Eastern CANUSA Forest Science Conference

November 1-3, 2012

University of New Hampshire

Durham, New Hampshire

Conference Proceedings

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Hosted by:

University of New Hampshire

Compiled by:

Theodore E. Howard

Iuliia Drach

Introduction

WELCOMING REMARKS – Dr. Theodore Howard, Professor of Forestry Economics and Chair, Department of Natural Resources and the Environment, Conference Chair

Good morning and welcome to the University of New Hampshire. Bonjour et bienvenue à l'Université du New Hampshire. We are pleased to be hosting the 6th bi-annual ECANUSA Forest Science Conference. We are also pleased that you have made it to Durham, despite the widespread damage from Hurricane Sandy.

While UNH is hosting ECANUSA 2012, we enjoy the support of several organizations including UNH's Department of Natural Resources and the Environment and its Ruth E. Farrington Fund as well as the USDA Forest Service's Northern States Research Cooperative and its cooperating institutions, UNH, the University of Maine, the University of Vermont, and SUNY ESF. We are also sponsored by the Canadian Consulate in Boston; Consul General Patrick Binns sends his congratulations and best wishes for a successful conference. We have also benefited from the work of previous ECANUSA host institutions and their respective conference chairs.

There are several reasons we decided to host ECANUSA at UNH this year. Among these are that UNH has a 100 year tradition in forestry education and research and that we are highly regarded for both endeavors. We also share a common forest resource and similar problems with the rest of the ECANUSA region. Our theme, Forest Science at the Urban-Rural Interface, however, reflects our close proximity to the Boston-Washington megalopolis. And, just as Hurricane Sandy blanketed nearly ECANUSA's entire domain, the people of the region, and their values, have had, and will continue to have, profound impacts on forestry, and by extension, on forestry research.

Remarks by John Aber

With this as backdrop, it is appropriate that one of the world's foremost forestry researchers welcome you to UNH and to this conference. Dr. John Aber is Provost and Executive Vice-President of the University of New Hampshire. A 2012 recipient of the prestigious Wilbur Cross Distinguished Achievement Medal from Yale University, Dr. Aber is widely published and cited in the field of forest ecology and is especially known for his work in nitrogen cycling. In addition to his research and teaching, he has served as UNH's Vice-President for Research and held other leadership positions. He was the guiding force behind our doctoral program in natural resources, now natural resources and earth systems science, the largest and most successful doctoral program at UNH. He has also found time to serve on town government positions, and in our early days at UNH, as soccer coach to first and second graders! We, in the Department of Natural Resources are justly proud to have John as a colleague and friend. Please welcome Dr. John Aber.

Remarks by Katherine Sinacore

Too many years ago I was a doctoral student in forestry economics at Oregon State University. We were encouraged by our faculty mentors to attend the Western Forest Economists Meeting every May. At my first meeting, I met a graduate student from the University of Minnesota and while we have collaborated only once during the intervening three plus decades, our paths continue to cross and we share insights and conversations and did so as recently as late week in at the Society of American Foresters' meeting in Spokane, Washington. My point is that we hope that the many graduate students attending this

conference will forge long term connections with your fellow graduate students with whom you will share ideas, conversations, and collaborations over the coming decades of your careers.

On behalf of ECANUSA 2012, Katherine Sinacore has a special welcome for all graduate students. Katherine has a BS in Biology from Wake Forest University and is currently in the second year of her master's degree program in Natural Resources: Forestry Option. Her research focuses on uneven-aged management of northern hardwood stands – and you can learn more by visiting her poster during lunch time today! Please welcome Katherine Sinacore.

INTRODUCTION OF KEYNOTE SPEAKERS

Address by Sen Wang

As I noted in my initial remarks, the theme for this conference is "Forest Science at the Urban-Rural Interface." The forests of eastern Canada and the northeast United States are juxtaposed with urban and urbanizing areas. To understand the roles of science in helping society understand its environment and to help society achieve its goals, we need to have a better understanding of society itself.

Our first keynote speaker, Dr. Sen Wang, will help us do just that. Dr. Wang is a forestry economist with the Canadian Forest Service, based in Ottawa. His research areas include economics and policy and Canada's competitiveness in international forest products markets. He holds a BA in English from the University of Beijing, and MS and Ph.D. degrees in forest management and forestry economics, respectively from the University of British Columbia. His recent work on the power of urban values made him a natural choice for our conference. His topic today is "Forests in an Increasingly Urbanized Society". Please welcome Dr. Sen Wang.

Address by Pamela Templer

As forest researchers, especially in the northern tiers of New England and the great forests of Quebec and the Maritimes, we often lose sight that there is another forest, the urban forest. This urban forest is as an ecosystem as worthy of our study as the forest primeval, "the murmuring pines and the hemlocks" of Longfellow's Evangeline: A Tale of Acadie. We heard from Dr. Wang about the importance of urban social values. Now we turn to the science of forest ecology to learn about the ecological processes in the forest in which this urban population lives.

Our second keynote speaker is Dr. Pamela Templer, associate professor of biology at Boston University, Boston, Massachusetts. Her doctoral degree is from Cornell University. Dr. Templer specializes in ecosystem ecology and she is particularly interested in the effects that human activities, such as fossil fuel combustion, introduction of non-native plant species, land use change and climate change, have on forest ecosystems. She is involved in the Boston ULTRA-Ex (Urban Long-Term Research Area Exploratory) project**,** a National Science Foundation-funded research platform investigating the space-time variation in Metropolitan Boston's carbon metabolism. Dr. Templer's talk is titled "Nitrogen and Carbon Cycling in Urban Forests: Implications for Water." Please welcome Dr. Templer.

Address by Robert Nelson

Marion Clawson, economist and originator of the travel-cost model of valuation widely used in forest recreation and other resource valuation studies, and former director of the US Department of the Interior's Bureau of Land Management, the agency with the largest public land management responsibility in the United States, wrote a small book in the 1970s, titled "Forests for Whom and for

What?" As we have wrestled with that question in the US, two conflicting perspectives have emerged – one of multiple use, the other of ecosystem management.

While the debate is often cast in scientific terms, our next speaker will suggest a different, and deeper, approach. Dr. Robert Nelson is professor of public policy at the University of Maryland's School of Public Policy. He worked in the Office of Policy Analysis of the Office of the Secretary of the Interior from 1975 to 1993 and has served on Congressional and Presidential Commissions. He has worked extensively in the international arena. Dr. Nelson holds a Ph.D. in economics from Princeton University (1971). He has become an authority on secular religions and his publications will get you thinking about science, religion and resource management. It is a pleasure to welcome Dr. Robert Nelson to ECANUSA 2012.

Acknowledgements

The 6th ECANUSA Forest Science Conference, as with any ECANUSA conference, is only possible with the support and hard work of many organizations and individuals. We enjoyed the support of several organizations including UNH's Department of Natural Resources and the Environment (NREN) and its Ruth E. Farrington Fund. NREN staff, Judith O'Donnell worked tirelessly on the program and communications with participants; graduate students Gabriel Roxby, Daniel Kilham and Katherine Sinacore assisted with the program and field trip. Iuliia Drach compiled the abstracts and other materials to form the record of this conference. UNH's Office of Conferences and Catering helped with meeting logistics.

The USDA Forest Service's Northern States Research Cooperative (NSRC) and its cooperating institutions, UNH, the University of Maine, the University of Vermont, and SUNY ESF. We are especially grateful to the Cooperative for a grant that funded many aspects of the conference and helped showcase research funded by the NSRC. We were also sponsored by the Canadian Consulate in Boston.

We extend special thanks to William Leak and Mariko Yamasaki, USDA Forest Service Northern Research Station, for hosting our Saturday field trip on the Massabesic Experimental Forest in nearby Alfred, Maine. Any day in the woods with Bill and Mariko is a day well spent.

We have also benefited from the work of previous ECANUSA host institutions and their respective conference chairs. Everyone shared their wisdom with us, helping make the conference a success.

We also acknowledge the participants, whether presenters or listeners, for coming to UNH and being part of the 6th ECANUSA Forest Science Conference. We look forward to seeing everyone in 2014 at the 7th conference to be hosted by the University of Quebec at Rimouski (L'Université du Québec à Rimouski).

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Conference Program

Eastern CANUSA
Forest Science Conference

UNIVERSITY OF NEW HAMPSHIRE
Durham, New Hampshire

Thursday, November 1st, 2012 Through
Saturday, November 3rd, 2012

7:00 PM	**9:00 PM**		**Thursday, November 1, 2012** **ICE – BREAKER SOCIAL & DINNER (CASH BAR)**
8:30 AM	**11:30 AM**		**Friday, November 2, 2012 GENERAL SESSION** **Holloway Commons Conference Center**
			Introduction & Welcome: • Dr. Ted Howard, University of New Hampshire • Dr. John Aber, Provost, University of New Hampshire • Katherine Sinacore, Graduate Student, University of New Hampshire **Keynote Presentations & Plenary Sessions:** • Dr. Sen Wang, Canadian Forest Service (8:40 - 9:30 am) ***"Forests In An Increasingly Urbanized Society"*** • Break (9:30-9:50 am) • Dr. Pamela Temple, Boston University (9:50-10:40 am) ***"Nitrogen and Carbon Cycling in Urban Forests: Implications for Water and Air Quality"*** • Dr. Robert Nelson, University of Maryland (10:40-11:30 am) ***"Multiple-Use Forest Management versus Ecosystem Forest Management: A Religious Question"*** **Lunch & Poster Session** (12:00-1:30 pm) Location: Huddleston Ballroom

CONCURRENT SESSIONS
FRIDAY, NOVEMBER 1, 2012

1:40 PM	3:20 PM	SILVICULTURE SESSION ~ A1	MANAGEMENT & ENVIRONMENTS SESSION ~ A2
		Growth, Mortality and Harvest In 10 Silvicultural Treatments Over 60 Years On The Penobscot Experimental Forest in Maine, USA *Laura S. Kenefic, John C. Brissette and Aaron R. Weiskittel*	How Landowner Engagement Affects Forest Management Practices In Northern Vermont *Ellis, B. E. and R. H. Germain*
		Nonselective Partial Harvesting In Maine *Ben Rice, Robert Wagner and Aaron Weiskittel*	Remote Sensing of Canopy Condition Across the Northeast: Trends and Patterns 1984- 2009 *Jennifer Pontius and Mary Martin*
		Tree Regeneration In Partially Harvested Mixed Wood Stands in Maine *Jeffrey M. Lombardo, Laura S. Kenefic, Jeremy S. Wilson and Aaron R. Weiskittel*	Northern Forest Logging Industry Assessment: Phase 1 Result *Bennet Leon, Jeffrey Benjamin, Jessica Leahy, and Richard Root*
		How Silvicultural Treatments Affect Carbon Storage On The Penobscot Experimental Forest: A 60 Year Perspective *Joshua Puhlick, Aaron Weiskittel, Laura Kenfic, Ivan Fernadez, Shawn Fraver, Lindsay Rustad, Ranky Kilka and John Brissette*	Development and Evaluation of The Acadian Variant of The Forest Vegetation Simulator *Aaron Weiskittel, John Kershaw and Mathew Russell*

		Response of Softwood Regeneration to Commercial Thinning in Two Northeastern Spruce-Fir Stand Types: 1st Decade Results From the Commercial Thinning Research Network in Maine *Matthew Olson, Spencer Meyer, Robert Wagner & Robert Seymour*	Modeling Forest Canopies Using Laser Point Quadrat Sampling And Survival Analysis *Daniel Maynard*

CONCURRENT SESSIONS
FRIDAY, NOVEMBER 1, 2012

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		Does Forest Certification Make A Difference for First Nations? Analyzing the FSC Process and It's Impacts for First Nations In The Boreal Forests of Quebec and Ontario *Stephen Wyatt and Sara Teitelbaum*	High-Elevation Spruce-Fir Forest In The Northern Forest: An Assessment of Ecological Value and Conservation Priorities *David A. Publicover and Kenneth D. Kimball*
		Public Perceptions and Values For Ecological Goods and Services In a Northern New Brunswick Watershed *Tonia Anderson*	Measuring Amphibian Gene Flow Across Species, Scale and Sampling Scheme In A Managed Forest *Stephanie Coster, Adrienne Kovach and Kimberly Babbitt*
		The Notion Of Governance In the New Forest Regime Of Quebec *Luc Bouthillier*	Structural Conversion of Young Conifer Regular Stands: The Convergence of Environmental and Economic Interests *Gagne, L. Sirois, L. and Lavoie, L.*

		An Oral History Place Attachment Project: Understanding the Changing Forest Landscape through the Eyes of Maine's Oldest Citizens *Marilynne Mann and Jessica Leahy*	Effects Of Woody Debris Retention On Herbaceous Layer Biodiversity In 25-Year-Old Plantation Forests In Northern New Brunswick: The First Two Years Post Commercial Thinning *Sean R. Haughian and Katherine A. Frego*
		Influence Of Management Intensity On The Productivity Of Early Successional Acadian Stands In Eastern Maine *Andrew S. Nelson, Robert G. Wagner, Michael R. Saunders, and Aaron R. Weiskittel*	Benchmark Carbon Stocks From Old-Growth Forest In Northern New England, USA *Hoover, C. M., Leak, W. B., and Keel, B. G.*

CONCURRENT SESSIONS
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		Measuring Ecosystem Health In The Connecticut Highlands *Mary L. Tyrrell, Gillian S. Paul, Jeffrey S. Ward, Corrie Folsom-O'Keefe, Patrick Comin and Stella J.M. Cousins*	Sugar Maple In The Lower St. Lawrence: Will The Increase In Abundance Continue? *Valérie Delisle-Gagnon, Luc Sirois and Dominique Arseneault*
		Response Of Tree Growth and Water Use Efficiency to Climate Change and Nitrogen Deposition In A Temperate Deciduous Forest In the Northeastern U.S. *Katie Jennings, Heidi Asbjornsen and Kathleen Eggemeyer*	Growth Versus Protection From The Cold: A Tradeoff For American Chestnut Grown At The Species' Northern Range Limit? *Paul G. Schaberg, Thomas M. Saielli, Gary J. Hawley, Joshua M. Halman and Kendra M. Gurney*

		Predicting High Quality Sites of *Fraxinus Nigra* (Black Ash) Across Maine and Northern New York: An Approach to Prioritizing A Region's Response to Environmental Stressors *Kara K. Lorion, William H. Livingston, John Daigle, Robert Lilieholm and Darren Ranco*	The Legacy Of Foliar Winter Injury On Xylem Growth And Aboveground Carbon Sequestration For Red Spruce In the Northeastern Forest *Alexandra M. Kosiba, Paul G. Schaberg, Gary Hawley, and Christopher F. Hansen*
		Impaired Physiology of Sugar Maple (Acer Saccharum) Under Aluminum-Treatment May Alter Competitive Relations With Sympatric Species *Joshua M. Halman, Paul G. Schaberg, Gary J. Hawleyand Christopher F. Hansen*	The Relative Importance Of Harvesting And Local Site Factors In Structuring Regeneration Abundance And Composition *Mohammad Bataineh, Laura Kenefic, Aaron Weiskittel, Robert Wagner, John Brissette, and Robert Seymour*
		Prospects for Rehabilitation Forestry Through Carbon Market Participation On Over-Harvested Former Industrial Northern Hardwood Forests *William S. Keeton, Emily T. Russell-Roy, Jennifer Pontius, and Charles Kerchner*	The Effect Of Riparian Forest Structure On In-Stream Nutrient Uptake And Metabolism In The Northeast *Heather A. Bechtold, Emma J. Rosi-Marshall, Dana R. Warren, William Keeton, Jon J. Cole*
CONCURRENT SESSIONS SATURDAY, NOVEMBER 2, 2012			
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		Fifty-Plus Years Of Stand Development Following Shelter Wood Cutting In Northern Conifers *John C. Brissette, Laura S. Kenefic and Aaron Weiskittel*	Sustained Yield Management On Family Woodlands In Vermont's Northern Forest *Maker, N.F. and R.H. Germain*
		Partial Cutting In Old-Growth Boreal Stands: A Feasible Approach? *Jean-Claude Ruel*	Expanding Interface In The Northeast's "Asbestos Forest": Implications For Future Fire Control Program *Lloyd Irland*
		Plantation Of Hybrid Poplar Clones On A Forest Clear-Cut Site: Early Survival And Growth *Hector G. Adégbidi*	Whole Tree Conventional Harvesting: Assessing Productivity Differences *Gabriel Roxby and Theodore Howard*
		Linking Microenvironment Changes To Regeneration Dynamics After Patch-Selection Cutting In Quebec's Temperate Mixed Wood Forest *Patricia Raymond and Marcel Prévost*	
11:40 AM	**12:00 PM**	**CONFERENCE WRAP UP**	
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Featured Papers

Tree Regeneration in Partially Harvested Mixedwood Stands in Western Maine: Preliminary Findings

Jeffrey M. Lombardo[1], Laura S. Kenefic[2], Aaron R. Weiskittel[3], and Jeremy S. Wilson[4]

ABSTRACT

Mechanized partial harvesting conducted with a feller buncher and grapple skidder has become common on commercial forestland in Maine. These types of operations leave residual stands characterized by distinct trail systems with between-trail matrices of lightly to heavily partially cut forest. The long-term effects of these unique spatial patterns on growth and yield are poorly understood, particularly with regard to tree regeneration. This paper investigates the influence of harvest trails on seedling and sapling density and browsing in six mechanically partially harvested mixedwood stands in western Maine, 8-10 years after the most recent harvest. The results showed an average of 38% of stand area in machine trail corridor, in which no overstory trees (≥ 11.4 cm diameter at breast height [dbh]) were present. Densities of seedlings (<1.3 cm dbh) were highest outside of the area utilized by harvest equipment; we observed an average of 94,920 stems ha^{-1} in the matrix (i.e., between trails) and 64,349 stems ha^{-1} in trails. Densities of saplings (1.3 to <11.4 cm dbh) were also greater in the matrix areas: 1,119 stems ha^{-1} in the matrix and 711 stems ha^{-1} in trails. Browsing was observed throughout these stands, impacting 45% of seedlings over 30.4 cm in height. These preliminary findings suggest that trails in mechanically partially harvested mixedwood stands have the potential to negatively impact first-decadal stand-level growth; they are unoccupied by residual overstory growing stock and have a lower density of seedlings and saplings than non-trail areas. Ongoing analyses of regeneration composition of desirable and competing species, as well as relationships between regeneration, site conditions, and understory competition will further clarify the extent and distribution of regeneration relative to machine trails, and assist forest managers in planning operations and follow-up silvicultural treatments.

Keywords: partial harvest, natural regeneration, Acadian Forest, silviculture

Introduction

Currently, 94% of timber harvests in Maine are classified as partial harvests (Maine Forest Service 2012). Many of these harvests occur on commercial forestland, where mechanized operations conducted with equipment such as feller bunchers and grapple skidders create distinct spatial patterns. Often, the residual stand consists of a forest matrix interspersed with 4 to 6-m wide strips cleared for skidding at approximately 20-m intervals. The long-term effects of these distinct patterns on growth and yield in the Acadian Forest region are poorly understood, particularly with regard to tree regeneration. Regeneration composition, species richness, and density have been quantified in partially harvested stands in the region at the stand level (Brissette et al. 1996), as well as within harvest-generated gaps (Olson and

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Wagner 2011), but variability in regeneration in relation to trail pattern has not been documented in this region.

The goal of this research is to quantify the status of the residual stand and associated regeneration following mechanized partial harvesting, to inform operations and subsequent silvicultural treatments. Objectives are to quantify structure and composition of the residual overstory, density and composition of the sapling and seedling regeneration classes, and browsing by ungulate populations in order to adequately characterize the distribution of trees along trails.

Methods

In order to characterize the regeneration response in partially harvested stands following mechanized operations, we quantified density and composition of the overstory, saplings, and seedlings, and browsing by ungulates (deer and moose) in six mixedwood stands on commercial forestland in western Maine (Table 1). Sampling was conducted between the months of May and August, 2012. All stands were stocked with mature trees prior to harvest, which occurred approximately ten years before sampling. All sites were managed by a single company and harvested with feller bunchers and grapple skidders between 2002 and 2004. The history of these stands is not well documented prior to 1980, but it is known that no harvests took place for at least 20 years prior to the most recent entry. The most recent treatment was an improvement cutting which removed poorly formed and overtopped species in order to encourage growth of residual trees of desirable species. Species at risk of forest pests and diseases, such as balsam fir (*Abies balsamea* (L.) Mill), were removed whenever possible. Soil drainage of the stands, described by Briggs' (1994) drainage class guidelines, ranged from moderately well drained to well-drained.

Table 1. Stand-Level Attributes of the 6 study stands.

Stand	Area (ha)	Overstory*	Briggs' Site Class+	Plots	Post-Harvest Basal Area (m^2ha^{-1})	Treatment Year
1	8.3	RS,YB,SM,BF	2	21	17.5	2004
2	9.6	YB,RS,SM,BF	2	21	14.2	2003
3	4.1	YB,RS,SM, BF	3	24	17.8	2003
4	6.5	RS,RM,YB,SM	2	25	17.6	2002
5	10.0	RM,YB,RS,SM	1	23	14.4	2003
6	9.0	RS,YB,SM,RM	2	22	12.7	2004

*Species Abbreviations: RS-red spruce, YB-yellow birch, SM-sugar maple, BF-balsam fir, RM-red maple
+Site Class: 1-well drained, 2-moderately well drained, 3-somewhat poorly drained

Table 2.
Height classes utilized in 1/2500 ha seedling plots.

Class	Height (cm)
1	0 - 30.4
2	30.5 - 69.9
3	70.0 - 182.9
4	183.0 - <1.3cm dbh

Within each stand, three transect start points were placed in ArcGIS 10.1 (ESRI 2011) by generating random points within stand polygons. A 100-m transect was projected from each of these points, using a randomly generated azimuth integer (Random.org 2012) between 0 and 360 until an azimuth was projected that fell completely within the stand, creating a total of eighteen transects. In the field, plots were placed every 20 m along transects and in the center of skid trails upon trail intersection. This resulted in 63 matrix plots and 73 trail plots. While walking the transects, length of intersection with harvest trail or residual matrix was noted and used for a determination of the total stand area in different conditions.

Transects were subdivided into two condition types: matrix, the portion of the stand containing overstory trees 11.4 cm or greater in diameter at breast height (dbh, cm), and trail: the corridor including the machine tracks which was devoid of any overstory trees. At each plot, a 20 ft^2 (approximately 2 m^2) basal area factor (BAF) prism was used to capture trees with a dbh greater than 11.4 cm at 1.37 m above ground level; dbh and species of these trees were recorded. A 5.6-m radius (1/100-ha) plot was used to count saplings 1.3 cm or greater in dbh. Fixed radius plots with a radius of 1.1 m (1/2500 ha) were positioned over plot center, within which seedlings less than 1.3 cm dbh were counted by height class (Table 2).

Preliminary data analysis was conducted in order to determine total stand area in trail; density, composition, and within-stand position of regeneration; and proportion of stems browsed. All analysis utilized R (version 2.15.2) statistical analysis software (R Development Core Team 2012). Pairwise comparisons of raw means were conducted with a one-way analysis of variance (ANOVA) and Tukey's honestly significant difference at $\alpha = 0.05$. For this preliminary assessment, only density data were analyzed.

Results

Harvest trails from the most recent entry occupied 38.2 ± 2.8% (mean ± standard error) (range 29-47%) of stand area, while the remaining 61.8 ± 2.8% (range 53-71%) of stand area was a matrix containing some overstory trees (Figure 1). Within the trail corridors, 61.7% of the area (23.6% of the entire stand) showed visible evidence of ground disturbance from machinery. Browsing rates appeared to be undifferentiated between the trail and matrix. The proportion of stems over 30.4 cm that were browsed over all plots was 0.44, while the trail and matrix had browse proportions of 0.46 $\pm$0.03, and 0.43 $\pm$0.03, respectively (Figure 2). Seedling and sapling densities were significantly higher in the matrix ($p=0.017$; Tables 3 and 4).

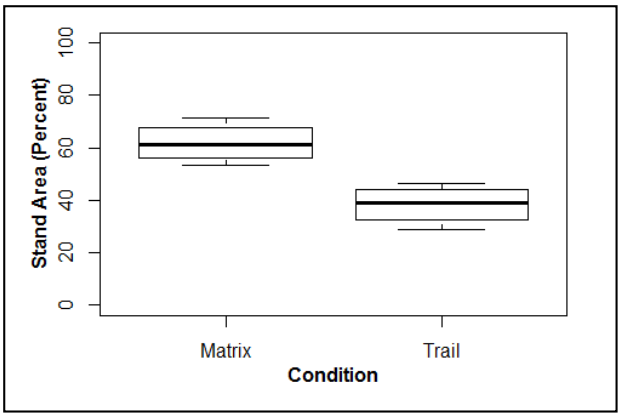

Figure 1. Percentage of total stand area in each condition.

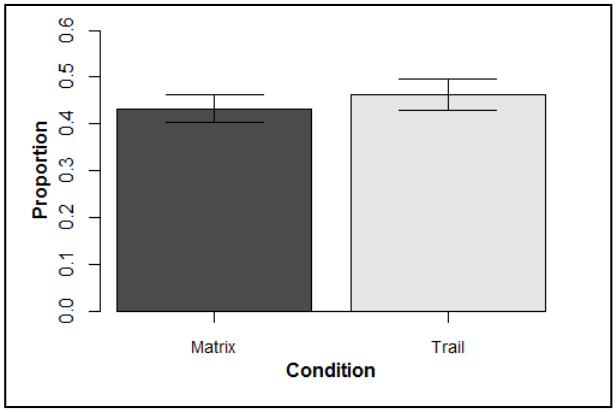

Figure 2. Mean browse proportion with standard error of stems over 30.4cm by plot condition.

Table 3. Mean seedling density by plot condition.	
Condition	Density (stems/ha)
Matrix	94,920 (11,959)
Trail	64,349 (7,531)
Parenthesized values represent standard error	

Table 4. Mean sapling density by plot condition.	
Condition	Density (stems/ha)
Matrix	1,119 (141)
Trail	711 (83)
Parenthesized values represent standard error	

Discussion

The high percentage (38%) of area without overstory trees (≥11.4 cm dbh) in the partially harvested study stands is a noteworthy finding, and suggests that stand-level overstory growth is less than what it would be with more complete utilization of canopy growing space. It is likely that the growing space is instead occupied by understory plants. Studies monitoring traditional chainsaw-cable skidder operations in Maine under a range of basal area removals suggested a lower proportion of the stand in trail, with trail area ranging from 12-22% (Nichols et al. 1993).

As noted in the results, there were fewer seedlings and saplings in the trails than in the forest matrix. This may be due in part to increased competition from understory vegetation (a hypothesis we will test in future research). In addition, though not directly investigated in this study, accumulation of logging residues and compaction are common in areas tracked by machines (Martin 1988, Zenner et al. 2007) and may impede regeneration. Another issue is that machinery must completely clear the trail of all trees in order to move unimpeded through the stand. At a minimum, care must be taken to protect advance regeneration within the matrix from damage, because established seedlings and saplings are known to be important in perpetuating mixedwood stands of tolerant conifer species (Davis 1991, Fraver and White 2005). This is especially important if management strategies are designed to favor red spruce over balsam fir, as was the case in these stands, the former of which is outgrown by balsam fir under a range of light conditions (Moores et al. 2007).

Browsing seems to be a factor in the development of the study stands, though it remained constant across our defined condition types. While the species preference of regeneration browsed by ungulates has yet to be determined in this study, we would hypothesize that preferred forage sources such as hardwoods would sustain a higher proportion and severity of browsing (e.g., see Lautenschlager 1997).

Conclusions

Preliminary results reveal differences in seedling and sapling densities between the trails and residual matrix in our mechanically partially harvested study stands. Estimating the area of the stand affected by harvest trails and the density, as well as composition, of regeneration under this partial harvest system informs trail layout. These data also inform managers regarding the need for follow-up treatments such as timber stand improvement or release, and the type of silvicultural treatment that may be most suitable at the next commercial entry. More analysis is needed to determine if other measured attributes such as canopy openness, trail width, ground condition, soil drainage, and distance from skid trails have an impact on stocking and density of regeneration of commercially valuable species. Furthermore, the effects of understory competition and browsing on these dynamics should be investigated. We anticipate that our findings will inform forest managers about the status of regeneration and the growth potential of an important subset of partially harvested stands within the Acadian Forest.

Acknowledgements

Funding for this research was provided by Agenda 2020, a U.S. Forest Service – American Forest and Paper Association collaboration; the U.S. Forest Service, Northern Research Station; and the University of Maine, School of Forest Resources. Field and laboratory assistants were Nick Ramberg, Aaron Megquier, Karl Buckley, Vance Brown, Linn Jennings, and Brittany Ross. We thank our cooperator, a forestland resource and management company, for proving access to the study sites. Reviews of an earlier version of this manuscript were provided by Patricia Raymond of the Quebec Ministry of Natural Resources and Mohammad Bataineh of the University of Maine.

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Expanding Interface in The Northeast's "Asbestos Forest": Exploratory Assessment in New Hampshire

Lloyd C. Irland[1]

ABSTRACT

An initial exploration of the connections between land use and forest fire risk in New Hampshire is reported. Though forest fire occurs at a low level, it is still subject to occasional extreme events. There is a strong association between the occurrence of fire prone types and the developed areas of the state. In the towns experiencing 100 acres or more of fire in 1947-48, today there reside 100,000 people. Not only that, but population density is positively associated with forest fire occurrence. The counties that experienced high levels of fire in 1947-48 continued to do so in 2002-2011, so the geography of fire was relatively stable. Further research is needed to modify, extend, and elucidate factors underlying these relationships and trends.

Keywords: New England, New Hampshire, forest fire risk, WUI, Intermix.

In Northeastern North America, the past two decades have seen exceptionally mild fire activity except in Quebec and Labrador. The term "asbestos forest" is frequently heard. The Northeastern Forest Fire Protection Compact includes four eastern Canadian provinces and seven Northeastern states. It provides a variety of services including sharing crews and equipment. The Compact is assessing its long-term needs for maintaining fire prevention and control capabilities (Irland Group, forthcoming). An extensive long-term database on fire history has been assembled. Some findings of this research include: (1) fire activity regionally has fallen sharply in recent decades, measured by areas burned and fire numbers; (2) intense regional droughts occur across a large portion of the region on a 50 year average return period – past regional droughts have generated major increases in wildfire; (3) such droughts have not occurred since the mid 1960's; (4) fire season weather has been unusually wet in recent decades; (5) several factors are steadily eroding fire control programs and firefighting capacity in the region; (6) forest fire managers and local fire chiefs are increasingly concerned that low-density rural sprawl is increasing lives and property at risk, at the same time as it becomes more difficult to maintain response capabilities; (7) long-term annual fire histories, as well as limited data on individual fires, display extreme value (infinite variance) behavior. This means we can count on large fires in the future, of a size far larger than recent averages.

This paper reports exploratory research that highlights trends in fire within New Hampshire since the late 1940s, and important connections to population and development patterns. The extensive sprawl into forested areas of the past decade has created new risks to life and property that have been unappreciated. Outside of the immediate forest fire/emergency management community, the slow erosion of response capability is not being noticed. Research on land use change has been extensive (see, e.g., Haight, et al. 2004; Hayden, 2004; Johnson, et al. 2012; Stewart, et al. 2007; Stein, et al. 2005; Tyrell, et al. 2004; Yale School of F&ES et al 2008). Work on the interface fire issue has naturally concentrated on the Southeast and West, where, as Hammer, et al. (2009) put it, the "wicked fire" problem meets the "wicked WUI" problem. In Southeastern Massachusetts, the problem is well appreciated (see, e.g., Blanchard and Ryan 2007). Various regional assessments have highlighted the problem at a broad level, with limited local detail (NWRA Steering Committee, 2010).

Background: Fire History – the New Hampshire Experience

For a short summary of this project, concentrating on the New Hampshire data will be useful. In common with other Northern Forest states, the state experienced a strong decline in fire severity after the 1930s and 1940s (Fig. 1). Some general hypotheses about the reasons are explored in several background papers (Irland Group 2012a, b, and c). Yet, even as the averages fell, the variability in annual area burned did not fall nearly as much (Fig. 2). The figure shows the top 20 fire years for each period, ranked from low to high, and standardized to 1 for ease of comparison. This shows that high variability in annual behavior continues. This is characteristic of extreme value behavior.

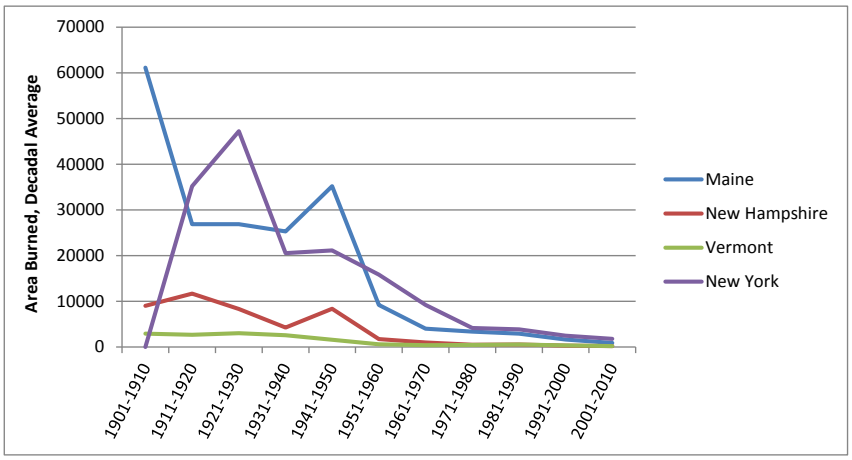


Figure 1. Northern forest states, area burned, decadal averages.

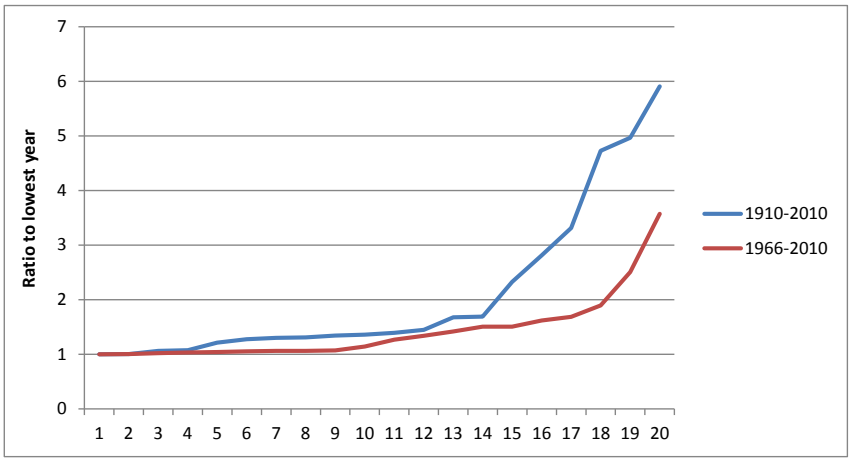


Figure 2. Top 20 New Hampshire fire years, 1910-2010 and 1966-2010, standardized to 1.0

Further, at a finer-grained level, extreme behavior is always more marked. Looking at the sizes of the 24 largest fires of October 1947 (Fig. 3) shows extreme variation in sizes. Weather conditions up to and including that month have not recurred since in this area -- which is no guarantee that they never will. It is not necessary to believe that an identical fire outbreak lies ahead of us to be moved to take this past experience seriously.

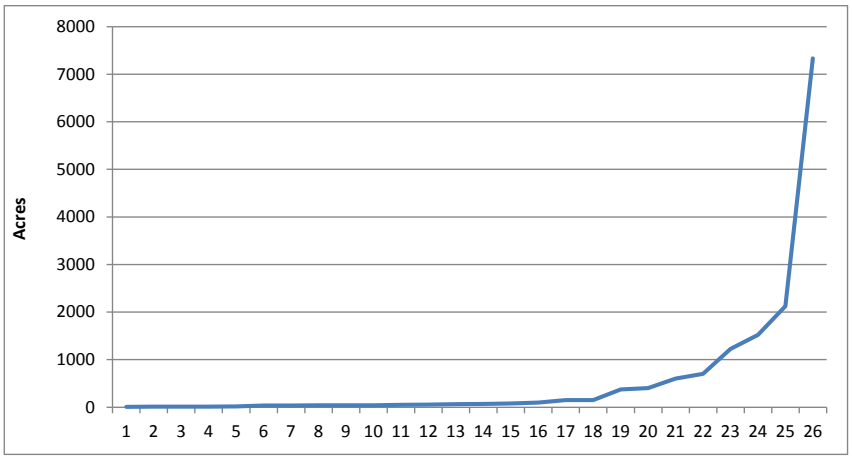


Figure 3. 24 largest fires, New Hampshire, October 1947

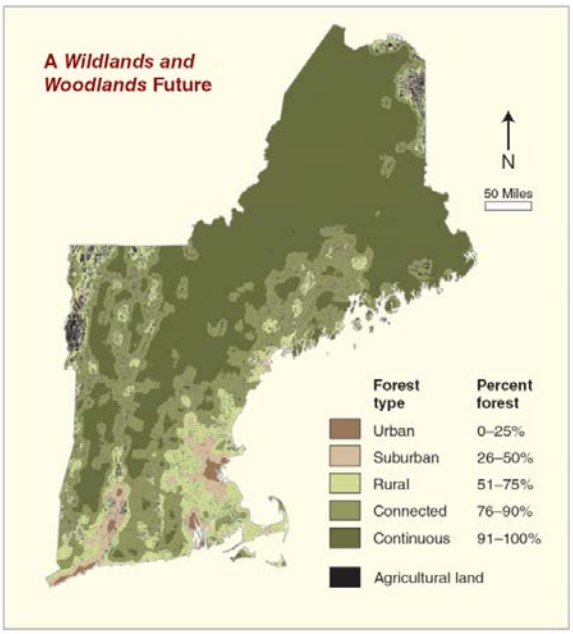
In the late 1940s, the region's landscape was primarily rural (Fig. 4); debris burning and other farm-related ignition sources were much more common. Farm property was the principal class of property at risk from wildfire.


Figure 4. (Source: New Hampshire State Forestry Annual Report, 1948).

The geographic distribution of the region's subsequent development is well known (see references); plainly considerable low density sprawl occurred at the suburban margins and around recreational areas (Fig. 5). The coincidence between low density sprawl and the more fire-prone forest types is a concern in local areas, such as Southeast Massachusetts, and ought to be more widely appreciated. It is generally agreed that northern hardwoods are in the "asbestos" category, while pitch pine is the most fire prone; some of the oak types on dry soils can readily support surface fires (Appendix Table 1). Unfortunately, there is no readily available mapping in adequate detail to be more specific about the location of these types.

The land use categories in Fig. 5 differ from those used in Table 1. For the entire Northeast, more than half the land area is in intermix and WUI conditions as assessed by Stewart, et al. (2007). Not surprisingly, in Southern New England, 65% or more of the land is WUI, while New Hampshire is intermediate at 41% – almost as high as New Jersey (49%). What this means is that for New York, New Jersey, and New England together, 33% of the landscape is in WUI. Apart from forest fire officials, fire

chiefs, and a few others in local areas that are obviously at high risk, the implications for fire control do not seem to be well appreciated.



Source: Developed from the NLCD (2001). Note: The values for 'percent forest' are based on the natural land classification of the NLCD and include: deciduous forest, mixed forest, evergreen forest, woody wetlands, open water, scrub/shrub, emergent herbaceous, wetland, grassland/herbaceous, barren land, shrubland, and estuarine wetland.

Figure 5. A wildlands and woodlands future (Source: Harvard Forest, Wildlands and Woodlots project).

For another handy map, see "The WUI in the Northeastern US," USDA-FS, NRS News, Feb. 2009 (Northern Research Station newsletter). All of the WUI mapping is being updated by the Radeloff lab (www.**silvis**.forest.wisc.edu) to the 2010 Census data. Until that is done, for a nice 2010 population density map, See: http://www2.census.gov/geo/maps/dc10_thematic/2010_Profile/2010_Profile_Map_United_States.pdf.

Table 1. WUI, Intermix, and Interface in Northeastern States, 2000.

	WUI	Intermix	Interface	Total Land
Connecticut	2,245	1,860	384	3,101
Rhode Island	466	405	61	669
Massachusetts	3,283	2,657	626	5,016
Vermont	1,805	1,556	249	5,920
New Hampshire	2,380	2,180	200	5,739
Maine	3,929	3,655	274	19,750
New York	8,831	7,082	1,748	30,216
New Jersey	2,187	1,474	712	4,745
Totals	25,126	20,869	4,254	75,156

See original source for definitions.

Source: Stewart, et al. (2007). USFS Summary stats. Jan. 2005.

Fire Prone Areas of New Hampshire: Changes Since 1947

While other methods could be imagined, it is an interesting exploratory exercise to ask three questions. (1) where, exactly, were the largest fires of 1947? (2) has the geography of fire changed since then? and (3) how many people are living in those areas now? For the first question, based on the reports of the State Forester, we can map the occurrence of the largest fires, taking those exceeding 100 acres. Other cutoff points might be preferred, after all this is about the size of a traditional New Hampshire farm. On the other hand, in a heavily developed area, this could encompass a considerable amount of valuable property. Especially noteworthy is that this fire outbreak barely scratched the mountainous areas that burned so heavily at the turn of the century. The fires of 1947 occurred much closer to the people.

Have geographic patterns of forest fire in New Hampshire changed much since 1947? Or was that year really unusual? This question may turn out to be very complex, but as an initial portrait, we can plot fire numbers over the decade 2002-2011 versus fires in 1947and 1948 (Fig. 7). The relationship for area burned showed no association at all. Because of the volatility of annual fire numbers, a decade is a useful period for the current time period. This chart suggests a remarkable stability, especially surprising considering all the changes in the state's landscape in the postwar period. Viewed at a county level, the ones with much fire in the late 1940s had much in the 2000s, and vice versa. Further research could likely tease out some of the residual variation. Notably, the improved access and professionalization of fire services in the more developed regions did not lead to any strong flattening of this curve.

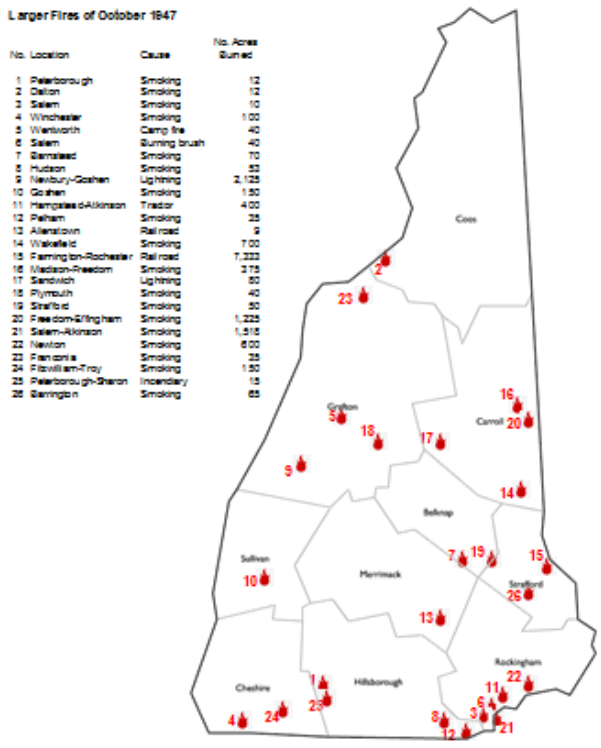


Figure 6. The fires of October 1947 that exceeded 100 acres.

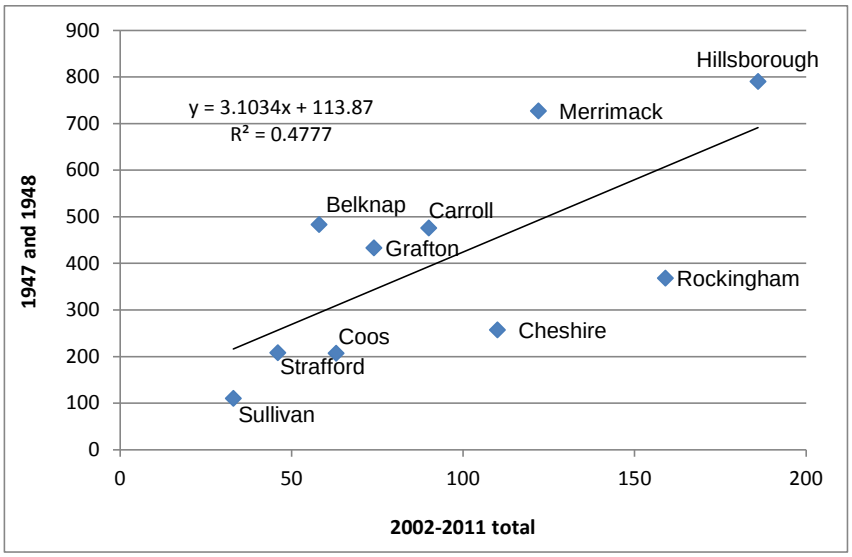


Figure 7. New Hampshire: number of fires, 2002-2011 versus 1947 and1948.

Does sprawl lead to more ignitions? This is indeed suggested by a comparison of fire numbers and area burned per square mile versus population density (Figs. 8 and 9). The data are standardized to land area to remove the influence of differing sizes of counties. This is a cross section at one time period and not a chronosequence, so more remains to be explored. Also, this expresses population density relative to all land, not just forest; the effect of this assumption should be tested in further work. These relationships are very loose and can be considered suggestive only, a first step toward further exploration.

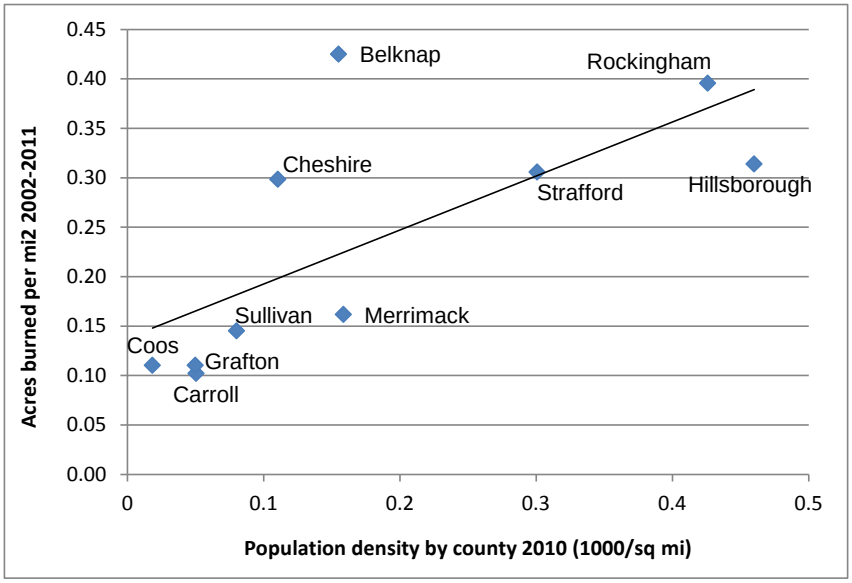


Figure 8. Acres burned per square mile, 2002-2011 versus population density.

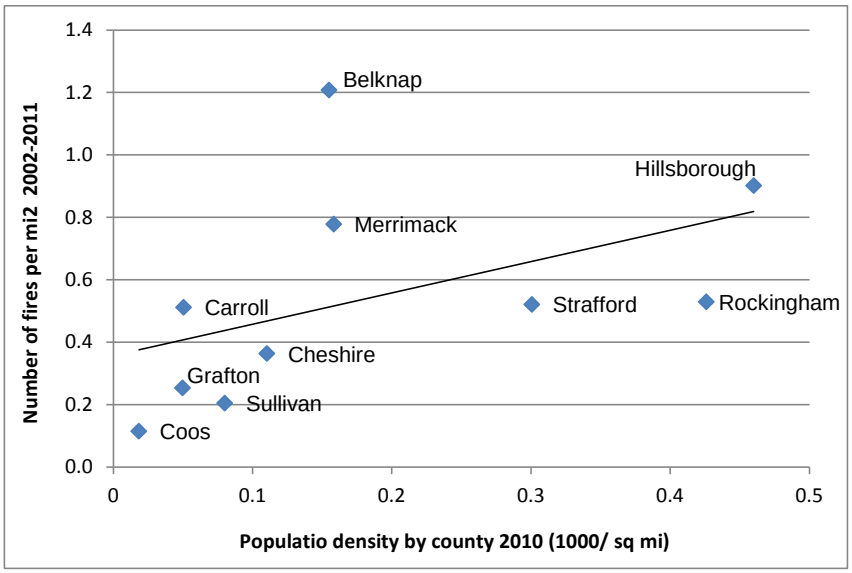


Figure 9. Number of fires per square mile, 2002-2011 versus population density.

The third question above is easily answered. In the towns experiencing fires of 100 acres or larger in 1947, 110,000 people now reside. Three of these are cities of 16,000 people or more. Could an entire city of this size, with all its impervious area, be threatened by a runaway forest fire? Would its firefighting resources be able to hold the line? Perhaps the residents of these cities should not assume that their outlying areas are any more fireproof than are the smallest villages in this list. One need not assume an identical replay of 1947, however, to agree that this question bears some further attention.

Table 2. 2010 population of New Hampshire towns with 1947 fires greater than 100 acres.

Winchester	4,341
Goshen	810
Fitzwilliam-Troy	4,541
Madison-Freedom	5,062
Hampstead-Atkinson	15,274
Newton	4,603
Wakefield	5,078
Freedom-Effingham	2,954
Salem-Atkinson	28,766
Newbury-Goshen	2,072
Farmington-Rochester	36,538
Total	110,039

3. Conclusions

New Hampshire has followed other Northern Forest states in a declining trend of area burned and fire numbers for decades. Yet, the lower levels of fire are accompanied by continued extreme behavior, in that unusually large fire years and individual fires continue to occur. The state is dominated by northern hardwood types, generally agreed to be essentially fireproof, but has local occurrence of more

fireprone types. The correspondence between fireprone types and extensive sprawl is ominous (see, for a similar forest condition, Massada et al. 2009). Not only that, but the towns which experienced fires 100 acres and larger in 1947 are now inhabited by 110,000 people. There has been an interesting stability in the geography of fire in New Hampshire: the counties that experienced relatively high levels of fire in the late 1940s continued to do so in the 2000s. Further, forest fire occurrence is roughly positively correlated with population density across counties. Additional research in greater geographic and temporal detail may modify this initial picture, and may suggest useful insights for land use, fire control, and forest management use.

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Appendix Tables

Appendix Table 1. Forest type groups in northeast

State	New York	Vermont	New Hampshire	Maine	Massachusetts	Connecticut (2009)	Rhode Island	New Jersey
Type Group								
Total forest land	18,864	4,580	4,826	17,665	3,015	1,687	350	1,962
Northern hardwoods	10,507	3,229	2,526	7,211	738	87.3	26	126
Pitch pine	78		8	5	68		12	416.8
Eastern white pine, northern red oak, white ash	517	88	363	343	334	61.6	15	7
Northern Hardwoods as percent of Total	56%	71%	52%	41%	24%	5%	7%	6%
Pitch pine	0.4%	-	0.2%	0.0%	2.3%	0.0%	3.5%	21.2%

Appendix Table 2. New Hampshire fires, FY 1947-48, by county

		No. Acres Burned	No. Fires	Average Size
Belknap	1947	217	23	9.43
	48	155	35	4.43
Carroll	47	76	26	2.92
	48	2,523	64	39.42
Cheshire	47	1,055	45	23.44
	48	419	65	6.45
Coos	47	34	17	2.00
	48	1,052	46	22.87
Grafton	47	48	21	2.29
	48	275	53	5.19
Hillsborough	47	556	100	5.56
	48	255	86	2.97
Merrimack	47	106	55	1.93
	48	2,225	67	33.21
Rockingham	47	184	81	2.27
	48	2,698	78	34.59
Strafford	47	94	21	4.48
	48	179	25	7.16
Sullivan	47	12	14	0.86
	48	297	19	15.63

Source: Reports of the State Forester.

Abstracts
of
Oral Presentations

Plantation of Hybrid Poplar Clones on a Forest Clear-Cut Site: Early Survival and Growth

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In the context the triad forest management whereby forest land is divided into distinctive zones of (i) extensive management, (ii) intensive management and (iii) reserves, plantations of fast growing tree species such as hybrid poplar established for the production of wood fiber and carbon sequestration are thought of as components of the intensive zone. As such, which poplar hybrids or clones can ensure the success of such plantations in Northwest New Brunswick? In 2008, a plantation was established from cuttings to assess the juvenile success in a forest environment of 5 hybrid poplar clones (D51, DN70, DN136, NM6 and NM5). Survival and grazing rates, number of stools with multiple stems, height and collar diameter were measured during the first three years of growth, from 2008 to 2010. After three years of growth, survival rate varies from 39.8% to 94.5% while grazing rates range from 2.1% to 13.1%. More than 50% of the planted cuttings, all clones combined, developed multiple stems. In 2010, the average height ranged from 24.8 to 118.5 cm while the average collar diameter varied from 5.3 to 25.6 mm. NM5 had the highest survival, height and diameter, the lowest grazing rate, and also the highest percentage of multiple stems stoolsti it is thus recommended for biomass accumulation. DN136 and NM6 which had the lowest percentage of multiple stems stools and average rates of survival, growth and grazing are recommended for wood fiber production plantations.

Public Perceptions and Values for Ecological Goods and Services in a Northern New Brunswick Watershed

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Healthy watersheds provide valuable ecological goods and services (EG&S) to Canadian communities. These include the supply and purification of fresh water, provision of wildlife habitat, among others. Because EG&S' lie outside the traditional domain of commercial markets they are often under-valued, and consequently under-protected. The purpose of this study was to: (i) assess how the general public perceives the rights and responsibilities of private landowners in managing EG&S' in the Little River Watershed (LRW), in northern New Brunswickti and (ii) estimate the social benefits derived from environmental improvements in the watershed. A public mail survey was given to 800 residents living in or around the LRW using a modified Tailored Design. Survey participants were asked a number of questions regarding their perceptions of landowner rights and responsibilities, and were then given a series of choice experiments to elicit their willingness-to-pay for improvements in water quality and wildlife habitat in the watershed. Other attributes included in the choice experiments were landowner income losses and income tax increases to pay for the environmental improvements. Results imply that respondents are willing to pay to see water quality and wildlife habitat improvements, yet require compensation if landowner income losses are greater than 10%. These results will aid community groups, land managers, and policy makers to better understand the public's perspectives on land management and the social benefits derived from EG&S improvements in the LRW.

The Relative Importance of Harvesting and Local Site Factors in Structuring Regeneration Abundance and Composition

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Natural regeneration remains the dominant method of establishing new trees and stands in the Northern Forest. This trend is expected to continue in the future in light of the growing prominence of partial harvesting. However, limited understanding of how partial harvesting influences regeneration composition and abundance restricts our ability to select appropriate silvicultural practices and accurately project future wood supply in harvested stands. The objective of this paper is to evaluate the relative importance of harvest history and local site factors in structuring regeneration (i.e., species composition and abundance) of partially harvested stands within the U.S. Forest Service long-term silvicultural study at the Penobscot Experimental Forest in central Maine. Partially harvested stands include three variations of the selection system as well as fixed and modified diameter-limit cuttings. Regeneration pattern was directly related to site and harvest variables using full and partial redundancy analysis. Local site factors and harvest history explained 26% of the total variation in regeneration composition and abundance. Controlling for site factors, harvest history explained 6% of the total variation. These findings emphasize the role of local environmental heterogeneity in structuring regeneration and suggest that silvicultural treatment is just one of many factors determining regeneration outcomes.

Acknowledgments: This paper is part of a preliminary analysis for a Northeastern States Research Cooperative (NSRC) recently funded project "*Evaluating and predicting the regional effects of silviculture and site factors on regeneration in the northern conifer forest-Theme 3*". In addition, data used in the analysis were collected with support from NSRC Theme 1 under project "*Influence of silvicultural treatment, site characteristics, and land use history on native and nonnative forest understory plant composition on the Penobscot Experimental Forest in Maine*".

The Effect of Riparian Forest Structure on In-Stream Nutrient Uptake and Metabolism in the Northeast

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Streams are linked to the surrounding riparian forests, and because of this in-stream functional processes can be directly related to forest structure. Throughout the northeast, riparian forest structure (age, stage, and composition) is changing as a result of both natural and anthropogenic processes (i.e., historic clearings, exotic pests, forest management). We investigated the relationship between riparian forest structure and incoming light, stream ecosystem metabolism, and nutrient uptake on a seasonal basis in streams draining old growth and mature second growth riparian forests in the Adirondack Mountains, NY. Our findings demonstrate that there is more available light in old growth due to larger and more frequent gaps in the canopy compared to mature forests, particularly in August. However, this increased light availability did not result in large differences in stream primary production (GPP). For example, in August, we found no difference in GPP or community respiration between streams draining old growth and mature riparian forests. Stream algal species may be adapted to shady conditions typical of this region and may be experiencing photo-saturation in areas with complex structure like old growth. Mean annual stream nutrient uptake velocity was marginally faster in old growth streams compared to second growth streams. Complex riparian forests have higher light and streams draining these forests have a greater capacity to retain nutrients.

The Notion of Governance in the New Forest Regime of Quebec (Canada)

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Quebec's forest policy officially acknowledged the notion of governance with the adoption of a new forest regime in March 2010. Besides a willingness to favour market mechanisms for wood allocation and a commitment towards ecosystem-based forest management, the Government established a governance system enabling local actors to participate in the decision-making process. About forty integrated forest management local committees (*Tables locales de gestion intégrée*) were created on about 45 M ha of publicly owned commercial forest in Quebec. These committees include representatives from an array of interest groups. These committees' are articulated around principles aiming at consultation effectiveness. The committee intends to facilitate networking between actors to achieve a better dialogue and collectively define orientations for the future of the concerned areas. However, the terms of these partnerships between the State and the local stakeholders involved remain blurred. The State counts solely on the civic dialogue to identify local expectations and problems. It abstains from formally defining the collaborative learning process expected from actors involved in the partnership. The capacity of these committees to redefine problems and solutions seems very limited, if not absent. The relation between the members of these committees and the State representatives remains consultative, with the State remaining in charge of the decisions translated into forest management plans. Moreover, no role is specified from the committees' members for the implementation and the monitoring of the plans emerging from the consultation process. In a near future, it seems predictable that actors will demand policy revisions to concretely define the partnership between local actors and government representatives, reminding us that the partnership, at the heart of governance, goes beyond consultation and includes action.

Fifty-Plus Years of Stand Development Following Shelterwood Cutting in Northern Conifers

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Two variants of uniform shelterwood are included in a long-term U.S. Forest Service study at the Penobscot Experimental Forest (PEF) in Maine, USA. The experiment was established between 1952 and 1957 in stands dominated by a mix of conifers, including eastern hemlock, balsam fir, red spruce, northern white-cedar, and eastern white pine. There are two stand-level replicates of each treatmentti shelterwood with overstory removal in two stages (SW2), and shelterwood with overstory removal in three stages (SW3). Both treatments regenerated even-aged stands of mostly red spruce and balsam fir, with a smaller component of white pine. In SW2 a residual overstory of about 7 m^2/ha was left, but in SW3 there was no residual overstory. The SW3 replicates were split, with half receiving precommercial thinning when the developing stands were about 2 m tall. Stand development has been followed by monitoring regeneration and measuring trees with dbh > 1.3 cm on permanent sample plots 12 times since the first cut in each replicate. In this presentation we will describe stand dynamics from initiation to stem exclusion focusing on the abundance and composition of regeneration, sapling ingrowth, mortality, and current stand structure and composition. The influence of site will also be discussed.

Measuring Amphibian Gene Flow across Species, Scale and Sampling Scheme in a Managed Forest

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In the face of anthropogenic landscape change, understanding the factors that affect dispersal and gene flow is essential for conservation management. Landscape genetics provides a mechanism to examine how landscape features affect gene flow in natural populations. The relationship between environmental variables and genetic distance can vary with species, spatial scale and sampling scheme. To investigate these effects, we used a least cost path analysis and partial Mantel tests to identify environmental factors that influenced gene flow in two pond-breeding amphibian species in a managed forest. We compared a larger spatial extent with coarse-grain sampling to a smaller spatial extent with finer-grain sampling. At the smaller spatial extent, we also examined the effects of increased thematic resolution of the landcover data. We found increased power at the finer spatial scale and evidence for species-specific responsesti the more mobile species, wood frog (*Lithobates sylvatica*), displayed higher connectivity than the less mobile spotted salamander (*Ambystoma maculatum*). Open water and roads were barriers to gene flow for salamanders, while isolation by distance drove genetic patterns in wood frogs. Forestry had minimal effect on gene flow in either species. This study highlighted that species with similar habitat requirements, life cycles and taxonomies can have differing dispersal patterns and responses to landscape structure. It also revealed the importance of scale and sampling scheme in identifying landscape features that affect gene flow.

Sugar Maple in the Lower St. Lawrence: Will the Increase in Abundance Continue?

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Increased in abundance and dominance of sugar maple has been observed along its natural range since European settlement. Years of forest exploitation as been suggested to be the cause of a decrease in trees interspecific competition, thus promoting the establishment of Sugar Maple. This study aims to evaluate the potential of Sugar Maple increase in stands of a mixed forest of eastern Québec.

We hypothesized that: i) there is place for more expansion of the Sugar Maple's stands in the next years and ii) that environmental characteristics have an influence on the establishment of Sugar Maple decreasing or improving his augmentation in abundance in mixed forest.

We analyzed the sapling composition, and growth in 90 quadrats systematically placed in a 4km^2 site, 30 km in south of Rimouski, were an increase in abundance and dominance of Sugar Maple is observed since 1930. The sapling composition is compared to environmental parameters such as forest cover types, structure, density, luminosity, topographic position, and soil humidity. Past disturbances were evaluated from ten aerial pictures from 1930 to 2000. If our hypotheses are confirmed, we will conclude that the increase in abundance of sugar maple is still going on in Lower Saint-Lawrence and that human perturbation is one of the principal causes. This study will give a better understanding of this phenomenon and permit an adaptation of the forest management with regards to the increase of sugar maple population.

Keywords: temperate forest, Sugar Maple, Disturbances, Spatial pattern, mixed forest.

How Landowner Engagement Affects Forest Management Practices in Northern Vermont

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Family forest owners (FFO) control 40 percent of forestland in the United States (US), significantly more in the eastern US. Timber harvesting on these lands has seen a significant increase in recent decades. This makes the sustainable management of these forests increasingly important for protecting a wide variety of ecosystem services. Researchers have used a variety of models to examine the level of landowner engagement on their forestland, but few studies have explored how these models correlate to actual forest management. In this study we interviewed landowners and conducted field surveys on 59 FFO properties of at least 25 acres of forestland in a four-county region of Vermont, who had harvested timber in the last 5 years. We examined landowner engagement in forest management using Diffusion of Innovation and Prime Prospects Analysis. Regardless of model, we determined that higher level of landowner engagement was associated with better implementation of silviculture and Best Management Practices (BMP) during harvest operations. The study describes individual drivers and landowner characteristics associated with landowner engagement and forest management practices. This information will help policy makers and natural resource managers to better understand and facilitate sustainable practices through outreach and education programs on family forests.

Assessing the Growth Potential of the Northern Forest Maple Industry

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NSRC sponsored research is evaluating the current status and growth potential of the maple syrup industry in the Northern Forest region. Maple syrup production is particularly suited for urban-rural interfaces in the Northern Forest since relatively small tracts of land can be used productively each year without timber harvesting, which has become increasingly difficult for small forested parcels in these locales. Maple sugaring is also becoming a much larger component of rural economies, as modern technology has allowed for much larger businesses to develop in order to supply syrup for growing international markets. We have estimated the number of potentially tappable trees and the percentage of these trees that are utilized for syrup production in the northeastern states and provinces. Landowners' attitudes towards sugaring have been assessed and perceived barriers and incentives to utilize their trees for syrup production. The effect of public policies on maple sugaring and forest conservation will be discussed, highlighting the public policies that have the greatest impact on syrup production in the region.

The Structural Conversion of Young Conifer Regular Stands: The Convergence of Environmental and Economic Interests

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In 2008, four young (30 years old) stands were selected in the balsam fir-yellow birch ecoregion to initiate the process of converting from regular to irregular stands. Three types of commercial thinning combined with gaps were made to restore some old-growth attributes and to compare the quality and value of first processing products. The quality and value of first processing products have obtained with optimizer system. Commercial thinning from below and by freeing 50 or 100 elite-trees per hectare has been compared. The results indicate that thinning from below produces significantly more small logs (≤10 cm) and significantly less logs of 12-16 cm than other types of thinnings. Overall, 45% of the wood harvested by thinning from below were optimised to be cut in 2 x 3 inches compared to 34% for the other types of thinnings. On the other hand, thinning from below produces significantly less 2 x 4 inches pieces than the other types of thinnings. There was no difference in the production of 2 x 6 inches pieces resulting from different types of thinnings. These results suggest that the use of commercial thinning by freeing elite-trees is an interesting silvicultural tool, from the economic point of view, to initiate the conversion process.

Keywords: structural conversion, commercial thinning, even-aged stand, uneven-aged stand, lumber

Impaired Physiology of Sugar Maple (Acer Saccharum) Under Aluminum-Treatment May Alter Competitive Relations with Sympatric Species

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Inputs of acidic deposition have depleted calcium (Ca) and increased the availability of phytotoxic aluminum (Al) in soils within the Northeastern U.S. – a phenomenon particularly well documented for the Hubbard Brook Experimental Forest (HBEF) in New Hampshire. Sugar maple (*Acer saccharum*) is one species that is particularly sensitive to Ca deficiency and potential Al toxicity, both of which have been shown to reduce basal growth and impair the physiology of the species. We collected increment cores from sugar maples and American beech (*Fagus grandifolia*) in a replicated study with Ca-addition, Al-addition, and control treatments to compare growth trends between species. In addition, we assessed root damage, carbohydrate concentrations, and foliar nutrition in sugar maples to determine treatment specific effects on the species. We found that co-dominant and intermediate sugar maples exhibited greatest growth in Ca-treated plots, but that American beech began growing greater in Al-treated plots in the last two years of recorded growth. Results from our physiological measures of sugar maples showed that Al-treatment increased root damage, impaired carbon relations, and resulted in reduced Ca in foliage. The effects of Al-treatment on sugar maples suggest that those maples growing in Al-treated plots may be at a competitive disadvantage when compared to an Al-tolerant species such as American beech.

Effects of Woody Debris Retention on Herbaceous Layer Biodiversity in 25-Year-Old Plantation Forests in Northern New Brunswick: the First Two Years Post Commercial Thinning

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Biodiversity conservation is an implicit management goal for protected areas, but in landscapes that have few protected areas, it may be necessary to extend this goal to intensively managed forests. We examined the responses of herbaceous vascular plants as part of a collaborative multi-taxon study to assess the impacts of alternative commercial thinning practices on biodiversity conservation in privately owned plantations. We hypothesized that plant diversity and composition would not differ among thinning treatments over the first year, but would exhibit significantly greater diversity than uncut reference stands in the second year, attributable to increased opportunities for invaders through increased light and exposed soil. Each of six, 25-year-old, white spruce plantations was divided into four treatment blocks, one of which was left as an unthinned reference. The other three blocks were thinned (40% of the basal area) and given one additional treatment: (1) no-debris, tree tops and brush were removedti (2) business-as-usual, tree tops and brush were retainedti or (3) enhanced structure, clumps of trees were killed by girdling. Herbaceous vascular plants were surveyed using extensive visual search (presence-absence) methods and intensive (%-cover) methods. In the first post-treatment summer (2011), there were no significant differences in diversity or abundance of vascular plants among blocks, presumably due to a time-lag between thinning and plant community response. Data from two years (2012 data to be collected) will be analyzed, and the results of the tests of our hypotheses and their consequences will be presented.

Benchmark Carbon Stocks from Old-Growth Forests in Northern New England, USA

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Forest carbon offsets are becoming an increasingly popular climate mitigation option. However, many questions surrounding the role of forests as a carbon sink remain. One of the most critical items to address is the maximum amount of carbon that can be potentially stored in a forest of a given type. How much more carbon can be stored in an old-growth forest compared to an undisturbed second-growth forest, or a sustainably managed working forest? To begin to answer that question, we sampled old-growth stands in Maine, Vermont, and New Hampshire to establish benchmark values for carbon storage in the forests of northern New England. Our main objectives were to develop estimates of carbon stocks in key live and dead biomass carbon pools of hardwood and softwood forests in northern New England and compare data collected from mature second-growth forests to the old-growth benchmark values. We sampled twelve sites to estimate total carbon stocks in aboveground live and dead biomass, down dead wood, forest floor, and soil to 20 cm. Total carbon stocks averaged 216 t/ha for northern hardwoods and 267 t/ha in softwood sites, with 116 and 125t/ha in the aboveground live tree biomass for hardwoods and softwoods, respectively. Our results showed old-growth softwood averaged about 25% more carbon than old-growth hardwood. Old-growth hardwoods supported live biomass carbon stocks similar to those in mature hardwood stands, although forest floor stocks in old-growth were about twice as high. Old-growth softwood averaged about 40% higher in total carbon than the mature hardwood stands.

Expanding Interface in the Northeast's "Asbestos Forest": Implications for Future Fire Control Programs

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In Northeastern North America, the past 2 decades have seen exceptionally mild fire activity except in Quebec and Labrador. The term "asbestos forest" is frequently heard. The Northeastern Forest Fire Protection Compact includes four eastern Canadian provinces and seven Northeastern states. It provides a variety of services including sharing crews and equipment. The Compact is assessing its longterm needs for maintaining fire prevention and control capabilities. An extensive longterm database on fire history has been assembled, as well as datasets on individual fires not known to have been previously used by scientists. Some findings: (1) Intense regional droughts occur across a large portion of the region on a 50 year average return periodti past regional droughts have generated major increases in wildfireti (2) Such droughts have not occurred since the mid 1960's. (3) fire season weather has been unusually wet in recent decadesti (4) In local areas, fuel buildups are becoming significantti (5) Several factors are steadily eroding fire programs and firefighting capacity in the regionti (6) fire managers are increasingly concerned that low-density rural sprawl is increasing lives and property at risk, at the same time as it becomes more difficult to maintain response capabilities. (7) longterm annual fire histories, as well as limited data on individual fires, display extreme value (infinite variance) behavior. This paper outlines research results on fire history and summarizes a Compact White Paper addressing these issues.

Response of Tree Growth and Water Use Efficiency to Climate Change and Nitrogen Deposition in a Temperate Deciduous Forest in the Northeastern U.S.

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Rising atmospheric CO_2, nitrogen (N) deposition and changing precipitation patterns in the northeastern U.S. can influence tree growth and water use through the physiological processes of gas exchange across the leaf surface. Understanding the influences of climate change and anthropogenic disturbances on forest carbon and water cycles is critical to modeling the impacts of future climate scenarios as they relate to carbon sequestration and ecohydrology. We hypothesized that trees in this region would exhibit changes in water-use efficiency over recent decades as a response to rising CO_2 and N deposition, without a concurrent increase in woody biomass production. To test this hypothesis, we collected increment cores from two dominant tree species, *Quercus velutina* and *Pinus resinosa*, within the Chronic Nitrogen Amendment Plots at the Harvard Forest Long-Term Experimental Research site. Sample trees were located in plots across a steep N deposition gradient stimulating future potential rates as industry and urban uses increase. Tree rings were analyzed using dendrochronology and stable isotope (^{13}C, ^{18}O) techniques to evaluate the historical effects of climate and N deposition on woody increment growth, water-use efficiency, and interactions between nutrient availability and plant water relations. This presentation will focus on methods and preliminary results.

Prospects for Rehabilitation Forestry through Carbon Market Participation on Over-Harvested Former Industrial Northern Hardwood Forests

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Decades of heavy-cutting and high-grading in the northeastern United States provide an opportunity for rehabilitation and increased carbon stores, yet few studies have examined the feasibility of using carbon markets to restore high-graded forests. Weevaluated the effectiveness of rehabilitation on 391 ha of high-graded forest in Vermont, USA. Thirteen silvicultural scenarios were modeled over 100 years using the Forest Vegetation Simulator. Carbon offsets were quantified with the Climate Action Reserve (CAR) and American Carbon Registry (ACR) protocols and evaluated under voluntary and regulatory carbon price assumptions. Results indicate that management scenarios involving no harvest or low-intensity harvest yield the greatest incentives, yet these scenarios include a range of short-term rehabilitation options that provide flexibility for landowners. The choice of protocol also significantly influences results. Although ACR consistently generated more offsets than CAR for the same scenarios ($p < 0.05$), the protocols yielded similar net present values of US$121–US$256·ha^{-1} under high offset price assumptions. These returns are comparable to those generated from timber harvest alone under more intensive management scenarios. While timber will continue to be a primary source of revenue for many landowners, carbon markets may increasingly appeal as a new incentive for restoring high-graded forests.

Growth, Mortality, and Harvest in 10 Silvicultural Treatments over 60 years on the Penobscot Experimental Forest in Maine, USA

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The U.S. Forest Service, Northern Research Station began a long-term experiment in northern conifer silviculture on the Penobscot Experimental Forest (PEF) in Maine in 1952. Since that time, ten treatments have been applied to twice-replicated, stand-level management units (MUs), resulting in 60 years of data describing tree and stand response to a range of management alternatives. Treatments include variants of even-aged (shelterwood) and uneven- aged (selection) silviculture, exploitative cutting (diameter-limit and commercial clearcutting), and no management (reference). Data have been collected every 5 to 10 years and before and after harveststi commercial harvests have been conducted more than ten times in some MUs. We will present the components of gross growth (accretion, ingrowth, mortality, and harvest volumes) for a number of treatments in the long-term study. The following questions will be answered: what are growth and mortality rates over 60 years, and how do they compare among treatments? Which treatments have generated the greatest harvest volumes so far? How are the components of growth affected by stand structure and composition? And, last but not least, can we tell if even- or uneven-aged silviculture is more productive?

The Legacy of Foliar Winter Injury on Xylem Growth and Aboveground Carbon Sequestration for Red Spruce in the Northeastern Forest

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Red spruce (*Picea rubens* Sarg.) decline has been attributed to foliar winter injury caused by freezing damage that results in foliar mortality, crown deterioration, negative carbon (C) balances, and tree decline. We assessed the influence of the 2003 winter injury event – a severe region-wide event that damaged over 90% of red spruce in the northeastern U.S. – on xylem growth and C sequestration for spruce stands in Vermont, New Hampshire, and Massachusetts where winter injury was quantified in 2003. Growth declines relative to pre-injury (average for 2001 and 2002) growth persisted for three years following the winter injury event. We estimated that this event reduced the regional C sequestration of red spruce >17.78 cm DBH by about 673,000 metric tons of C. Since winter injury severity was positively and significantly related to elevation, we examined relative changes in red spruce growth following the 2003 winter injury event for trees at three elevation groups. While relative growth was below pre-injury levels and significantly less for high compared to low elevation groups from 2003-2006, growth between these groups was indistinguishable through 2010. Mid-elevation plots exhibited significantly higher growth relative to pre-winter injury levels from 2007-2010, and by 2010 had rebounded from growth declines. In contrast, the high elevation plots continued to show net C reductions through 2010 – an enduring legacy of the 2003 winter injury event. The long-lasting reductions in growth following the 2003 winter injury event were followed by an unprecedented upsurge of growth, particularly in 2009 and 2010 at mid-elevation plots.

Northern Forest Logging Industry Assessment: Phase 1 Results

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The logging industry provides a critical function within the forest resources industry by harvesting and transporting this valuable and renewable resource to wood processing facilities and consumers. The forest resources industry is an integral part of the economy, ecology, and culture of the Northern Forest region of New York, Vermont, New Hampshire, and Maine. This study focuses on the equipment infrastructure, proportion of timber production by various harvesting methods, and barriers to production experienced by logging contractors operating in the Northern Forest. Results are presented from a mailed survey in Maine in 2011 and in New York, Vermont, and New Hampshire in 2012. This research will compare business attributes, harvest production, and operation details with an emphasis on the logging equipment infrastructure and capacity. Trends in the logging sector will be monitored with a periodic mailed survey and will serve the industry through technical reports disseminated through collaborating professional organizations. Funding was provided by the Northeastern States Research Cooperative – Theme 1 (US Department of Agriculture Forest Service Grant No. 10-DG-11242307-050) and the Maine Agricultural and Forest Experiment Station (Publication No. 3260).

Tree Regeneration in Partially Harvested Mixedwood Stands in Maine

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Currently, 94% of timber harvests in Maine are classified as partial harvests (Maine Forest Service 2010). Many of these harvests occur on commercial forestland, where mechanized operations conducted with equipment such as feller bunchers and grapple skidders create distinct spatial patterns. Often, the residual stand consists of a forest matrix interspersed with 4 to 6m wide strips cleared for skidding at approximately 20-m intervals. The long-term effects of these distinct patterns on growth and yield are poorly understood, particularly with regard to tree regeneration. In order to characterize the regeneration response in partially harvested stands following mechanized operations, we are quantifying density and composition of regeneration, and competing understory vegetation, in six stands of softwood-dominated mixedwood on commercial forestland in Maine. All stands were harvested approximately ten years ago, and stocked with mature trees prior to harvest. Additional variables of interest include canopy cover, overstory basal area, soil characteristics, woody debris, slope, and aspect. Sampling is stratified between matrix and trail areas, with a determination of total stand area in trail. We anticipate that our findings will inform forest managers about the status of regeneration in an important subset of partially harvested stands.

Predicting High Quality Sites of Fraxinus Nigra (Black Ash) Across Maine and Northern New York: An Approach to Prioritizing a Region's Response to Environmental Stressors

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Fraxinus nigra (black ash) is a species of ash tree most commonly found in moist lowland sites and is typically thought of as a wetland species. While there is not a large population of black ash throughout the eastern United States, this species nonetheless serves an important socio-economic and ecological role. Native American tribes have used black ash for centuries to weave baskets, which have become a key component in the tribes' histories, cultures, and economies. Black ash also fills a particular ecological niche in that it can colonize wetland sites and is relatively drought-tolerant. Thus based on its socio-economic role for Native American tribes and the ecological niche it fills, it is essential to identify and map high quality sites where black ash grows so that the species may be better monitored and protected from environmental stressors. Such information is necessary in prioritizing responses to a potential introduction of the emerald ash borer (*Agrilus planipennis*). These high quality sites will be defined as sites where black ash (1) can regenerate successfullyti (2) have wide increments of annual growth at DBH that are suitable for basket-making (greater than 2mm for 20 consecutive years)ti and (3) show little to no decline in annual growth levels over time. By identifying the characteristics that classify a site as high quality for black ash, a comprehensive GIS map will be created detailing and predicting the locations of high quality sites that can be used by other researchers and land owners aiming to monitor and protect black ash.

Sustained Yield Management on Family Woodlands in Vermont's Northern Forest

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Families own most of the Northern Forest and the use of sustained yield management on their woodlots could provide social and economic benefits to the region for generations. A better understanding of management trends in the Northern Forest will help to shape sustainability efforts. We investigated 59 recently harvested, family-owned properties with 25 acres or more of timberland across a four-county area of Vermont. On each, we evaluated the use of silviculture and the application of Best Management Practices (BMP) to determine the extent of sustained yield management. We examined relationships between these indicators and a number of factors, including sawtimber procurement pressure and enrollment in Vermont's Use Value Appraisal tax program (UVA). Use of sustained yield management appeared limited in Vermont's Northern Forest, but was more frequent than in other parts of the Northeast. Participation in UVA was associated with higher use of sustained yield management. Sawtimber procurement pressure showed no effect. UVA's success demonstrates the potential impact of incentive programs, while a lack of sawtimber procurement influence shows that markets can be strengthened without adverse effects on management. A cursory investigation of the influence of different types of loggers highlights the importance of accounting for them in sustainability efforts.

An Oral History Place Attachment Project - Understanding the Changing Forest Landscape through the Eyes of Maine's Oldest Citizens

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Ties to land and forest landscape can be strong -- affecting attitudes and motivating behavior -- yet these bonds are difficult to measure. To date, place attachment research has largely ignored long-time residents, not examined place attachment change over the life course, and left the theory unexploited as a central planning concept in rural development. Using oral history methodology, this study explores place attachment in the Kennebec River Watershed, an area with rich history in forest industry. Personal interviews were held with 21 Maine residents, averaging 90 years of age, during late 2010 and early 2011. Unique aspects of attachment by residents with a long history of living where forest has been the dominant landscape are tied to social, recreational, economic and environmental dynamics of life. This paper contributes to theory by analyzing determinants of place dependency and impact on attitudes and behavior. Results indicate that place dependency plays a significant role in quality of life and ability to adapt to change. Residents, keenly aware of attachment to social community and less aware of the dynamics of attachment to place, were able to shed light on the importance of forest and land use throughout their life course. This study clarifies connections to landscape and helps identify ways to engage people about the future and discusses public involvement strategies related to rural development.

Modeling Forest Canopies Using Laser Point Quadrat Sampling and Survival Analysis

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In laser point quadrat sampling, a laser rangefinder is shot vertically into the canopy at a series of sample points. The resulting set of leaf intercept heights can be used to model the canopy profile or to estimate leaf area index. This sampling method has been used with limited success, primarily due to the large number of sample points needed to obtain accurate estimates. This paper addresses these limitations by outlining how leaf intercept heights are a form of time-to-event data, analogous to what are commonly observed in biomedical studies. This equivalence allows for the use of existing survival analysis methods to be used in the analysis of point quadrat data. To illustrate the usefulness of this relationship, a field study was conducted in northeast Oregon. Within each of sixty plots, ninety leaf intercept heights were recorded using a laser rangefinder. A survival-based Weibull regression model was used to estimate canopy profiles and leaf area indices via the parametric form of the hazard function. The relatively small number of samples per plot and the high foliage density in many of the stands led to an underestimation in canopy density by the traditional point quadrat estimators, while the survival-based estimators appeared robust to these limitations and yielded more realistic results. Overall, the incorporation of survival analysis methods into point quadrat sampling greatly increases the usefulness of this sampling method, resulting in a powerful tool for quickly assessing the structure of forest canopies.

Influence of Management Intensity on the Productivity of Early Successional Acadian Stands in Eastern Maine

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Early successional stands composed of naturally regenerated hardwood and conifer species are abundant in the forests of northeastern North America, but it may be possible to increase growth and enhance composition with various management techniques. Unfortunately, there are few long-term experiments documenting the response of these stands to different levels of manipulation We examined the response of early successional stands to combinations of three management intensities (low-thinning/release, medium-thinning/release plus enrichment planting, and high-intensive plantations) and three compositional objectives (hardwood, mixedwood, and conifer). Seven years after treatment, the low and medium intensity hardwood treatments had similar yields to the untreated control but with substantially lower densities. In the low and medium conifer treatments, removal of hardwoods promoted conifer dominance, but hardwoods re-established in the gaps without conifers. As previous research has shown, these stands will likely result in conifer-dominated mixedwood stands. The low and medium mixedwood treatments had greater yields than the conifer treatments because of intentional hardwood retention. The high intensity plantations had substantially lower yields than the naturally regenerated treatments. The lower yields in the hardwood plantations are likely due to the contrasting performance of the four hybrid poplar clones planted in the treatments. Clone NM6 (*Populus nigra* × *P. maximowiczii*) outperformed the three *P. deltoides* ×*P. nigra* clones in pure plantations and in mixture with white spruce. The site is typical of many reforested sites in Maine – rocky and poorly-drained—suggesting that hybrid poplar may not be a viable alternative for increasing forest bioenergy production in the state. Alternatively, thinning naturally regenerated shade intolerant hardwood species may be a better option, since thinning the stands may provide periodic product removal while promoting residual stand growth.

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Response of Softwood Regeneration to Commercial Thinning in Two Northeastern Spruce-Fir Stand Types: 1st-Decade Results From the Commercial Thinning Research Network in Maine

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Traditional silvicultural thinning is implemented to boost growth and final yield of crop trees with no specific intention of triggering a regeneration response. However, there is reason to anticipate thinning will initiate some tree regeneration, particularly in stands dominated by understory-tolerant species. The goal of this project was to increase our understanding about the influence of commercial thinning on the development of softwood regeneration during the first decade after treatment in two northeastern spruce-fir stand types. Data for this study came from a long-term commercial thinning experiment in two spruce-fir stand types: younger, fir-dominated stands treated with pre-commercial thinning (PCT) and older, spruce-dominated stands without PCT (Commercial Thinning Research Network). We tested two groups of hypotheses: 1) fir regeneration density is greater in fir-dominated stands, while the densities of spruce and all softwoods combined are greater in spruce-dominated stands and 2) commercial thinning increases the density of fir, spruce, and total softwood regeneration. Our findings indicated species-specific differences in regeneration development between stand types and commercial thinning has stimulated the development of natural softwood regeneration within the first decade following treatment in a manner similar to a shelterwood establishment cut. Therefore, commercial thinning has the potential to serve as a "de facto shelterwood" entry in similar spruce-fir stands while still providing the benefit of concentrating growth on fewer crop trees. The management implications of these and other findings of this study will be discussed.

Remote sensing of canopy condition across the northeast: Trends and patterns 1984-2009

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Forest health in the northeast is of increasing concern due to a convergence of stressors that are predicted to increase in number, severity and frequency with ongoing climate change and anthropogenic pressures. Traditional studies utilize long-term measurements at monitoring plots to track changes in forest health. In order to monitor canopy condition on a larger spatial scale, this study uses a continuous canopy condition index predicted using Landsat TM5 satellite imagery to quantify trends from 1984 to 2009. Initial results indicate that, while forest condition varies greatly from year to year, the condition of forested ecosystems across the northeast has remained relatively stable over the past 25 years ($\square$ = 0.02, s = 0.06, *where 0 = no change*). This is likely due to the natural resilience of northeastern forests and their rapid recovery following small scale disturbances. A regional geospatial analysis indicated that declining condition was significantly concentrated in high-elevation spruce-fir-paper birch forests ($p<0.0001$). Possible causes of decline include the interacting effects of acid deposition, red spruce winter injury, wind throw, and a lack of secondary species to rapidly fill gaps created by mortality and decline. A field validation and investigation of the decline trend product indicated that stands with higher species diversity and structural complexity ($p = 0.04$), higher cation exchange capacity in the organic horizon ($p=0.0002$) and greater water availability ($p < 0.0001$) were significantly associated with stable or improving trends. These results emphasize the natural resiliency of northeastern forests, while highlighting the sensitivity of upper elevational spruce-fir stands to continued decline.

Please Note: this is NSRC Theme 2 supported research

High-elevation Spruce-Fir Forest in the Northern Forest: An Assessment of Ecological Value and Conservation Priorities

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High-elevation habitats are a limited yet critical component of the northeastern landscape. They are recognized as a distinct habitat in many state wildlife action plans and regional bird conservation plans. They provide the primary habitat for Bicknell's thrush, the northeast's rarest migratory songbird and a species of highest conservation concern, as well as many other species of conservation concern. They are likely to provide refugia for spruce-fir-dependent species in a future warmer climate as this habitat is projected to decline significantly at lower elevations. While the overall level of conservation of these areas is high relative to other parts of the landscape, significant areas (especially in northern New Hampshire and western Maine) remain unconserved. Evaluation, prioritization and conservation of the most important areas is an objective of many state and regional wildlife conservation plans.

This project seeks to assess the relative ecological value, conservation status and current condition of high-elevation areas across the region to guide future conservation efforts. The project will**:** 1) delineate all discrete blocks of land above 2700 feet in Maine, New Hampshire, Vermont and New Yorkti 2) assess the conservation status of each areati 3) assess the ecological significance and current condition of each area based on available GIS data and aerial photographyti 4) identify potential undocumented occurrences of rare subalpine (balsam fir-heartleaved paper birch) forest natural community from NAIP aerial photography and targeted field verificationti 5) rank areas to identify the most ecologically significant unconserved areasti and 6) identify potential conservation strategies for these areas.

How Silvicultural Treatments Affect Carbon Storage on the Penobscot Experimental Forest: A 60-Year Perspective (NSRC THEME 3 Project)

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We examined carbon storage following nearly 60 years of forest management on the Penobscot Experimental Forest (PEF) in central Maine. The effects of four treatments (control, selection cutting, shelterwood cutting, and commercial clearcut) on current (2012) carbon stored in live trees, dead wood, understory plants, soils, and harvested wood products were evaluated. Two replicates of each treatment were examined using permanent sample plots. For live trees and dead wood, attributes such as species, diameter, and decay class were used to estimate biomass from regional regression equations, which was then converted to carbon mass by using species and/or decay class specific carbon concentration estimates. We also destructively sampled herbaceous plants and soils on subplots associated with each permanent sample plot to determine the carbon mass of these samples. Since the permanent sample plots were inventoried before and after each harvest, trees removed from the site for processing were estimated and used to derive harvested volumes. Carbon storage in wood products and landfills was estimated using a production approach based on methods described by Smith et al. (2006). We also used pretreatment data collected on permanent sample plots (in the 1950s) to estimate above ground live tree carbon across the PEF. Carbon levels varied spatially across the PEF, which were driven by a north-south effect, total basal area, and eastern hemlock basal area. This suggests using covariates such as initial total basal area in models used to compare treatment effects. Overall, this study has important implications for evaluating the long-term influence of silviculture on carbon sequestration.

Linking Microenvironment Changes to Regeneration Dynamics after Patch-Selection Cutting in Quebec's Temperate Mixedwood Forest

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Because gap dynamics has been known as a major driver of yellow birch – conifer stands in Quebec, a study was set in 1999 to assess the gap-based approach. Five treatments were tested on 1-ha experimental units (four replications): uncut control, patch clearcut and three 50% patch-selection cutting patterns combining harvest by circular gaps with 33 % single-tree selection cutting (1H: 8 x 20 m gapsti 1.5H: 4 x 30 mti 2H: 2 x 40 mti H = dominant tree height). Half of opening areas were spot scarified. In this experiment located in the Laurentian massif foothills, light distribution was found to be influenced by gap size, aspect and slope, which in turns affected regeneration dynamics. There was a trend of increased light with increasing slope, while the zone of maximum light within a gap moved during the day. Mid-tolerant yellow birch regeneration density was higher in patch-selection treatments combined to scarification. Solar radiation was near its optimal light requirements for growth in these gap sizes (e.g. 1H = 40%ti 1.5H = 48%). On the opposite, regeneration densities of shade-tolerant red spruce and balsam fir were poor in gaps. Their most favorable niche was the southern border of gaps that remained shaded during almost all day, as a consequence of the high latitude (47°N). Under northern latitudes, the zone of maximum light is found in the north, while the southern border receives little direct sunlight. It is important to consider both slope and aspect when planning gap creation with regeneration methods.

Nonselective Partial Harvesting in Maine

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Over the past 20 years forest management in Maine has shifted from a heavy reliance on clearcut harvesting to partial harvesting practices. Over the past five years partial harvesting has accounted for an average of 96.8% of the 461,895 acres harvested annually in the state. Partial harvesting includes selective methods such as shelterwood, group selection and single tree selection methods and also nonselective methods. Nonselective partial harvesting is a mechanized practice that removes timber from within trails with some removal directly adjacent to trails, typically leaving a matrix of unharvested areas between trails. This transition in harvesting practices is occurring within the context of continuing changes in timberland ownership patternsti concerns over long-term forest management effectsti and lingering questions over the quality of silvicultural practices in the region. Little is known about the silvicultural outcomes associated with nonselective partial harvesting practices. Therefore, we are unable to describe the current state of Maine's forestlands or provide the information necessary to make meaningful projections of future forest conditions. With these severe deficiencies, assessments of Maine's wood supply, long-term wildlife habitat viability, and economic forecasts are severely constrained. In order to begin developing an understanding of the effects of nonselective partial harvesting, we examined how patterns of nonselective partial harvesting have affected the structure and composition of residual stands.

Modeling Mortality Risk after Commercial Thinning Operations in the Province of Quebec

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Through time, wind has revealed his capacity to alter the landscape particularly in the managed forest. There is currently a growing interest for the use of partial cutting. However, partial cutting can increase the risk of windthrow, depending on climatic, topographic, edaphic, and stand characteristics. Commercial thinning has been proposed as a treatment that could be used more widely in boreal forests of Quebec. The present project aims to contribute to a better understanding of commercial thinning effect on mortality. This project is supported by ten years of acquisition and monitoring data from a network of 150 pairs of permanent plots distributed in different vegetation zones in the province of Quebec. Each pair of plots is comprised of a treated area (thinned) and a control area (unthinned), containing each one a 400 m^2 plot and separated by 150 m. This research will lead to the establishment of an empirical model to anticipate windthrow hazard. For the model formulation the most influential variables as the wind speed, local exposure, stand characteristics and edaphic characteristics are considered.

The first results show that the thinned plots are been more vulnerable to windthrow. For the most common stands, the mortality rate was: For Black spruce 1.32% in unthinned plots and 4.87% in thinned plotsti for Jack pine 0.67% and 2.05% for the control and treated plots respectively and finally for balsam fir 0.55% (unthinned) and 2.62% (thinned).

Whole Tree Conventional Harvesting: Assessing Productivity Differences

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Whole-tree harvesting is widely used in the northeastern United States to supply biomass energy plants with fuel, but questions remain regarding its long-term sustainability. To assess its effects on the northern hardwood forests that make up a significant portion of northern New England, we conducted a regeneration survey of twenty-nine (29) small clearcuts in central New Hampshire and western Maine in 2011. We measured fourteen (14) whole-tree harvested (WTH) and fifteen (15) conventionally harvested (CH) sites and compared the productivity of the 10–14 year old regeneration. Height and diameter of all trees >2 m in height were measured within 1 m-radius plots. Biomass was calculated using species-specific regression equations based on measured diameter. No significant difference was observed in height, diameter or calculated biomass of stems >2 m in height between WTH and CH treatments. We conclude that no significant effects of residue removal on site productivity from whole-tree harvesting are observed within our sample of northern hardwood sites as this point in their stand development.

Partial cutting in old-growth boreal stands: a feasible approach?

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The Eastern boreal Canadian forest is largely composed of old-growth stands with an irregular structure. Traditionally, even-aged systems have been used to regenerate these forests. Ecosystem-based management, however, would prescribe the use of irregular or uneven-aged methods. The lack of expertise with such approaches in virgin boreal stands has hindered their broad-scale application in Eastern Canada.

To assess the capacity of these approaches to maintain old-growth attributes of *Picea mariana-Abies balsamea* forests, we applied four silvicultural treatments differing in the level of tree retention: a clearcut with advance growth protection, a severe partial cut protecting small vigorous merchantable stems, and two patterns of selection cutting. We also assessed whether the partial cutting approaches could become broadly used on an operational basis by looking at simple forms of application and by assessing their economic profitability.

We found that many of the old-growth attributes can be maintained with partial cutting, even without tree marking. Parallel studies have shown that, unlike the conventional approaches, silvicultural treatments with >55% of tree retention largely maintain the animal assemblage associated with old-growth forests. High levels of mortality observed over the short term raise questions about the future development of these stands. Financial analysis has shown that the approaches can be profitable over time, but the first entry will likely be less profitable than with conventional ones. The situation may be different with future entries where bigger trees would be harvested in partial cutting systems.

Growth versus Protection from the Cold: a Tradeoff for American Chestnut Grown at the Species' Northern Range Limit?

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Hybridization of American chestnut (*Castanea dentata*) with Chinese chestnut (*C. mollissima*), followed by backcrossing to American chestnut, is being conducted to increase the resistance of resulting stock to the fungal pathogen *Cryphonectria parasitica*. Backcross breeding is being employed to restore American chestnut throughout its range, including relatively cold, high elevation sites in southern and central regions, as well as the chestnut's northern range limits. Until now a comparative analysis of growth and cold hardiness of American chestnut sources grown in cold environments has not been conducted. We assessed first-year growth and shoot winter injury of American chestnut seedlings from 13 genetic sources: four southern, four central, and five northern sources, each representing one or more half-sib families, grown in common garden in Vermont. No differences in height or diameter growth or shoot winter injury attributable to the region of source origin were detected. However, significant differences in growth and winter injury were detected among sources within each region. We also separated sources according to temperature zones (warm, moderate and cold based on meteorological data recorded near source origins), and found that seedlings from the cold zone had lower growth but consistently experienced the least shoot winter injury. In general, there appeared to be a tradeoff between growth and winter injury: sources that experienced the greatest growth were generally the most vulnerable to shoot winter injury. Further testing may identify sources that better bridge apparent tradeoffs between cold tolerance and growth (exhibit good growth and elevated cold tolerance).

Measuring Ecosystem Health in the Connecticut Highlands

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The Highlands region, stretching from Pennsylvania to western Connecticut, is identified by the US Congress as having high conservation value as a forested landscape of national significance. We have assessed forest ecosystem health across a spectrum of fragmentation conditions in four sub-watersheds in the Connecticut Highlands and identified a simple set of key, easily-measurable indicators, which can be used for state-wide monitoring of forest health trends. The indicators will be used to develop a community-based monitoring protocol, which will be piloted in the spring of 2012.

Using a multi-faceted intensive forest inventory in combination with land cover analysis describing forest continuity, we collected vegetation and bird data on 80 plots randomly distributed in the four watersheds. Models were developed that predicted the presence of at risk bird species. Those with both plot and landscape scale variables were the most predictive of bird species presence, however landscape scale models were still able to predict the presence of six bird species relatively well and were used to map distribution across the study area.

We found that many key forest characteristics could not be differentiated on the basis of landscape fragmentation. The only significant effects of forest fragmentation were found to be lower frequency, but higher cover of native herbaceous species, fewer tree cavities, higher soil pH, lower soil P, and reduced occupancy by Black-throated Blue Warbler, Eastern Wood Pewee, and Veery.

Does Forest Certification Make a Difference for First Nations? Analysing the FSC Process and Its Impacts for First Nations in the Boreal Forests of Quebec and Ontario

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Forest certification has become a key driver in forest management both in Canada and worldwide. Certification processes include social commitments, which are helping to define the ways in which the public engages with forest companies. The Forest Stewardship Council (FSC) system, the subject of this presentation, has specific requirements around respect for Aboriginal rights and interests. This presentation will look at the application of the FSC boreal standard in Quebec and Ontario in order to determine if, and how, certification is addressing a diversity of First Nations concerns. The method of research is content analysis of FSC certification reports at two levels—the first a broad synthesis of reports, the second a specific case study. Special attention is paid to the role of 'conditions', also known as 'corrective action requests'. Research results reveal that certification is pushing forest managers to improve practices on a wide variety of fronts, the most common being the issue of agreements and the identification and protection of First Nations resources. However, due perhaps to the complexity of Aboriginal rights issues in Canada, auditors appear to be adopting a view of certification as a "work in progress" rather than requiring strict conformance with the standard.

Development and evaluation of the Acadian Variant of the Forest Vegetation Simulator

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Using funding from the Northeastern Research States Cooperative Theme 3 and the US Forest Service Northern Research Station, the goal of this project was to develop a new variant for the Forest Vegetation Simulator (FVS) that is applicable to the Acadian region of Maine and New Brunswick and flexible enough to account for a range of potential future conditions. Specific objectives were to: (1) compile the regional growth and yield datati (2) develop an index of potential productivityti (3) fit total height and height to crown base static equations by speciesti (4) develop diameter and height increment equations by speciesti and (5) estimate growth modifiers for management activities. Since the start of the project in 2008, several significant developments have been made. First, an extensive database of nearly 3 million observations spanning over 50 years of observation and a large geographic area has been compiled. This database has been used to develop equations for maximum and stand-grown crown width as well as height and height to crown base have been estimated for the primary species in the Acadian Region. These equations give drastically different predictions when compared to the existing equations currently used by FVS-NE. Currently, diameter and height increment equations are being developed and some interesting trends are starting to emerge. These results as well as the future direction of the project will be discussed.

Abstracts
of
Poster Presentations

Impact of Moose Browsing on Forest Regeneration in Northeast Vermont

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Moose (*Alces alces*) play an important role in the ecological and economic resources of northern New England, a landscape dominated by commercial forests. Given that high density moose populations can negatively impact forest regeneration, and that high density populations have occurred in northern New England, land managers have concern that moose influence forest regeneration in the region. The objective of this study was to measure the impact of moose browsing on forest regeneration in an area of previously high moose density in Wildlife Management Unit E1 in northeastern Vermont. In June 2012 we surveyed 38, 4.1-16.2 ha clearcuts categorized into 4 age classes (3-5, 6-10, 11-15, and 16-20 years old), 8-10 clearcuts per age class. In each clearcut we established ~100-400 milacre survey plots in which we identified the dominant stem and its relative height, and performed a qualitative inventory of browse damage based on crooks, forks, and brooms. Preliminary analyses indicate that commercial species were the dominant stems in 73, 75, 74, and 85% of the 4 age classes, respectively. The average occurrence of damaged dominant stems in the 4 age classes was 75, 74, 75, and 57%, respectively. Temporal comparisons will be made to assess change in relative damage (or recovery) and species composition over time. Regeneration data will be compared to moose density over the 20 year span, and to the timing of Vermont's effort to reduce the area's moose density in the past 5 years.

Regulation of Ontogenetic Trends in Morphology and Productivity of Forest Trees

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In all conifer species stem wood productivity decreases beyond the midpoint of a species' average lifespan. Other age/size-related trends include change in form from conical to flat-topped crowns with no height growth, greater branching, and production of more robust needles. Studies on very tall tree species have focused on physical restraints, including water stress from longer transport pathways. However, relevance of constraint-based hypotheses to explain age-related changes in trees typical to most temperate mesic forests has been largely unsuccessful. To address this deficiency, we have recently proposed a conceptual model based on life-stage environmental adaptation: the Ecologically Stable Strategy (ESS) hypothesis (Day and Greenwood 2011). This study tests a prediction of the ESS hypothesis that old trees shift resource allocation from competitive height growth, and concurrent stem diameter increment that maintains stability, in mid-aged trees to conservative strategies maximizing long-term reproductive output in the old life-stage.

In red spruce, old-growth trees maintain a high level of photosynthetic productivity, but shift carbon allocation to non-structural carbohydrate (NSC) reserves that increase resilience to stress and disturbance. Old-growth trees store nearly four times as much NSC in their stem parenchyma tissue than mid-aged trees, and foliage production shifts to longer-lived, more robust foliage. Our research suggests that stand leaf area devoted to old trees continues to maintain high rates of productivity and CO_2 sequestration, in addition to well-documented ecosystem services associated with wildlife habitat and aesthetic values, high quality veneer grade logs and specialty lumber products that cannot be obtained from younger trees.

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Modeling Discolored Wood Columns in Sugar Maple (*Acer Sachharum* Marsh.) Tree Stems

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The presence of traumatic discolored wood column in the core of sugar maple (*Acer saccharum* Marsh.) stems reduces the proportion of white colored wood and thus lowers its commercial value. Therefore, this study aimed at (i) exploring the tree characteristics related to the proportion of discoloration, (ii) assessing the clear and discolored wood volume allometry with tree size, and (iii) predicting the extent of discoloured wood column in sugar maple stems from different sites using tree characteristics. Using 109 trees from three different sites of southern Quebec, we found that the proportion of discolored wood was inversely proportional to sapwood volume and proportional to tree age. Discolored wood volume increases disproportionately with tree diameter, while varying among sites. A non-linear mixed effect model provided good estimates of discoloured wood taper. Disk height along the stem was used as a predictor with DBH, CR, and tree height as covariates. Vigorous and younger trees showed significantly lower proportion of discolored wood volume. Although the observed injury surface area was positively correlated to the discolored wood volume, injury information did not explain a large part of the discolored wood proportion variation. Overall, older and larger trees with many injuries on less productive sites are likely to develop larger discolored wood proportions.

Keywords: discolored wood, sugar maple, tree characteristics

Are Redback Salamanders Sensitive to Soil Calcium? Contrasting Evidence from Across the Northern Forest Region.

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Many amphibians are sensitive to changes in pH and their distribution may be limited by acidification and loss of calcium (Ca) from upper soil horizons. Low soil pH has been shown to limit suitable microhabitats of eastern redback salamanders (*Plethodon cinereus*) – a keystone species in northern hardwood forests that strongly shapes leaf litter food webs and metabolism of key nutrients. Recent research in upland hardwood forests of the Adirondack Mountains, NY found a strong positive relationship between redback abundance and soil Ca. Diet analysis of those salamanders found that they consumed more Ca-rich invertebrate prey than other salamander species at the same sites. To evaluate whether these relationships existed across the broader Northern Forest region, in 2011 we replicated the Adirondack study at upland forest sites across Vermont and New Hampshire. Salamanders, their stomach contents, and forest floor invertebrates were sampled at sites representing a gradient in Ca availability. We found that redback salamanders were the most abundant salamanders but their abundance was unrelated to soil Ca, unlike in the Adirondacks. Interspecies competition with northern dusky salamanders at the Adirondack sites, but absent from our sites in Vermont and New Hampshire, may explain differences in results. Diet samples of 157 redback salamanders along this Ca gradient are being analyzed to determine if any differences in prey exist based on soil chemistry. In light of recent studies indicating redback salamanders may be able to acclimate to low-pH forest soils, more in-depth sampling at these sites was done in 2012.

The Uniqueness, Conservation Value and Ecophysiological Basis for Maritime 'Pine-Island' Vegetation Communities

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Bedrock outcrops along the eastern Gulf of Maine contain 'vegetation islands' inhabited by ericaceous shrubs, grasses and forbs. The most successful of these vegetation islands develop around one or more pitch pine (*Pinus rigida*) trees. Our preliminary investigation suggests that 'pine-island' plant communities are less stressed by summer drought than their non-pine counterparts and have greater soil depths, resulting in communities with greater species richness, a more complex and stratified community structure, and higher productivity of dominant shrub-stratum species. Large differences between pine-dominated and non-pine communities indicate that pitch pine is a keystone species in these communities. The presence of a pine shifts community attributes between two alternative stable states and is required for a successional sere that, if undisturbed, moves these sites from bare ledge to a maritime spruce forest.

Pitch pine may contribute to community success through several mechanisms. Pitch pine almost always establishes in fissures, suggesting that they are tapping water sources that are located well below the surface, and supplying co-occurring plants with soil water through hydraulic redistribution to upper soil strata. The higher aerial profile of pitch pine may also contribute to water and nutrient availability by interception of fog and marine aerosols, decreasing leaf-to-air vapor pressure deficits, and adding leaf and branch litter to soil organic matter. However, geographic isolation and poor migration potential make pine islands one of the most at-risk community types in a changing climate. The knowledge base we are developing will be critical for management of these unique plant communities.

Commercial Thinning Has Effects on Edible Forest Mushrooms

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In Bas-St-Laurent, Quebec, large areas of spruce plantations, known to have significant abundance of fungi, will undergo commercial thinning in the coming years. These silvicultural treatments could have a significant impact on edible forest mushrooms productivity, which relies on mycorrhiza. In this context, it is relevant to understand the effects of thinning on mushrooms productivity, in terms of abundancy and weight. We also want to understand which environmental variables are implicated in mushroom productivity. Transects were monitored in 52 white and/or Norway spruce plantations, including half that were commercially thinned over the past 5 years. Transects were visited every 10 days, between early July and mid-October 2011. All edible mushrooms (7 species surveyed) found in the transects were picked and individually weighed. PH, texture and temperature of the soil were measured, as well as air temperature, slope and woody debris on the ground. Our results shows that commercial thinning significantly reduced the number of fruit bodies of the species studied, with the exception of *Lactarius deterrimus*, and *L.piceinus* which were not affected by the treatment. An augmentation of the weight of *B.edulis* and *L.deterrimus* was also observed after the commercial thinning. Results of this research could help improving the sequence of silvicultural treatments in order to optimize mushroom harvesting and wood production.

Keywords: Edible mushroom, commercial thinning, *mycorrhiza*, spruce plantation, agroforestry.

Spatial Variability and Climatic Determinism of Tree Form in Quebec

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In order to characterize the forest resource and to estimate biomass and carbon stocks in forests, it is important to study the tree form through (i) the vertical growth pattern and (ii) allometric relationships (e.g. H = f(DBH), Vol = f(DBH), etc.) in individual trees. Moreover, this is of particular interest when studying the relationships between functional traits (e.g. competition index) and tree form in order to understand its ecological determinants.

Equations of both vertical growth pattern and allometric relationships were estimated on nine commercial species, using stem analysis on 7536 trees from the Quebec inventory. The Quebec area is large (460 000 km^2) and the spatial variability of equations has not been investigated at the moment. In addition, Quebec is divided in several bioclimatic regions leading to trees growing in contrasted climatic conditions (from boreal to temperate), as well as in contrasted site conditions (soil, nutrient availability, solar radiation…).

The aims of the project are twofold. (i) We will establish the spatial variability of tree form equations for each species using geoadditive models. (ii) We will investigate the ecological and climatic determinism of this spatial variability. This would allow for the comparison of different species life-strategies along environmental gradients.

Keywords: vertical growth pattern, allometric relationships, spatial variability, climate

Expanding Interface in the Northeast's "Asbestos Forest": Exploratory Assessment in New Hampshire

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An initial exploration of the connections between land use and forest fire risk in New Hampshire is reported. Though forest fire occurs at a low level, it is still subject to occasional extreme events. There is a strong association between the occurrence of fire prone types and the developed areas of the state. In the towns experiencing 100 acres or more of fire in 1947-48, today there reside 100,000 people. Not only that, but population density is positively associated with forest fire occurrence. The counties that experienced high levels of fire in 1947-48 continued to do so in 2002-2011, so the geography of fire was relatively stable. Further research is needed to modify, extend, and elucidate factors underlying these relationships and trends.

Keywords: New England, New Hampshire, forest fire risk, WUI, Intermix.

Population Change at the Urban-Rural Edge: Demographic Trends in the Northern Forest

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This research was sponsored by the Northeastern States Research Cooperative. This poster examines recent demographic trends in the Northern Forest using the most recent data available. The Northern Forest spans over 26 million acres in four states. Population and housing growth in this long-settled region has been modest, but there is considerable internal variation, with some places growing rapidly while nearby communities lost population.

We combine longitudinal demographic data from the Census with economic, spatial housing and forest data from other sources to investigate population redistribution trends. We compare demographic trends in the 34 Northern Forest counties (Forest counties) to that in 58 nearby counties (non-Forest counties).

In 2010, 2,289,000 resided in the Forest counties. Population gains were greater in these counties (3.4 percent) than in the non-Forest counties (2.3 percent). Net migration was critical to the region's recent growth because the Northern Forest counties gained migrants between 2000 and 2010, rather than losing them as they had during the 1990s. Population gains was greatest in proximity to large urban areas and in high amenity counties. Population gains were smallest in manufacturing counties, where migration gains were minimal.

The housing stock has grown modestly over the last several decades, though changes in housing density and timing have been spatially uneven. Yet, forests remain widespread, even in areas with moderately high housing densities. These changes have produced an extensive intermix of people and forest in the region that resource managers must be cognizant of in planning for the future of the Northern Forest, its people and institutions.

Balancing Ecological and Economic Values in Northern Hardwood Stands: What are the Trade-Offs?

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Abstract is not available

Post-Harvest Changes in Forest Floor Carbon in the Vermont Managed Forest Soil Reference Plots

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Forest soils are a significant sink for global carbon yet little is known about the long term impacts of harvesting practices on this reservoir. Vermont has a long history of logging and with over 75% of Vermont land currently forested it is apparent that it will also have a robust future. In 2008 the Northern States Research Cooperative (NSRC) funded a project under Theme 1: Sustaining Productive Forest Communities: Balancing Ecological, Social and Economic Considerations. With this funding, 18 reference plots scheduled for harvesting were established throughout the state of Vermont. These plots were analyzed using The USDA Forest Service Forest Inventory and Analysis (FIA) protocols, and with enhanced soil testing pre-harvest conditions were determined. From this data, it was concluded that soil carbon storage varied greatly with depth, elevation, and land use/management history. Based on these findings, we hypothesize that post-harvest data will also demonstrate great variation. In the summer of 2011 two northern hardwood forests plots, Sterling Town Forest in Stowe and Green Mountain National Forest in Peru, were sampled post-harvest using the same protocols used in the plots establishment. The preliminary data indicates a decrease in forest floor depth, which is consistent with previous study findings. In the summer of 2012, 2-5 more plots will be resampled. At that point the data can be compiled to draw conclusions of the overall impact of harvesting on the Vermont's forest soil carbon resources.

Mapping Vulnerability to Defoliation by Spruce Budworm Using Landsat Satellite Imagery and FIA Field Plots

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Periodic infestations of the eastern spruce budworm (*Choristoneura fumiferana* (Clem.)) cause widespread defoliation, growth reduction, and mortality of balsam fir (*Abies balsamea*) and spruce (*Picea spp.*) trees throughout the northeast United States and eastern Canada. Proactive planning for budworm outbreaks requires knowledge of host species distributions and forest vulnerability so that the consequences of infestation can be better understood and effective policies and response strategies put in place. Stand susceptibility to defoliation is strongly related to host species abundance; vulnerability (growth reduction and mortality due to defoliation) is strongly related to host species abundance and age. Both are substantially reduced by the presence of non-host species. We have mapped budworm host species relative abundance, forest age, and vulnerability to defoliation across the commercial forestlands of northern Maine using Landsat satellite imagery and reference data provided by USFS Forest Inventory and Analysis field plots. We developed a novel technique to model and map species distributions using support vector machines parameterized by a multi-objective genetic algorithm to simultaneously minimize prediction error and bias. We adopted a similar approach to model and map standreplacing disturbances and forest age using a nearly 40-year time series of Landsat imagery (1973-2010). Budworm vulnerability classes were mapped by combining relative abundance estimates of fir and spruce species with forest age. Results provide the basis for a large-scale, spatially explicit assessment of vulnerability in advance of the next outbreak. Moreover, our modeling methods are transferable to other regions, other tree species, and other forest attributes of interest.

Scaling the Mechanical Properties from Mini-Clear Samples to Full-Size Lumbers

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Wood stiffness and strength are two important qualities for structural products like lumber. Evaluating silvicultural effects on lumber requires costly conversion tests. Instead of using expensive full size lumbers, several studies have used small pieces such as mini-clear samples to investigate wood mechanical properties, e.g. stiffness and strength. However, scaling measurements from mini-clear samples to full-size lumbers is not straightforward. Mini-clear samples are free of macro defects whereas knots influence the mechanical properties on full-size lumber. The objectives of this study are, first to establish a methodology for the scaling process and second to apply the scaling method to study silvicultural effects on lumber quality. Moduli of elasticity and rupture of both mini-clear and full-size samples of white spruce (Picea glauca) were obtained from two spacing trials in Ontario. The first step is to determine how the size influences mechanical properties. Secondly, compositional disparities (e.g. proportion of juvenile wood) and external defects (e.g. knot characteristics) are also to be considered. Tree metrics such as crown and branch attributes which are associated to the properties of juvenile wood and knots will be studied. A model presenting the relationship between mini-clear samples and full-size lumbers at individual tree level will be developed. Finally, the model will be evaluated at the stand and site level and the marginal or additional effects on the scaling process will also be studied.

Keywords: Modulus of elasticity, modulus of rupture, mini-size clearwood, *Picea glauca*, scaling method

Comparing City and Forest Tree Dimensional Relationships: Do We Need Allometric Equations Specific to Urban Environments?

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Abstract is not available

Long-Term Outcomes and Tradeoffs of Forest Policy and Management Practices on the Broad-Scale Sustainability of Forest Resources: Wood Supply, Carbon, and Wildlife Habitat

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The natural resources of the Northern Forest and the economies that depend on them are coming under increasing threat from a complex of anthropogenic disturbances. Many of these disturbances originate in large part outside the region (e.g.; acid rain, mercury pollution, climate change) and will require regulatory or market-based solutions. Other disturbances have some roots in the region (e.g.; harvesting, fragmentation, parcelization), providing a valuable opportunity for research to quantify disturbance effects and facilitate better land management. Modeling tools are already available to land managers for evaluating if management activities will meet stakeholder objectives. However, tools that can only be applied to individual ownerships have limited utility for informing regional resource sustainability. The forest landscape change model LANDIS-II provides spatially-explicit simulations of disturbance and succession and can model differences in management behavior between owners. We used LANDIS-II to simulate future forest conditions across 4 million acres of commercial forestland in Maine, including 65 landowners, under alternative management scenarios. Scenarios were designed to evaluate cumulative effects of forest policy and harvest intensity on aggregate outcomes. To guide scenario design, we calculated past (1988-1993) and recent (2000-2010) harvest rates for all landowners using Landsat-derived disturbance data. Results suggest that if the relative proportion of acreage clearcut vs. partial harvest were to return to the rates of the late 80s and early 90s, total and spruce-fir live biomass would be higher and a greater proportion of mature forest would be left intact over the next 100 years.

Evaluating Species Composition and Timber Quality in Selection Silviculture Systems

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Abstract is not available

Operational Mapping of Forest Disturbance Gradients with Fused PALSAR and Landsat

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Disturbance from natural and anthropogenic processes is a frequent occurrence in northeastern forest ecosystems. Timely and accurate assessment of disturbance events is critical for land managers to respond effectively and appropriately. Concordantly, assessing the severity of disturbance is critical for broad-scale management and policy. New satellite remote sensing tools such as Phased Array Synthetic Aperture Radar (PALSAR) and Light Detection and Ranging (Lidar) hold the potential to operationally identify disturbance and quantify its ecological effects more precisely than with optical imagery (e.g., Landsat) alone. A gradient of disturbance case study events was assessed in New England using multiplatform remote sensing in an operational context. Plot level field work was carried out across multiple regions to calibrate and validate forest structural metrics. Geostatistics, image decomposition, and data fusion techniques were applied to map disturbance events and determine the level of sensitivity of each sensor and combination of sensors. Canopy fractional cover, forest structure, and biomass indices generated with fused PALSAR, Lidar, and optical imagery were stronger compared to each sensor individually. Maps of disturbance, remote sensing algorithms, and case study illustrations will be presented and shared with the science community. We will also provide a management context by highlighting the ability of these tools for assessing common northeast disturbances from stressors such as development, storms, and insect infestation.

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The Effects of Forest-Buffer Width on Pool-Breeding Amphibian Demography.

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Forested buffers are a common management tool for pool-breeding amphibians in eastern North America, yet the demographic consequences of buffer size have not been experimentally tested. We used clear cutting to manipulate buffer widths at 11 vernal pools in central Maine. Each pool was randomly assigned to one of three treatments: uncut (i.e., reference treatment), 100-m buffer, or 30-m buffer. From 2004 to 2009, we captured all adult spotted salamanders (*Ambystoma maculatum*) and wood frogs (*Lithobates sylvaticus*) using these pools. We assessed the relative importance of buffer treatment and other factors on breeding-adult abundance, recapture rates, and sex ratios. Buffer treatment affected salamander abundance, but treatment effects were mediated by pool hydroperiod, with the strongest impacts at 100-m pools, where abundance increased sharply with mean hydroperiod. Wood frog abundance increased with mean hydroperiod across all treatments. For both species, the proportion of recaptured adults was lowest at 30-m pools. Salamander, but not frog, recapture rates recovered with time; by six years post-cut, salamander recapture rates were similar across treatments. Salamander sex ratio increased post-cut at both the 100 and 30-m treatments, while frog sex ratio did not vary across treatments, years, or hydroperiod. In our study, clear cuts were associated with short-term negative demographic consequences for these species, with 30-m-treatment populations experiencing the most severe impacts. Demographic recovery may strongly depend on landscape composition and configuration. We are investigating the landscape genetics of these populations to better understand how local and landscape variables impact spotted salamander and wood frog demography.

Songbird Abundance and Diversity along a Soil Calcium Gradient in the Adirondack Mountains, NY

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The depletion of soil calcium, an important macronutrient, by acidic deposition has been linked to changes in plant and invertebrate communities, as well as to reproductive declines in some avian species. To investigate the effects of calcium depletion on overall avian abundance and diversity, we sampled bird communities at 13 sites representing a soil calcium gradient of upland northern hardwood forests in the Adirondack Mountains, New York. We found evidence that avian abundance may be linked to mineral soil calcium availability. Some species may favor higher calcium sites with lower acidic deposition inputs for establishing breeding territories. However, there was no relationship between species diversity and soil calcium concentration or acidic deposition levels. These preliminary results indicate that some species may be more sensitive to calcium availability and acidic deposition than others. We will discuss how avian communities at low calcium sites may differ from communities at high-calcium sites. The study can provide guidance for conservation efforts in the Adirondack Mountains, elucidating whether highly buffered sites may act as neorefugia for biodiversity by retaining potential for long-term acidification resistance and recovery.