1999. Structural characteristics of old-growth, maturing, and partially cut northern hardwood forests. *Ecological Applications* 9:1316-1329.

Mladenoff, D.J. and J. Pastor. 1993. Sustainable forest ecosystems in the northern hardwood and conifer forest region: concepts and management. Pages 145-180 in: G.H. Aplet, N. Johnson, J.T. Olson, and V.A. Sample (eds.). *Defining Sustainable Forestry*. Island Press, Washington, DC 328 pp.

Nyland, R.D. 1998. Selection system in northern hardwoods. *Journal of Forestry* 96:18-21.

O'Hara, K.L. 1998. Silviculture for structural diversity: a new look at multi-aged systems. *Journal of Forestry* 96:4-10.

Seymour, R.S., A.S. White, and P.H. deMaynadier. 2002. Natural disturbance regimes in northeastern North America: evaluating silvicultural systems using natural scales and frequencies. *Forest Ecology and Management* 155:357-367.

Tyrrell, L.E. and T.R. Crow. 1994a. Dynamics of dead wood in old-growth hemlock-hardwood forests of northern Wisconsin and northern Michigan. *Canadian Journal of Forest Research* 24:1672-1683.

Tyrrell, L.E. and T.R. Crow. 1994b. Structural characteristics of old-growth hemlock-hardwood forests in relation to stand age. *Ecology* 75:370-386.