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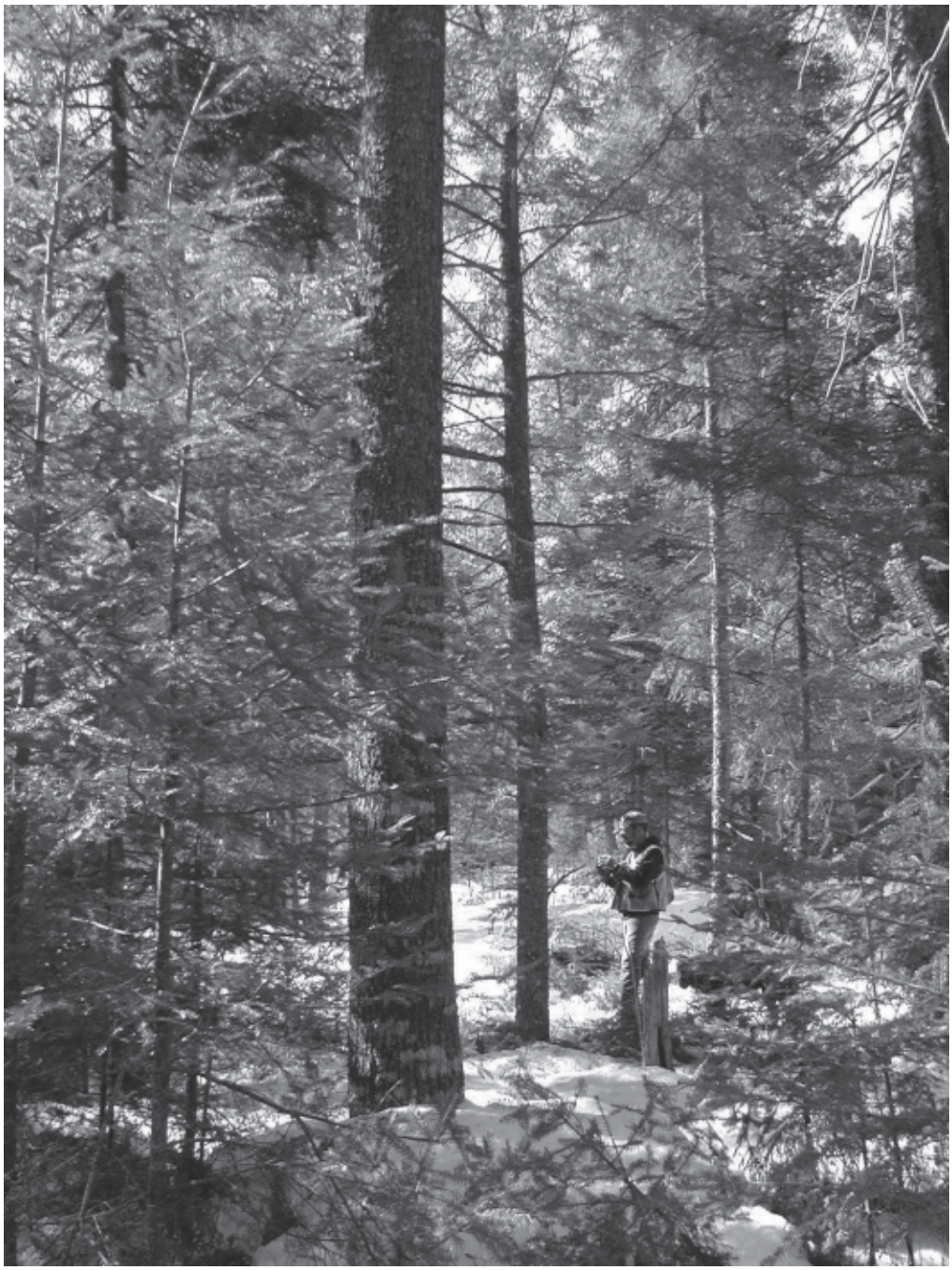
Changing Forests – Challenging Times

Proceedings of the New England Society of American Foresters 85th Winter Meeting



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Cover Photo

Uneven-aged northern conifer stand on the Penobscot Experimental Forest in Maine

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CHANGING FORESTS – CHALLENGING TIMES

Proceedings of the New England Society of American Foresters 85th Winter Meeting

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Laura S. Kenefic and Mark J. Twery

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THE VALUE OF LONG-TERM SILVICULTURE RESEARCH FOR ALL CATEGORIES OF LANDOWNERS, LARGE AND SMALL, PRIVATE AND PUBLIC

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The value of long-term research is that individual people do not live as long as trees and therefore are unable to watch, learn, and understand the growth and regeneration processes. Even foresters who are supposed to be aware of this fact often get distracted by life's other issues. This leads to forgetting what you know and trying to relearn it.

Long-term silviculture research actually includes any study longer than 10 years. History shows that this type of work needs to be done by a governmental or educational organization. Private industry or landowners almost never have the commitment to carry through. Many projects are started and few are finished.

Results from long-term research must be implemented by foresters working with landowners to be of any use at all. This applies to all categories of landowners.

Long-term research on regeneration and site productivity are of particular value. Foresters make decisions daily that they believe to be science-based. They think they understand issues related to regeneration and productivity, but often do not.

Only a few foresters and research efforts have had the luck, interest, and fortitude to accomplish long-term research. All foresters talk about it but few actually do it. In my opinion, Bill Leak and the USDA Forest Service Northeastern Research Station epitomize this wonderful combination of circumstances.

LONG-TERM ECOLOGICAL RESEARCH AT THE HARVARD FOREST

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Permanent plots are a key component of a long-term ecological research program. They provide direct insight into forest development, complement reconstructive and space-for-time techniques, and serve as controls to experimental areas. Sites in which the trees are mapped provide detail into disturbance processes and spatial patterns of forest dynamics. Permanent plot studies have been part of the Harvard Forest's mission since it was established in 1907; we present a few examples to illustrate some of the insights that they have provided.

Since 1909, quantitative forest inventories of the Harvard Forest have been undertaken regularly. One of these inventories was completed in 1937, fortuitously providing detailed baseline data to compare to the post-1938 hurricane forest. In 1992, an augmented inventory of the 1937 plots was completed; analyses highlighted how past land-use is a dominant force in determining current forest structure and function (Motzkin et al. 1999). This extensive plot system is complemented by a 3-ha stem-mapped site that has been remeasured decadally since 1969.

The Soil Warming Plots and Nitrogen Saturation Plots were established in 1990 as part of the Harvard Forest Long-Term Ecological Research program. These are very long running plots for experimental manipulations, and have yielded surprising, non-linear trends over time (Melillo et al. 2002, Aber 2004). A large stem-mapped hemlock plot was also established in 1990, and its intensive reconstruction provides a valuable base from which to observe its anticipated decline as the hemlock woolly adelgid invades the site.

Maintaining field sites and records for long-term plots is a major commitment, especially when results do not easily lend themselves to publication at each remeasurement cycle. Harvard Forest has a research assistant, an archivist and a data manager engaged in this activity. Even with this commitment, it is a challenge to keep up with plot remeasurements and data management, especially as new studies are simultaneously developed. However, the insights from the long-term plots are irreplaceable and this continuing legacy is central to the value of Harvard Forest.

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USE OF *CYBOCEPHALUS NIPPONICUS* (COLEOPTERA: NITIDULIDEA) FOR BIOLOGICAL CONTROL OF ELONGATE HEMLOCK SCALE, *FIORINIA EXTERNA* (HOMOPTERA: DIASPIDAE), IN PENNSYLVANIA FORESTS

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We have released 82,000 predatory scale-feeding Korean nitidulids, *Cybocephalus nipponicus,* at 25 hemlock sites infested with the exotic elongate hemlock scale, *Fiorinia externa*, in southern, eastern, central and northern areas of Pennsylvania in 2003 and 2004. We released 40,000 *C. nipponicus* at 14 sites, and made augmentative releases at 5 of these sites, between June and November 2003. We released 42,000 *C. nipponicus* at 11 new sites and made augmented releases at 12 sites between May and November 2004. We plan to release 14,000 *C. nipponicus* at seven (preferably new) sites in 2005. We are working out the details of timing the seasonal releases with the Alampi Laboratory. It is possible that we may make releases later in the season to ease time constraints involved with completing projects.

Area Forest Pest Management Specialists used beating sheets to evaluate overwintering and reproduction of C. *nipponicus* in the field. Forty C. *nipponicus* adults were recovered at sites where the predator was released in 2003. Of these, nine were recovered in the spring, and 31 were recovered in October. Most recoveries were at a site in the southern area. The presence of adults confirms that the beetles are able to overwinter in the field. Although we have not yet recovered the tiny beetle larvae, we assume reproduction is also occurring because of the short lifespan of the adults. These preliminary results are encouraging for establishing this biocontrol agent in the field.

We assessed the effectiveness *C. nipponicus* in reducing *F. externa* populations by comparing the number of live *F. externa* on branch samples from a control and release tree at a site in Lycoming County, PA in 2003 and 2004. Several samples contained white hyphae and a black fungus, some of which were confirmed to be *Aschersonia*. There were also some tiny black arachnid predators and parasites present on many of the branches.

On 07/23/03 we observed 1,867 live *F. externa*, 1,222 on 20 branches (Mean=61.1± 6.1 per 3cm branch) from a control tree, and 645 on 20 (32.3 ± 3.9) branches on a tree where 2,500 *C. nipponicus* were subsequently released. A predatory neuropteran in the family Coniopterygidae was present on one branch. Many parasitized scales were present. Three months after we released *C. nipponicus* on 10/10/03 we observed 1,149 *F. externa*, 675 on 20 control (33.75 ± 5.3) and 474 (23.7 ± 3.6) on 20 release branches. We then revisited the site the following year, when we decided to evaluate only ten branches on each control and release tree. On 06/10/04 we observed 345 *F. externa*, 202 on 10 control (20.2 ± 5.1) and 143 (14.3 ± 2.8) on 10 release branches. No mature males were observed. On 07/29/04 we returned for a final evaluation and observed 754 *F. externa*, 555 on 10 control (55.5 ± 6.9) and 199 (19.9 ± 5.2) on 10 release branches. Nymphs were mostly on new growth, which was more abundant on the control tree. This may help explain differences in abundance between control and release trees more than the release of the predatory beetle, but it is still encouraging to see fewer live scales on the CN release vs. the control tree for all evaluations we made. Jim Lashomb and a graduate student from Rutgers are currently assessing the efficacy of *C. nipponicus*. We will follow his investigations closely to determine if we will continue to use *C. nipponicus* for biocontrol of *F. externa*.

A GROWING NETWORK: REGIONAL INVASIVE PLANT INITIATIVES IN NEW ENGLAND

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The invasive plant problem is complex and solutions require people from many disciplines. Collaborative invasive plant initiatives are underway in New England and opportunities abound to become involved. Individuals from diverse professions and avocations have joined the New England Invasive Plant Group (NIPGro) that provides conferences, newsletters, email news briefs, and an information clearinghouse to inform members and foster networking. The next conference is planned for Sept. 16-18, 2005. Four hundred and fifty volunteers are trained by the Invasive Plant Atlas of New England (IPANE) to identify and collect data on species known or suspected to be invasive in the region. Data collected is verified and made available online in map or data format, along with a wealth of additional information and photos. More training sessions will be held this spring. NIPGro and IPANE staff are working to facilitate an Early Detection and Rapid Response network that will enable New Englanders to detect, assess and preempt the establishment of new invaders. State invasive plant committees, federal agencies, and another regional organization, the Northeast Aquatic Nuisance Species Task Force provide advice and links to a larger audience. A grant from the U.S. Department of Agriculture currently funds NIPGro and IPANE. The primary organizers are the Silvio O. Conte National Fish and Wildlife Refuge, the University of Connecticut, and the New England Wild Flower Society. More information can be found on the IPANE website (www.ipane.org).

INVASIVE PLANTS, DEER AND FOREST REGENERATION: OBSERVATIONS FROM SOUTHEASTERN VERMONT

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In the past fifteen years, foresters in southeastern Vermont have been increasingly disappointed with their forest regeneration treatments. We have watched good, knee-high northern hardwood regeneration on good sites succumb to deer browse, invasive exotics and aggressive hay-scented and New York fern.

This presentation is a collection of observations, theories and speculation about this change to our forests and how we may be able to adapt. For example, some of us believe that as colonies of invasive exotic plants become well-established and disperse increasing numbers of seeds to occupy new areas, deer aid in their success by selectively browsing our regenerating native species. We speculate that this in turn lowers the forest's carrying capacity for deer at the same time hunters are demanding higher deer populations. To successfully adapt, we may need a collaborative, multi-action approach that includes vegetation management that slows the spread of invasives, people management that breaks down social barriers between hunters and non-hunting landowners, and deer herd management that prioritizes forest health (carrying capacity) above consumer demands (hunter and wildlife observation satisfaction).

FOCUS SPECIES FORESTRY: AN APPLIED APPROACH TO INTEGRATING TIMBER AND BIODIVERSITY MANAGEMENT IN THE NORTHEAST

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Forest certification and other forest management programs have required foresters to place greater emphasis on biodiversity in their management plans. Many traditional wildlife management guides have featured management for a limited number of species on the a-la-carte menu format, i.e., the landowner or manager identifies species of interest and follows those recommendations. There are also some extremely comprehensive wildlife guides that are excellent background references, but due to their breadth and depth they do not readily lend themselves to field use or ready integration into forest management plans. Newer guides to biodiversity management typically emphasize general principles but do not have recommendations specific to species or forest types. Focus Species Forestry addresses these gaps by providing forest managers with a tool to readily integrate biodiversity considerations into more traditional approaches to forest management.

Focus Species Forestry has a goal of comprehensive biodiversity management, either as a stand-alone system or within the context of management for other values such as timber. It is based on 25 focus species that represent the breadth of forest types, development stages, and sensitive habitats found in the region's forests. In sum, these species serve as a coarse-filter "umbrella" whose habitat covers those of all other forest vertebrate wildlife species and most elements of forest biodiversity. A suite of 12 "primary" focus species has been identified to further streamline forest management considerations. These species cover early-successional forest, extensive intermediate to mature forest, late-successional forest, dead and decaying wood, vernal pools, and streams. Management plans for these habitat types are developed in conjunction with management for other values. Options for management at different scales (small woodlands and larger, landscape-scale forests) are also discussed. Sources of information for rare, threatened, or endangered species are also included.

The Maine guide is organized under six broad forest ecosystem types, and includes forest type and wildlife species management recommendations that can be integrated into typical forest management plans. By linking management to a relatively short list of easy-to-identify species and forest types, the goal is to make biodiversity management more understandable and attainable within a traditional forest management context.

Forest management plans based on Focus Species Forestry should meet the biodiversity requirements for FSC, SFI, and Tree Farm certification. The species, forest types, and management recommendations featured in the original Maine guide have broad applicability to the remainder of New England, New York, the Maritime provinces, southern Quebec and southern Ontario. A supplement is included with the Maine guide for application in other northeastern states and provinces. Plans are under way to develop a regional version of the guide.

LANDSCAPE-SCALE FOREST PLANNING — USING THE AMERICAN MARTEN AS A GUIDE

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Huber Resources is using a habitat model for the American marten as a landscape-scale harvest planning tool. Based on work by Dr. Dan Harrison of the University of Maine, a marten habitat unit is defined as approximately 1,250 acres in size. Marten cover necessary for denning, predator escape and foraging consists of hardwood, softwood or mixed wood stands over 30 feet in height and >80 square feet of basal area. A successful marten habitat unit will have 70% or more of its area occupied by these cover stands.

In planning future timber harvests across the landscape, the goal would be to have four or more marten habitat units per township size area (~23,000 acres) at any given point in time. The concept is that, over time, these marten habitats will shift across the landscape as the forest is harvested and re-grows. During the time they are in earlier stages of succession, they provide habitat for a different suite of species. The marten was selected as a surrogate species because the scale of habitat it requires appears to benefit a majority of other vertebrate species occurring in northern Maine forests.

PROFILES OF WORKING WOODLANDS: EXPANDING THE DEFINITION OF ACTIVE FOREST MANAGEMENT

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Forest conversion and fragmentation continues to increase in our Northeastern forests, creating smaller, fragmented parcels owned by landowners who may no longer identify with timber production. Solutions to these issues should be designed which are both ecologically sound while economically viable and may mean expanding the traditional definition of active forest management. Profiles of those that have developed a variety of business models will be presented. In addition, the presenters will discuss local efforts and new programs to help encourage and support small, natural resource-based businesses.

LONG-TERM FOREST GENETICS RESEARCH IN NORTHEASTERN NORTH AMERICA: A SAMPLER

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Tree breeding research began in the Northeast as early as the 1920s, when the Oxford Paper Company of Rumford, ME sponsored hybrid poplar breeding work by Dr. Ernest Schreiner. This research was transferred to the USDA Forest Service Northeastern Research Station in Durham, NH in 1937. For the rest of the 20th century, the Station remained active in long-term forest genetics research on a variety of species, including many research plantations on the Massabesic Experimental Forest near Alfred, ME. Some recent applications from research originated by the USDA Forest Service on white pine and sugar maple illustrate the continuing utility of this work. Various universities in New England also maintain long-term forest genetics research projects.

At about the same time that hybrid poplar research was beginning in the Northeastern U.S., forest genetics research was also underway in Canada. Much early work was based at Petawawa, Ontario. Over 300 genetic test plantings still exist there and are available for ongoing research activities. Applied tree improvement programs began in eastern Canada in 1976 with the cooperative New Brunswick Tree Improvement program that originated as a joint effort by forest industry, provincial and federal governments, and universities. The NBTIC seed orchards are now producing adequate supplies of black spruce, jack pine, and white spruce seed to meet all planting needs in the province. The provinces of Quebec, Ontario, and Nova Scotia maintain similar long-term applied tree improvement programs.

SAMPLING HEMLOCK WOOLLY ADELGID AND DEVELOPING INSECT-KILLING FUNGI FOR THEIR SUPPRESSION

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The hemlock woolly adelgid (*Adelges tsugae*) has been spreading through the eastern United States for over 50 years destroying hemlock forests and dramatically changing the landscape. However, the lack of an efficient sampling plan for detecting new infestations and quantifying the percentage of infested trees hampers foresters and researchers. A survey of 1,700 trees in 17 sites with a wide range of infestations forms the basis of the hemlock woolly adelgid (HWA) sampling plan. This is a statistically based plan that allows for defined reliability of population estimates. Yet the plan is relatively straightforward in its execution and is flexible enough to accommodate various sampling goals. The forest practitioner surveys 2 ground-level branches per hemlock tree for the presence or absence of white woolly masses of adelgid on 1-meter sections. Between 8 and 100 trees are sampled depending on how many positive trees are found. This allows determination of the percentage of trees infested at the specified precision level (0.25). No sampling plan can ever confirm that a hemlock stand is free of HWA. However, after sampling 100 trees and finding no HWA the conclusion made with 75% reliability using this plan is that HWA infest less than 2% of trees in the stand.

A concerted effort is underway to develop insect-killing fungi and other biological agents for management of HWA. The dramatic declines in gypsy moth populations in North America due to the fungus *Entomophaga miamaiga* highlight the potential of insect-killing fungi for forest pest management. Initially, we directed our research on insect-killing fungi toward collecting numerous isolates and then identifying those with the most insect killing activity. We also examined their suitability for mass production in anticipation of producing enough fungi for widespread application. Subsequent research examined fungal efficacy against HWA in the field on single hemlock branches to assess the rate and timing of fungal application. Lab and field trials examined the non-target effects of the fungi on *Sasajiscymnus tsugae*, an introduced predatory beetle of HWA.

The results to date are encouraging for the development of insect-killing fungi as a management tool for HWA. We are actively researching three isolates, a *Verticillium lecanni* and two of *Beauveria bassiana*, because of their positive profiles for efficacy, mass production potential and compatibility with the predatory beetle. Field trials between spring 2001 and fall 2003 indicate that significant reductions in adelgid populations occur with fall application of fungal conidia. These fungi, when applied at twice field application rate, did not negatively affect the predatory beetle, *S. tsugae*. Currently we are optimizing formulations for ULV delivery, further studying non-target effects and examining fungal persistence. The ability of applied fungi to persist in the environment and have lasting effects on HWA population dynamics influences the selection of deployment strategies for widespread applications.

MANAGING FOR BIODIVERSITY IN MAINE'S FORESTS: A MAINE NATURAL AREAS PROGRAM PERSPECTIVE

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As forest certification programs have grown in Maine, the Maine Natural Areas Program (MNAP) has played a key role in providing a number of biodiversity related services to landowners and foresters. Both SFI and FSC require assessment of biodiversity issues, and MNAP routinely provides a number of helpful services. MNAP data and products are also an important component of cost-sharing and forest management plans developed by consulting foresters, who may now acquire a variety of natural resource information at no charge through "one-stop shopping" at MNAP. MNAP's forestry-related services include:

(1) computer-based "screening" of the MNAP database to determine if any important features (see description of Beginning with Habitat below) are known from a particular site,
(2) field-based site reviews to evaluate potential impacts and develop harvesting plans that are compatible with protection of important features.
(3) ownership-wide "landscape analysis" using air photos, satellite imagery, and GIS-generated date to determine sites likely to support important features,
(4) ownership-wide field surveys to document rare species and exemplary natural communities, and
(5) field-based training on how to recognize and manage sensitive habitats.

Many of these services and projects may be available from Natural Heritage programs in other states.

A substantial amount of the state's biodiversity-related information has been mapped and distributed statewide through a groundbreaking, collaborative program known as "Beginning with Habitat (BWH)." BWH information includes rare species, exemplary natural communities, Maine Department of Inland Fisheries and Wildlife (MDIFW) essential habitats (e.g., bald eagle nests), MDIFW significant habitats (e.g., waterfowl and wading bird habitats), large habitat blocks (important for wildlife home ranges), streams and wetlands, and other related data. MNAP is spearheading the accessibility and use of this information by foresters, land use planners, land trusts, and private landowners.

The Maine Natural Areas Program, a division within the State's Department of Conservation, is part of an international network of similar "Natural Heritage" programs that obtain, assess, and disseminate information on biodiversity. MNAP shares information and works cooperatively with the Maine Department of Inland Fisheries and Wildlife, which manages wildlife species and information in the state. See the MNAP and BWH web sites (www.mainenaturalareas.org and http://www.beginningwithhabitat.org for details).

ORIENTAL BITTERSWEET: UNDERSTANDING ITS ECOLOGY AND PLANNING ITS CONTROL

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Oriental bittersweet (*Celastrus orbiculatus*) is a woody, twining vine introduced from Asia in the 1860s. It has been widely dispersed by birds, mammals, nurseries and the ornamental wreath trade. It is now common in much of the Northeast and poses a serious, long-term threat to silviculture in the region. Once established, Oriental bittersweet can quickly overtop trees along roads, in clearings and in forest gaps. Dense invasions can effectively halt forest succession and the vines can spread from treetop to treetop, creating dangerous felling conditions. Because of its ability to survive in the shade for several years and then grow rapidly after overstory removal, foresters should learn to recognize and control Oriental bittersweet in the understory before timber is harvested. This talk will focus on the suite of ecological traits that should be considered when monitoring for bittersweet and planning its control. Preferred control methods will also be discussed.

INFLUENCE OF FOREST PRACTICES ON STAND-SCALE HABITAT SELECTION BY LYNX IN NORTHERN MAINE: PRELIMINARY RESULTS

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Canada lynx (*Lynx canadensis*) occur across much of the northern United States and Canada, but little is known about lynx-habitat relationships in eastern North America. Results of the few habitat studies conducted on lynx throughout their North American range have been extrapolated to areas with potentially unique ecologies, including differences in climate, prey abundance, predator-prey communities, and rates of forest succession. Data on lynx-habitat relationships is lacking for eastern North America; Maine supports the only verified population of lynx east of Minnesota in the United States. Lynx have recently been provincially listed as an endangered species in Nova Scotia, and are of increasing management interest throughout eastern Canada.

Lynx are considered specialists on snowshoe hare (*Lepus americanus*), and habitat use by lynx is closely associated with density of snowshoe hares. It is important to determine the direct and indirect effects of silvicultural practices on habitat choice by wide ranging species that depend on hares, such as lynx. Within the Acadian forest, hares are closely associated with regenerating stands with an abundant coniferous understory. Silvicultural practices that create early-successional stages may increase densities of snowshoe hares and associated foraging opportunities for lynx. However, habitat use by lynx may be associated with more than just access to snowshoe hares, but with overstory and understory features related to protection from predation. Partial harvesting has the potential to reduce habitat quality for lynx because partially harvested stands had the lowest densities of snowshoe hares during winter among all overstory types (including regenerating clearcut, coniferous, deciduous, and mixedwood stands) sampled in north central Maine. Partial harvesting is commonly practiced in Maine and eastern Canada, but it is unknown how lynx respond to the forest structure and reduced density of hares in these stands. Thus, we evaluated the stand-scale effects of forest practices, including partial harvesting and clearcutting, on lynx in northern Maine.

We evaluated habitat selection at the scale of the forest stand by comparing the distance traveled by lynx in each overstory type to the percent of those overstory types within the home range of each lynx. We snowtracked six radio-collared lynx (3 females, 3 males) for 64 km January - March, 2002 and 2003. We utilized continuous GPS sampling to track lynx and recorded overstory type along the lynx trails. Habitat selection by lynx was strongest for short mid-successional regenerating clearcuts (11-14' tall, 11-22 years old). Partially harvested stands (1-10 years old) were also selected for, but were ranked below short mid-successional regenerating clearcuts. Lynx selected against tall mid-successional regenerating clearcuts (15-24', 11-26 years old) and strongly selected against mature second-growth stands. There was extremely low use of early regenerating clearcuts (<11 years old) and these stands were avoided at the scale of the home range likely because of very low densities of snowshoe hares.

REGENERATION STRATEGIES OF JAPANESE BARBERRY (*BERBERIS THUNBERGII* DC) IN COASTAL FORESTS OF MAINE

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Invasive exotic plant species have been shown to threaten biodiversity, habitat quality, and ecosystem functions, as well as agricultural and silvicultural economics via loss of revenue and high costs of invasive control programs. Invasion into intact closed-canopy forest ecosystems is less common than in open (e.g. grassland) habitats. However, one invasive species that has successfully invaded forests is the introduced ornamental shrub Japanese barberry (*Berberis thunbergii* DC.) in the family Berberidaceae. Japanese barberry was introduced over 125 years ago and is becoming a major threat to native systems, but relatively little has been published about the basic biology or ecology of the species. Gaps in knowledge include shortages of published information about regeneration dynamics and seedbanks. This study addresses the questions: (1) What is the density and origin of regenerating Japanese barberry and other species before and after removal of the Japanese barberry overstory? (2) Does a portion of Japanese barberry seeds remain viable for at least a year under natural conditions? (3) Do varying temperature and moisture regimes affect the germination success of seeds with and without the presence of Japanese barberry fruit pulp?

These questions will be addressed by two separate studies. The first study encompasses questions 1 and 2 and consists of a field study and greenhouse study. Monhegan Island, ME, and Wells National Estuarine Research Reserve in Wells, ME, have been chosen for study sites due to high levels of barberry invasion. A continuous stand of Japanese barberry will be delineated at each site, and transects will be cut through each stand to allow access to sample plots. A maximum of thirty 1m radius plots will be cleared and sampled on Monhegan Island in late summer 2004 before the current year's fruits ripen. Measurements will include percent cover of Japanese barberry, percent overstory shade, Japanese barberry regeneration counts, and the presence of other species. A pair of soil samples (14cm x 14cm x 10cm) will be collected from one half of each plot. One soil sample will be placed in a greenhouse setting, and Japanese barberry seedlings will be counted as they emerge. The other soil sample in each pair will be kept in cold storage over the winter and will be processed using the same methods in spring 2005. One soil sample in up to 30 additional sample plots will be collected in spring 2005 on Monhegan Island and from another 30 plots on the Wells Research Reserve. The undisturbed halves of all sample plots will be sampled in late summer 2005 to gather additional regeneration data for Japanese barberry and other species.

Study Two consists of collecting ripe fruits from the two sites and germination of intact fruits, extracted seeds, and commercially collected control seeds in growth chambers. Replicates of 25 control seeds and 25 extracted seeds will be incubated in growth chambers to identify the optimum temperature and moisture regimes for germination. An additional 25 seeds in berries will be used in each replicate to evaluate the influence of the fruit pulp on germination.

A BIODIVERSITY SCORECARD FOR SUSTAINABLE FORESTRY: SIMPLIFYING COMPLEXITY

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Maintaining biodiversity is a fundamental goal of sustainable forestry certification. But how do we know if "life in all its forms" is being maintained? Biodiversity can seem overwhelmingly complex. A quandary arises: the number of species and all their potential interactions simply cannot be quantified, and yet something that is not being measured cannot be managed. The only practical approach to assessing life in all its forms is to measure a relatively few components of the forest system (e.g., species, processes, stressors) that are correlated with as many other components of the system as possible—in essence, indicators. Most sustainable forestry indicators are called "policy response" indicators. That is, the indicator itself is the implementation of a company policy that is supposed to maintain biodiversity. Policy response indicators do not actually tell you *how* biodiversity is doing. We are developing a Biodiversity Scorecard for sustainable forestry. The Scorecard will be comprised of 8-12 "condition" indicators that inform the land managers about the status of biodiversity on their landbase. The Scorecard approach integrates the values of stakeholders into the indicator selection process to give the indicators social legitimacy. At the same time, condition indicators must be practical and affordable to measure by the land manager. This presentation will discuss the process for selecting condition indicators, and present some of the first indicators in the Scorecard. With quantitative indicators that reflect specific biodiversity values, landowners can actually link the results of the indicators with their decision making (i.e., they can make real decisions with the results). Condition indicators will begin to move sustainable forestry into the realm of quantitative science.

WHAT LANDOWNERS AND FOREST MANAGERS NEED TO KNOW ABOUT FOREST CARBON: A BACKGROUND FROM GLOBAL TO LOCAL

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Carbon sequestration is becoming an important land management objective because growing trees and vegetation can reduce the amount of carbon dioxide in the atmosphere. Many scientists believe that increasing the concentration of greenhouse gases such as carbon dioxide in the atmosphere will affect the climate. Concern over human-induced climate change prompted many nations, including the United States, to sign and later ratify the United Nations Framework Convention on Climate Change in the 1990s. The agreement to work to stabilize greenhouse gas concentrations has spawned an increasing number of discussions and activities about actions that can reduce atmospheric greenhouse gases. More recently, and at a more local level, states are increasingly working for clean air, including the possibility of regulating the amount of carbon dioxide release.

Human activities such as burning fossil fuels for transportation or electricity generation and altering land and vegetation for food or shelter release gases into the atmosphere. Eighty percent of the total greenhouse gas emissions of the U.S. is related specifically to carbon dioxide exchange. Depending on the land management activity, the unseen greenhouse gases are released or stored. Carbon can be taken from the atmosphere as carbon dioxide and stored—called sequestration—by growing trees and vegetation. Carbon continues to be stored in wood products after harvest, or in landfills after wood or paper products are thrown away. Thus, landowner management decisions affect how much carbon is being sequestered or emitted from their forests and farms. For the U.S. as a whole in 2003, it is estimated that forests store at least 10 percent of the total emissions from all other sectors. Land management activities are viewed as a relatively cost-efficient way of reducing net emissions.

Basic methods are presented for forest managers and landowners to learn how to estimate carbon sequestration for their forests. The more a landowner knows about their specific forests and management activities, the more precise the estimates. The existing 1605(b) voluntary reporting program for greenhouse gas activities in the U.S., and the updated methods currently under review, are discussed.

The unknown of greatest interest to most managers of forest land in the U.S. is: will there be payments for carbon credits, and if so, when? Although the answer is not known to this question, it is clear that markets for carbon credits from managing lands have edged closer to reality over the last decade. Since the Kyoto Protocol has been ratified and entered into force, carbon credits will be actively traded in at least some parts of the world. The more interest in a carbon market, the more likely the market will occur.

CARBON STORAGE IN NORTHEASTERN US FOREST SOILS

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Ongoing climate change negotiations have focused attention on the role of forests in the global carbon cycle; this role is also important in international sustainability agreements such as the Montreal Process. Consequently, understanding the effects of forest management on forest carbon cycles is a high priority. The soil carbon pool is poorly understood; little is known about the rate of carbon accumulation, the maximum amount of carbon that can be stored in soils, the effects of vegetation type on carbon dynamics, or the effects of forest management on soil carbon cycles. This study utilizes pre-existing thinning studies in the Northeastern and North Central Research Station areas to obtain baseline data and to assess the effects of management practices on soil carbon storage.

Soils from thinned and unthinned stands were sampled from the following forests over a 3-year period: Argonne Experimental Forest (EF), Bartlett EF, Fernow EF, SUNY Heiberg Memorial Forest, Kane EF, Middle Mountain Research Area (Monongahela National Forest), and the Penobscot EF. Thinning treatments varied by study site, though experimental designs were often similar. Generally, three replicate plots per treatment were available for sampling in each forest. Most of the studies were installed in the mid-1970s and had been thinned once. When available, old growth stands or stands without histories of recent management were also sampled.

Soil carbon content from 0-20 cm depth was variable across forests, ranging from about 30 – 70 metric tons of carbon per hectare (MT C/ha), with most plots between about 45-60 MT C/ha. Forest floor carbon content varied between 2.5 and 28 MT C/ha, with many sites falling between 7-10 MT C/ha. No consistent relationship between thinning intensity and soil or forest floor carbon content or concentration was found. In general, thinning treatments appeared to have no significant effect on carbon storage. At a few forests, however, significant differences were apparent. Work continues to identify which local factors may affect the response of the soil carbon pool to forest management treatments, including soil texture, parent material, and management history.

LONG-TERM HARDWOOD RESEARCH WORK IN QUÉBEC: THE EXAMPLE OF DUCHESNAY FOREST

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Duchesnay was officially created in 1933 and now covers a 8900-ha forested area. Diameter-limit cuttings were the common method used in mixedwood and hardwood stands. However, some areas were clearcut in the 1930s for charcoal production, therefore providing opportunities for even-aged management studies. The predominant cover is sugar maple-yellow birch-American beech.

The first studies date back to the mid 1940s and dealt with yellow birch regeneration and forest pathology. Major efforts in research coincide with Lise Robitaille joining the newly created provincial research service. As a forester, she worked on the second management plan of Duchesnay and initiated several basic studies in northern hardwood silviculture. A first group of studies is about diameter-limit cutting (1972-1974), precommercial thinning in a 30-yr-old maple stand, and management for sap and sugar production. Also, a high-graded stand was clearcut in 1972 providing opportunities for studying new methods. On half of the clearcut, site preparation, direct seeding and plantation were applied in May 1974 to determine which species performed the best in rehabilitating the area. Several hardwood and softwood species were used in the test, and the other half was left to develop naturally.

A second group of studies were started in the early 1980s, focusing on new regeneration methods and intensive management for veneer yellow birch production. For a while, strip-cutting was applied and some of the strips enriched with a low density of eastern white pine, Norway spruce and red spruce. In 1982, a combination of thinning, fertilization and pruning treatments were applied in the 10-yr-old hardwood stand. At the time, it was hypothesized that an earlier intervention would bring more interesting growth results.

While these studies were being followed-up, new situations developed, like some hardwood decline in the sugarbush study. Reaction against the use of clearcutting has prompted the development of a new uneven-aged management approach. A forest ecologist started new silvicultural studies at another research forest known as Mousseau Experimental Forest. Papers about these studies have been published mostly in French. In the early 1990s, new researchers joined the organization and took over the remeasurement process. Over those years, Duchesnay has been used by other agencies (Laval University; CFS Laurentian) as well. Tours on hardwood silviculture are being organized and ecotourism continues to develop with Sépaq.

ALTERNATE YEAR BEECHNUT PRODUCTION AND ITS INFLUENCE ON BEAR AND MARTEN POPULATIONS

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Maine's Department of Inland Fisheries and Wildlife is interested in determining the amount of beech (*Fagus grandifolia*) needed on the landscape to support bear and other wildlife populations. Long-term monitoring of Maine's black bear (*Ursus americana*) and marten (*Martes americana*) populations indicate that beechnut production may be correlated to alternate year patterns in bear reproduction and marten harvest rates. In northern Maine, 22% of the female black bears that were reproductively available reproduced following falls when beechnut production was poor. The proportion of reproducing females increased ($P < 0.001$) to 80% following falls when beechnut production was high. Female bears must accumulate sufficient fat reserves to reproduce. Female bears (≥ 7 yr of age) were heavier following good beechnut years. After 21 years of a consistent alternate year pattern in bear reproduction, the reproductive pattern changed in 2003. Possible explanations related to beechnut production and forestry are discussed. For marten, trapping harvests rates exhibit a strong alternate year pattern where harvest rates during odd-numbered years are double the harvest rates of even-numbered years. Marten harvest patterns are similar ($P < 0.001$; $r^2 = 0.65$) in northern Maine and the Adirondacks of New York, and appear to be inversely related to beechnut production. Two hypotheses have been proposed to explain the variance in harvest rates: (1) marten are difficult to attract to baited traps during years when beechnuts are abundant (2) increased energy intake from small mammals and nuts during a good beechnut year increases kit production or survival. This results in a large number of juveniles available for trapping the following fall. We conclude that more information is needed on mast production to better understand the influence of beech on northern ecological communities.

DIGGING OUT THE DATA: USDA FOREST SERVICE RESEARCH ON THE PENOBSCOT EXPERIMENTAL FOREST

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In 1950 a number of pulp and paper and land-holding companies purchased land in the towns of Bradley and Eddington, Maine. This land was leased to the USDA Forest Service, Northeastern Research Station to be used for a long-term experiment in silviculture of northern conifers. Frequently occurring conifers include balsam fir, red spruce, eastern hemlock, northern white-cedar, and eastern white pine, in mixedwood stands with maple, birch, and aspen species. Since the 1950s, a dozen silvicultural treatments have been applied in a 560-acre study. Each treatment is replicated at the stand level, with an extensive network of permanent sample plots. Growth and regeneration data have been collected before and after every harvest and at 5-year intervals between harvests since the study began, providing more than 50 years of data.

The Forest Service experiment on the PEF encompasses even-, two-, and uneven-aged silvicultural systems. Regeneration methods include selection cutting on 5-, 10-, and 20-year cutting cycles, shelterwood with two- and three-stage overstory removals, and shelterwood with retention. Common removal-driven harvesting practices, such as diameter-limit cutting and unregulated harvesting are also included in the study. Cooperators, mostly faculty and graduate students from the University of Maine, have conducted many short-term studies of ecosystem function and wildlife-habitat relationships within the long-term research area.

Forest Service research on the PEF has been an important source of information about advance regeneration, seed viability, feasibility of regeneration methods, leaf area relationships, effects of removal-driven harvests, sustainability of stand structure and composition, habitat suitability, and precommercial thinning. The most recent comprehensive evaluation of treatment effects established differences between treatments in stand-level gross growth, composition, quality, and structure (Sendak et al. 2003).

The experiment is approximately half way through an even-aged rotation for the dominant conifer species. Research Work Unit NE-4155 (Ecology and Management of Northern Forests) is revising the study plan based on analysis of stand structural and compositional changes and growth and yield over the first 45 years of the study. The existing uneven-aged systems will be continued with prescription modifications, and new treatments will be prescribed for the even- and two-aged stands. The Forest Service is committed to maintaining the research and anticipates that its value as a source of long-term data will continue to increase in the future.

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EFFECTS OF SILVICULTURE ON MATURE FOREST AND EARLY-SUCCESSIONAL SHRUBLAND PASSERINE BIRDS IN NORTHERN AND CENTRAL NEW ENGLAND

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In this presentation, we will outline some general patterns of mature forest and early successional shrubland bird distribution and reproductive success in relation to various silvicultural treatments. Mature forest birds are negatively affected by even-aged management during the nesting portion of the reproductive cycle because breeding habitat is lost in the treatment area itself, and because bird territories are displaced, and nesting success lower, in adjacent mature forest habitat. After the young leave the nest, however, many mature forest birds move into regenerating clearcuts with their broods; in New Hampshire we found that the ratio of mistnet captures in clearcuts versus mature forest was >100:1.

Even-aged management is beneficial to early successional birds. Regenerating clearcuts and shelterwoods are typically colonized within a few years of treatment. The time period during which the habitat created by these practices remains suitable varies among species, with some dropping out 3-5 years (e.g. mourning warbler), and others declining in abundance but remaining on site for as long as a decade (e.g. chestnut-sided warbler). It does not appear that patch size affects the distribution or reproductive success of shrubland birds in northern New England as long as patches are >0.5 ha and located in a cluster, as practiced in group selection (King et al. 2004). It is not clear whether small, isolated patches are lower quality habitat for these species. In southern New England, however, some species do appear to prefer larger patches (e.g. prairie warblers). Nest success in clearcuts in New Hampshire is extremely high, far higher than nest success in powerline rights-of-ways or managed wildlife openings. Nest success in Massachusetts clearcuts substantially lower than nest success in New Hampshire clearcuts. Whether this difference is due to differences in landscape composition, predator community, or habitat is the subject of current research.

Most mature forest and early successional birds are less abundant in stands managed using uneven-aged management than unmanaged forest and early regeneration even aged stands, respectively. There are exceptions to this (e.g. some flycatchers). Also, most if not all early successional passerines use openings created by group selection in northern New England as long as patches are >0.5 ha. Prairie warblers, which occur in southern New England, are far less abundant in small patches relative to clearcuts in Missouri, and the same is probably true for this and other species in southern New England. Group selection removes habitat for mature forest birds, and results in increased nest predation in adjacent mature forest, and because it creates more edge per unit area cut than even-aged management, group selection can contribute to the fragmentation of forest stands.

VOS – TASK FORCE RECOMMENDATIONS

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In December 2002, the Society of American Foresters (SAF) Council chartered the Volunteer Organizational Structure – Task Force (VOS-TF) with three objectives:

1) To evaluate the implementation success of the 1994 VOS TF report.
2) To evaluate the effectiveness of the current organizational structure in meeting the mission and strategic direction of the Society of American Foresters.
3) To recommend changes to improve the vitality and effectiveness of the organization.

Due to other intervening SAF conflicts, the task force roster was not finalized until August 2003, and SAF Council amended the charter for a completion date and report by December 2004. The 37-page report was submitted to SAF Council on December 4, 2004.

The VOS-TF reiterates its view that the recommended changes in SAF organizational structure and to broaden the scope of the forestry professional and the related membership of the SAF are vital to the future sustainability of SAF and the forestry profession. We urge the Council and SAF leadership to address them with utmost urgency.

Because of the number and nature of changes that it proposes, the VOS-TF suggests to Council that the first step in evaluating and implementing the recommendations should be a joint process that includes both Council and broader SAF leadership. This joint process is critical to ensure accurate understanding of what is proposed, to build leadership consensus in support of them, and to create a united message that is delivered with conviction to SAF members from their leaders.

It is the VOS-TF estimate that the implementation phase could take approximately 1 year to understand and gain acceptance and then 1 to 2 years for the subsequent implementation transition. It will require a membership referendum to alter the SAF constitution.

The recommendations are proffered so that SAF can regain its role as a strong and relevant organization for professional forestry and forest resources management.

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FORESTRY AND FOREST HERITAGE TOURISM OPPORTUNITIES FOR LANDOWNERS AND COMMUNITIES

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This workshop will provide information about forest heritage and a framework for assessing natural resource based tourism opportunities at woodlot and community levels. Participants will be oriented to planning and evaluation tools that incorporate personal, forest resource and business attributes into the opportunity assessment process.

GLOBAL TRADE IN FOREST PRODUCTS: IMPLICATIONS FOR THE FOREST PRODUCTS INDUSTRY AND TIMBER RESOURCES IN NEW ENGLAND

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Global trade in forest products has been expanding at 4.5% per year over the past decade; however, the U.S. is losing its competitive position. Today, we import 20% of our paper and board; 25% of our plywood and OSB; 37% of our softwood lumber; 55% of wood household furniture; 30% of hardwood molding, and 50% of softwood molding. In 1990, we were self-sufficient in OSB and plywood and we produced almost 80% of the softwood lumber, molding products, and household wood furniture consumed in this country. Globalization and other trends have exposed our domestic industries to new and stronger international competitors while shifts in currency exchange rates are playing a bigger role in global commodity markets. Studies have identified a clear trend in forest products (indeed U.S. manufacturing in general) away from labor intensive and toward more capital intensive enterprises.

The New England forest products industry is one of the least competitive regions in the U.S. Wood costs are approximately 20% to 25% higher than the U.S. South, and, as consumption of plantation wood expands, the South's cost advantage will increase. In addition, with commodities, scale economies are key, and plant size in New England is only about half the scale of sawmills and OSB mills in the South and Canada. How does the industry see New England as a potential investment - you can count on one hand the number of new mills (lumber, OSB, pulp & paper) built in the past decade.

What about the forest resource? We believe that to have a healthy forest resource, we need a healthy forest products industry. There is a high correlation between timberland values, timberland prices, and profitability of conversion facilities. The U.S. forest products industry is not as healthy as its counterparts in South America and Europe where average ROCE (return on capital employed) for past 6 years is 7.5% in South America; 6.5% in Europe; compared to 5.3% in the U.S. and 4.3% in Canada. Part of the reason is that real CAPEX spending by our lumber industry, for example, has fallen 28% in the past 6 years.

Is there a solution? We believe some of our industry has to move up the food chain by adding value to their product mix; others (ex. Boise and GP) will move up the supply chain by divesting timberlands and forest product operations while becoming "consumer product" companies; consolidation will help those that decide to stay in commodities; others will have to find niche markets while some disappear altogether. A key to moving up the food chain will be more R&D, but the forest products industry doesn't do much R&D. That will have to change. If the forest products industry is to become globally competitive, things need to change, which in turn will require strong leadership.

IMPACT OF A SHELTERWOOD HARVEST ON THE NET CARBON BALANCE OF A SPRUCE/HEMLOCK DOMINATED FOREST IN MAINE

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Forest management practices can have a large impact on rates of carbon sequestration in forest, yet little research has explored the magnitude and direction of these changes for different management practices. This is a critical issue in the northeastern U.S., where a majority of forests are managed with varying degrees of intensity. Harvesting activities give rise to a short-term decline in leaf area and an increase in detritus on the forest floor, but whether this leads to a reduction in net carbon sequestration over time depends greatly on rates of individual tree growth after harvest. We evaluated the impact of a commercial shelterwood harvest on forest carbon sequestration in a spruce-hemlock forest in central Maine. A cut-to-length system with forwarding was used. Under this management system, one ~60-year rotation includes three harvests, each removing about one-third of the basal area. This type of management has increased dramatically throughout the region over the past decade.

Harvesting removed about 15 Mg C/ha (SEM=2.1) (~30%), and created about 5.3 Mg C/ha (SEM=1.1) of aboveground and 5.2 Mg C/ha (SEM=0.7) of root/stump detritus. Leaf-area index and litterfall declined by about 40% with harvest. A comparison of summer-time net ecosystem exchange (NEE) of carbon between unharvested and harvested stands, both pre- and post-harvest, indicated that NEE for this period declined following the harvest by about 18%, which is less than expected based on basal area and LAI changes. Soil respiration declined slightly with harvest, suggesting no major soil C loss after harvest; harvesting had little effect on soil moisture and temperature. Three years after harvest, summer daytime NEE measurements indicate similar rates of carbon sequestration in both the harvested and unharvested stands. These results suggest that the forest has returned to pre-harvest rates of carbon sequestration faster than expected due to either increased total uptake or more efficient formation of woody biomass following forest harvest.

BRIDGING THE GAP

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Presenters will show that there are still young people in Maine who want to work in Maine's forests. Many of these people are enrolled in Maine's vocational forestry training programs across the state. They will also present information on various vocational educational leadership organizations and show how one in particular, National FFA, can be used to help students in vocational forestry and wood harvesting programs connect with logging contractors, foresters, and others associated with Maine's forest resources. Particular attention will be given to the FFA's Supervised Agricultural Experience program and how this can be used to develop leadership, business, communication, and organizational skills, as well as confidence.

Presenters will also discuss how forming a consortium of vocational forestry educators, forest products industry associations and foresters, logging contractors and others associated with this industry could serve to attract young people as well as enhance and further develop the education and training needed for young people to succeed now and in the near future in Maine's forests.

DEVELOPMENT OF FOREST CARBON STOCK AND STOCK CHANGE BASELINES IN SUPPORT OF THE 2004 CLIMATE ACTION PLAN FOR MAINE

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An overview of issues, data, assumptions, and results pertinent to the development of forest carbon baselines for Maine is presented. Forest carbon stocks and stock changes, including additional effects of land use change and long-term retention of carbon in some harvested wood products, were determined for the period from 1990 through the present. The analysis was compiled for the Agriculture and Forestry Working Group of the Maine Greenhouse Gas Initiative in early 2004.

Forests are the predominant land cover in Maine. These forest lands represent large reservoirs of organic carbon in live vegetation, dead woody materials, and in the soil. Growing forests are carbon sinks, which remove carbon dioxide from the atmosphere through photosynthesis and subsequent carbon reduction and incorporation into organic molecules. Alternatively, respiration and decay are mechanisms for emission of carbon from forests to the atmosphere. Carbon sequestered in plant biomass serves as a potential offset to the current net release of greenhouse gases in the U.S. Rates of sequestration or release of carbon to the atmosphere by forests can be affected by land use and forest management practices. Thus, estimates of recent trends in forest carbon serve as baselines for projecting outcomes of alternate mitigation options as presented in the Climate Action Plan. Current estimates indicate Maine forests are currently net carbon sinks.

Forest ecosystem carbon estimates are based on the simulation model FORCARB2, which develops inventory-based estimates of stocks according to discrete carbon pools. Stock change, or net annual flux, is based on the difference between two successive stocks divided by the number of years between surveys. Maine forest inventory surveys summarized by the USDA Forest Service for 1982, 1995, and 2002 serve to identify stocks; intermediate values and stock changes are based on interpolation and extrapolation of these stocks.

Land use change—either forest land becoming non-forest or non-forest land becoming forest—affects the change in total forest stocks between surveys principally through the addition or deletion of land included in a stock estimate. For purposes of the Maine Greenhouse Gas Initiative, carbon accounting on these changed-use lands was not transferred to another (non-forest) sector but rather the calculated forest stock change was modified to account for expected additional sequestration or emissions associated with the land use change. For example, forest land transferred to non-forest land use was assumed to emit two-thirds of tree carbon; the remaining carbon was included in the calculation of stock change. Carbon in harvested wood products can remain in products in use or in landfills for many years. Estimates of stock change are based on the model HARVCARB and on wood harvested and processed in Maine as well as imports, as reported in the annual Maine Wood Processor Reports.

COLE: CARBON ON-LINE ESTIMATOR, VERSION 2

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The Carbon On-Line Estimator (COLE) is an Internet-based forest carbon inventory database analysis tool. Each component of the program (data retrieval, statistical analysis and output) can be individually modified to accommodate major changes or additions. Carbon estimates are derived from FIA data and other ecological data, and includes multiple components of above- and below-ground carbon stocks and carbon stock change. The user selects the county, state, or region and variable of interest, and the appropriate data are retrieved. After the user selects an area and variables, COLE can produce statistical tables, figures, maps, and PDF reports, as designated by the user. Analysis complexity ranges from basic "one-click" analyses to advanced statistical analysis. All outputs can be downloaded for customized use.

Access COLE at: http://ncasi.uml.edu/COLE

LISTENING TO OLD BEECH & YOUNG CHERRY TREES – EXPERIENCES IN THE ALLEGHENIES & NEARBY

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This paper will provide an overview of the value and benefits associated with long-term forestry research, using examples from the Allegheny Plateau region of northwestern Pennsylvania. The presentation will include examples from "reference condition" long-term research as well as long-term manipulative research. The values and benefits to be examined include humility, ecological interactions, quantification of trade-offs, documentation of long-term cost & benefit streams, and answers to unanticipated questions. The talk will also discuss some of the costs of long-term studies and the barriers to sustaining them.

One focus will be on studies that represent the "reference condition" concept of long-term research, focused on studies in the Tionesta Scenic and Research Natural Areas (Bjorkbom and Larsen 1977), a 4,000-acre tract on the Allegheny National Forest. This area is considered one of the best representatives of the beech-hemlock forests that covered more than 16 million acres at the time of European settlement. Since being set aside as a Research Natural Area, it has provided critically important data about natural disturbance regimes at several scales, the impact of white-tailed deer on forest communities, and forest change in the face of exotic insects and diseases, specifically including the beech bark disease complex.

The other focus will be on medium and long-term studies conducted across the Allegheny Plateau region over the last 8 decades. These include studies of stand development (Marquis 1992), silvicultural systems, white-tailed deer impact (Horsley and others 2003), and forest liming (Long and others 1997). We will discuss some threshold for what makes a study "long-term" and give examples of surprises that arose in studies as they cross the threshold into "long-term." Finally, the paper will provide a brief overview of the relationship between long-term studies on the Allegheny Plateau and the practice of sustainable forestry in that region.

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ACADIA RESEARCH FOREST: A PRIMARY FOREST RESEARCH FACILITY FOR NATURAL RESOURCES CANADA, CANADIAN FOREST SERVICE - ATLANTIC

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The Acadia Forest Experiment Station was established in 1933 as the second in a series of federal sites across Canada to research and demonstrate good forest management for greater productivity, sustained yield, and economic benefit (Place 1992). It was later renamed the Acadia Research Forest (ARF). The ARF comprises about 9000 ha (22,230 acres) of softwood, hardwood, and mixed forests of both the Grand Lake and Eastern Lowlands Ecoregions. It is located approximately 25 km (16 miles) east of Fredericton, NB, Canada, where the main office of the Atlantic Forestry Centre (AFC) is situated. Since its establishment, many different experiments, studies, and projects have been conducted in various research disciplines or themes. In the early 1930s, Canada's Department of the Interior used the ARF for unemployment relief projects and the National Forestry Program, setting up and establishing long-term silvicultural experiments and demonstrations (Thompson 1955, Place 1992). In the early 1940s, during World War II, the ARF was used by the Department of National Defense as an internment camp and many of the long-term silvicultural experiments, demonstrations, and infrastructure were established by the internees. Entomological and pathological studies have been and still are conducted at the ARF. In 1950s and 1960s, concerns about clearcutting resulted in a number of long-term alternative silvicultural studies. A tree improvement program was formalized and established at the research forest in 1958. By 1965, the nursery at ARF was producing more than 100,000 trees annually to support research in tree improvement and reforestation programs. The nursery is now located at the AFC's main office in Fredericton. Since the 1980s, several experiments and studies have been initiated to respond to environmental policy concerns over air pollution, global change, carbon sequestration, and biodiversity. The facilities and forest history often attract researchers from other organizations for ongoing cooperative research projects. In addition to research and sustainable forest management, the ARF provides an area for educational forestry training, forestry demonstrations, and non-industrial uses such a bird watching. In summary, the ARF is steeped in history, possesses great natural beauty, and continues to be used for long-term research for present and future benefits. More information is available at the following website:
http://www.atl.cfs.nrcan.gc.ca/index-e/who-e/role-e/role-e/acadia-e.htm.

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WHAT ARE NATIONAL FORESTS LOOKING FOR FROM PROFESSIONAL FORESTRY ORGANIZATIONS?

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Much has changed in the forestry profession since I received my Forest Management degree over 25 years ago. My perspective on the future role of professional organizations is shaped by my experience working almost exclusively on a number of national forests across the United States with all kinds of professional resource managers and/or advocates. My perspective is that professional organizations remain effective and relevant to the discussions and policies on the management of public land when they demonstrate leadership in a number of key areas. The Society of American Foresters has been very active in many of these leadership areas; however,
some of the leadership venues appear to have a potential for greater consideration.

I would highlight six areas for additional discussion: development and retention of future professionals, ongoing assistance in the development of a land ethic, effective communication/ education with policy makers at the local and national level, continuing education/workshops, ongoing relationships with the media on forestry issues, and effective partnering with other professional organizations.

National Forests continue to be a place where we should practice forestry to meet ecological, economic and social objectives but they also serve as a place where we can engage the larger population in discussions on the benefits and tradeoffs of sustainable forest practices. Members of professional forestry organizations should continue to be a key partner with the Forest Service and other public land management agencies in looking for more effective ways to accomplish this goal.

IMPLEMENTING FOREST STEWARDSHIP PLANS IN URBANIZING AREAS – OPPORTUNITIES FOR RESOURCE PROFESSIONALS

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Completing a forest stewardship plan is the beginning and not the end of a sound management strategy for small forested ownerships. In urbanizing areas with small forest parcel sizes (for example, 13 acre average in CT), it is often difficult to find technical help to implement the plan. A grant to the CT Forest Stewardship Program provided by the USDA Forest Service State & Private Forestry is funding an effort to train individuals to properly perform selected non-commercial forest management and improvement practices. Examples of these practices include: wildlife habitat enhancement, ecological inventories, invasive exotic removal, and other practices for which there is not an immediate commercial or economic return. In urbanizing areas, few, if any, properly equipped and experienced firms and individuals are educated to the potential business opportunities presented by these issues, nor are they properly trained to perform the tasks specifically associated with forest land improvement and habitat enhancement practices.

A FOREST IN CONFLICT: THE PROPOSAL FOR A 3.2 MILLION ACRE NATIONAL PARK AND PRESERVE IN MAINE'S WORKING FOREST

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The proposal of a Maine Woods National Park and Preserve in the mostly industrial forest land of northern Maine has caused many debates. Questions about traditional uses of the north woods, issues of access and economic impact, are at the heart of the conflict.

In March of 2003, Maine Governor John Baldacci announced the Fall 2003 Blaine House Conference on natural resource industries. It was a gathering of experts from the fishing, farming, forestry, aquaculture, and tourism and recreation industries in Maine. They discussed challenges they face, contributing factors to those challenges, creative plans for sustaining them, and Maine's natural resource-based economy. The conference steering committee of 39 members was surveyed in the summer of 2003 regarding the proposed national park and issues surrounding the debate. The purpose of the survey was to examine diverse forest values, bring greater perspective to this issue, and inform further research.

The survey respondents believed there could be a "common ground" solution for Maine, especially in light of the decline of the timber industry and the rising value of outdoor recreation and tourism. They categorized the park proposal as an important natural resource policy issue. It is for that reason that this survey has led to further research designed to examine the proposal in the context of diverse values of the forest, as well as the array of conservation strategies for northern Maine.

LONG-TERM STAND DEVELOPMENT IN UNEVEN-AGED NORTHERN HARDWOODS UNDER SELECTION SYSTEM MANAGEMENT

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Uneven-aged silviculture has become more desirable for landowners interested in maintaining continuous forest cover while providing benefits such as timber production and wildlife habitat. Beginning in 1973, Ralph D. Nyland of SUNY-ESF established permanent plots in several uneven-aged northern hardwood stands undergoing partial cutting treatments at the Cuyler Hill State Forest in Cortland County, NY and at the Huntington Wildlife Forest in Hamilton County, NY. These plots were used to document changes in stand structure and patterns of regeneration.

The development of diameter distributions in uneven-aged stands indicates the likelihood of obtaining sustained yields over multiple entries. Diameters of tagged trees on permanent plots were collected prior to cutting and at 3 - 5 year intervals after treatment. The diameter distributions in stands receiving single-tree selection method cuts have retained the classic reverse-j shape, which is thought to resemble sustainable structures. However, other stands receiving partial cuts resembling diameter-limit cutting have developed an excess of pole-sized trees, with slower growth into the sawtimber classes.

These stands have also been used to evaluate the development of understory beech, which is a significant interfering plant to more desirable regeneration such as sugar maple. Bohn and Nyland (2003) evaluated the change in understory beech importance ten years after partial cutting. Species importance was assessed using an index value incorporating both abundance and heights of stems. We found that understory beech increased in importance on plots when initially established at moderate to high levels before cutting, and did not typically increase in importance where not previously established.

Currently, the stands are being used to evaluate changes in spatial variability of trees and the effects on volume production resulting from selection system and diameter-limit cutting practices. Stem maps in 2-acre areas in four stands were created to assess both point pattern of residual trees and plot-level variation in basal area. Preliminary results suggest that selection system silviculture results in a more uniform spacing of sawtimber-sized trees. Tending in pole and sapling classes during selection system management reduces localized competition but does not affect the overall spatial pattern of the stand.

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VARIATION IN SOIL CHEMICAL ANALYTICAL RESULTS AMONG GRADUATE STUDENTS

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Variability in soil chemical analyses results from spatial and temporal effects in the field as well as laboratory technique. We assessed the reliability of soil chemical analytical results among graduate students recently trained in laboratory procedures. Soil samples were collected in November 2003 from A and B horizons of three pits excavated from two different map units under agricultural management. Each of the 12 samples was processed through a 2-mm sieve, thoroughly mixed, and stored in five individual containers (60 total). Beginning January 2004, five students (each provided with 12 sample containers) analyzed their samples for pH, organic carbon, CEC, extractable P, total N, and exchangeable cations. An experienced (30+ yr) technician analyzed each of the 60 samples for the same variables. Analysis of variance (split-split plot) showed significant differences among students for all variables examined. However paired t-tests showed no consistent significant differences between four of five students and the experienced technician for most variables. We conclude that data from recently trained graduate students are reliable.

MASSABESIC EXPERIMENTAL FOREST

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The Massabesic Experimental Forest (MEF) is typical of much privately owned non-industrial forest land in New England. Located in Maine's southernmost county, the MEF was once farmland that was abandoned between the Civil War and the Great Depression. The eastern white pine-northern red oak forest type dominates upland sites. Eastern hemlock and red maple are also well represented throughout the forest.

The USDA Forest Service purchased the land between 1937 and 1942. The 3,700-ac MEF consists of two units, North and South, which are approximately the same size. About 3,000 ac of the MEF burned in October 1947, in the large fire that burned across southwestern Maine. Eighty percent of the timber on the MEF was either destroyed by the fire or salvaged.

When the MEF was established, permanent sample plots were installed, but many plot location stakes were lost in the 1947 fire and not re-established. Following the 1947 fire, emphasis changed from white pine management to pine artificial regeneration research, including aerial seeding and pesticides to control competing vegetation and white pine weevil. Management research was discontinued in the 1960s and a series of genetics studies searching for white pine weevil resistance was initiated, followed by a broader focus on tree improvement research. Recent research included investigations of soil nitrogen processes, aquatic insects, amphibian and owl ecology, and an inventory of all upland vascular plants, including trees, shrubs, and herbaceous plants.

The inventory was conducted on a grid of 399 sample points, using a combination of variable radius plot sampling and fixed-radius plots (Dibble et al. 2004). We found six forest cover types; the white pine type was most common, followed by pine-oak, and pine-hemlock. We identified 464 vascular plants, or about 25 percent of all vascular plants found in Maine. White pine, hemlock, red oak, and red maple were the most abundant and well-distributed tree species. Red maple was found on 94 percent of the plots, white pine on 86 percent, and red oak on 84 percent. Hemlock, white pine, red maple, and red and white oaks are the most common tree seedlings. With an average of more than 500 stems/ac, hemlock seedlings are three times more abundant than any other species on the MEF. Red maple seedlings are slightly less abundant than either pine or oak, but they are more uniformly distributed. Thus, without management or natural disturbance, the composition of the forest will likely shift toward more shade-tolerant species.

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FORESTER'S GUIDE TO NRCS' TECHNICAL SERVICE PROVIDER (TSP) PROGRAM

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The Natural Resources Conservation Service (NRCS) is implementing a new program to offer technical assistance to small woodlot owners through their Technical Service Provider (TSP) program. A Forester's Guide has been developed to increase awareness of this program to private consulting foresters and assist them in the registration process.

In the past, NRCS was unable to assist woodlot owners with technical forestry questions due to their limited number of forestry personnel. The TSP Program was developed to augment our technical assistance delivery capabilities. NRCS has always provided funds for financial assistance in implementing forestry practices within several of our cost-share programs, including the Environmental Quality Incentive Program (EQIP) and Wildlife Habitat Incentive Program (WHIP). However, these programs did not provide funds to the landowner for the technical assistance provided by foresters, including marking trees for forest stand improvement and tree pruning.

The Forester's Guide includes a general overview of the TSP program and some brief examples of how this program compliments various NRCS and other USDA cost-share (financial assistance) programs. A major focus of the guide is the step-by-step instructions on how to get on the TSP register. Other topics discussed include how landowners select a TSP forester and what qualifications are required. The most current state-by-state "not-to-exceed" technical assistance rates for typical conservation practices in New England are included as well.

WILDLIFE RESPONSES TO INVASIVE SHRUBS IN EARLY-SUCCESSIONAL HABITATS OF SOUTHEASTERN NEW HAMPSHIRE

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In New England, disturbance-generated habitats include native shrublands and early-successional forests. Regionally, these habitats support a diverse assemblage of plants and animals that may include several species that are of conservation concern [e.g., New England cottontails (*Slyvilagus transitionalis*) and golden-wing warblers (*Vermivora chrysoptera*)]. Management activities used to perpetuate early-successional habitats (e.g., timber harvests, mowing, or controlled fires) may increase their vulnerability to encroachment by alien plants because physical disturbances can temporarily remove native plants that are able to prevent alien plants from colonizing a site via competition. Concern is increasing regarding the consequences of alien plant invasions. In addition to reducing the abundance and diversity of native plants, the suitability of alien plants for wildlife may be less than native plants. For example, alien plants may be less palatable to native herbivores (including phytophagous insects) because native herbivores lack adaptations to the chemical or structural defenses that alien plants possess. In fact, this release from herbivore pressure has been suggested as one explanation for the success of some alien plants (*the enemy release hypothesis*). A reduction in insect abundance and diversity therefore may have ramifications on other wildlife taxa that are dependent on insects as a major food (e.g., nesting birds, amphibians, reptiles, and some small mammals).

We investigated the suitability of alien shrubs, including buckthorn (*Rhamnus* spp.), autumn olive (*Elaeagnus umbellata*), and multiflora rose (*Rosa multiflora*) on six sites in southeastern New Hampshire. Abundance of alien shrubs ranged from 13 to 93% of shrub cover. At each site, insect abundance and diversity were sampled among alien and native shrubs using timed counts and pitfall traps. Relative abundance and distribution of amphibians and reptiles were based on captures associated with cover boards and plastic cover sheets. Small mammals were inventoried with baited livetraps.

Our preliminary results indicate that alien shrubs did indeed support fewer species of insects. However, responses by insectivorous vertebrates were less definitive. Amphibian captures were too few to evaluate. Reptiles captured included garter (*Thamnophis sirtalis*), redbelly (*Storeria ccipitomaculata*), and milk snakes (*Lampropeltis triangulum*), but samples at all sites were dominated by garter snakes. This generalist snake did not respond to the abundance of alien shrubs. Small mammal captures included deer mice (*Peromyscus* spp.), short-tailed shrews (*Blarina brevicauda*), chipmunks (*Tamias striatus*), and jumping mice (*Zapus hudsonius*). Again, the generalist deer mouse dominated the sample and apparently was not affected by the abundance of alien shrubs. We conclude that alien shrubs can affect insect populations but the ramifications of this effect on insect consumers warrants additional investigation, especially among specialized consumers that are likely to respond to changes in the abundance of insect prey.

EXOTIC AND NATIVE TREE PLANTATIONS AT THE FOX RESEARCH FOREST AND VINCENT STATE FOREST, NEW HAMPSHIRE

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Many exotic and native tree plantations have been established at Fox Research Forest and elsewhere on New Hampshire State lands since the early 1930s (Baldwin 1965). These plantations consist chiefly of Norway spruce *(Picea abies)*, European larch *(Larix decidua)*, and Scots pine *(Pinus sylvestris)*. Other species planted to a lesser extent include Douglas fir *(Pseudotsuga menziesii)*, hybrid poplars *(Populus spp.)*, hybrid chestnuts *(Castenea spp.)*, concolor fir *(Abies concolor)*, red spruce *(Picea rubens)* and Austrian pine *(Pinus nigra)*.

The two species that received the greatest attention from the Fox Forest research program are Norway spruce and European larch. Fox Research Forest is the site of an International Union of Forest Research Organizations (IUFRO) provenance test for European larch. Seed collection continued from 1942 to 1944, seeds were planted at the Fox Forest nursery in 1946 and outplanted in 1948. This plantation contains replicates of 14 sources of seed from as far north as N58º 02′ and as far south as N49º 16′. Countries represented in the seed sources include Germany, the Czech Republic, Scotland, Poland, Finland and Sweden. There also are several non-IUFRO plantations of larch at both locations including two hybrid larch plantations (Dunkeld).

Vincent State Forest is the location of an IUFRO provenance test for Norway spruce. The seeds were planted in our nursery in 1938 and transplanted in 1940 and outplanted in 1942. This plantation contains replicates of 25 seed sources ranging from as far north as N65º 58′ to as far south as N43º 50′. Countries represented in the seed sources include the Czech Republic, Finland, Italy, Yugoslavia, Latvia, Norway, Poland, Romania, Sweden and Switzerland. Norway spruce was planted in a few other Non-IUFRO plantations at both locations.

An IUFRO plantation of Scots pine was started as sown seed in 1938, transplanted in 1940 and outplanted in 1942 at Vincent State Forest. Fifty-five replicates totaling about 25,000 seedlings represented 13 countries. Seed sources ranged from as far north as N68º 55′ to as far south as N48º 42′ and the countries represented included Belgium, the Czech Republic, Finland, Germany, Hungary, Italy, Latvia, Netherlands, Norway, Poland, Romania, Scotland and Sweden. This plantation did not develop well and consequently was harvested.

Other plantations of interest are the 1943 trial of Eastern white pine at Vincent State Forest, the 1952 plantation of Douglas fir at Fox Forest and the 1935 plantation of hybrid poplars at Fox Forest.

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MICE, MAST, AND GROUP-SELECTION HARVEST: 20 YEARS ON A MAINE PINE-OAK FOREST

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The white-footed mouse (*Peromyscus leucopus*) is a habitat generalist, a significant predator and distributor of acorns, and a competent reservoir host of Lyme disease spirochetes (*Borrelia burgdorferi*). It is the most abundant mammal species on the Holt Research Forest, Maine, a pine-oak forest within 125 km of the northern edge of this species' range. With 10 years of live-trapping and seed trap data, McKracken et al. (1999) showed *P. leucopus* summer abundance was positively correlated with previous autumn acorn crop. A new investigation recently opened with the benefit of 20 years of data (1983-2002). We recognized a 4-year periodicity in the *P. leucopus* abundance time series that was partly independent of acorn crop. Specifically, abundance always increased after a low population phase coupled with a large acorn crop, but in three summers population declines followed population peaks despite large acorn crops. A model that accounted for periodicity as well as acorn abundance had greater predictive value (r^2 = 0.69) than an acorns-only model (Elias et al. 2004). Causes of cycling are still unknown, but predator response could be one explanation. That *P. leucopus* abundance is not entirely tied to acorn mast has implications for oak regeneration and risk of Lyme disease exposure to humans.

Another research question was: What impact does group-selection harvest have on *P. leucopus* abundance? The harvest was conducted on 10 of 40 1-ha blocks in the winter of 1987-88. McKracken (1999) reported an association between the harvest and increased *P. leucopus* captures on harvest blocks in 2 of 4 years post-harvest. However, the tight post-harvest correlation between the harvested and non-harvested time series suggested no harvest-induced disruption in *P. leucopus* captures or periodicity.

These studies illustrate the advantage of long-term ecological research over the typical 2- or 3-year period of a graduate research project. If our study had been conducted 1986-88, with a study area-wide harvest between the peak *P. leucopus* phase of 1986 and the decline phase of 1987-88, one might conclude that the harvest suppressed numbers. Conversely, a harvest between the low year of 1993 and the increase year of 1994 and peak of 1995, might lead to the conclusion that *P. leucopus* increased as a result of the harvest.

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ABOVEGROUND BIOMASS AND NUTRIENT CONTENT IN DEVELOPING HARDWOOD STANDS AT BARTLETT EXPERIMENTAL FOREST, NH

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Biomass and nutrient content estimations serve as crucial indicators of the ecological status and economic value of forested ecosystems. A large portion of forests in the U.S. are second-growth and accurate estimates of aboveground biomass and nutrients in these forests are essential for developing land management strategies. In order to predict the future ecological status of forests and develop long-term management plans, knowledge of how biomass and nutrient content may change in forests over time is critical. Although many authors have investigated forest biomass and nutrient content, few have reported these values for relatively smaller trees (<12cm dbh). We have attempted to characterize the biomass and nutrient content status of four developing stands, two of which are approximately 15 years old and two of which are roughly 30 years old (since clear cut).

These stands are located within Bartlett Experimental Forest (BEF) where research activities have been conducted since 1931. BEF is located within the Saco Ranger District of the White Mountain National Forest in New Hampshire. This experimental forest currently encompasses approximately 2,600 acres. Many silviculture projects have taken place at BEF over the last 75 years, making it a prime site to investigate the properties of developing stands.

To characterize biomass and nutrient content in these stands at BEF, five major species were chosen to sample across each age group. In both stand age categories, younger (15 yr old) and mid-age (~30 yr old), the five species sampled included American beech, red maple, yellow birch and white birch and pin cherry. Three trees of each species per stand were destructively sampled, yielding a total of 60 trees sampled. Trees were destructively sampled by cutting as close to the ground as possible with either a chain or bowsaw. These trees were then separated into three major components; bole wood, branches and leaves. Branches were cut from the tree stem and leaves were stripped off of the branches by hand at the petiole. Each of the three components were weighed in the field and then sub-sampled.

Samples will be analyzed for macro and micronutrients including Ca, Mg, P, K, N, C, Mn, Fe and Zn. We will report nutrient content of leaves, branches, wood and bark for each tree species in each age category. We will also develop allometric equations relating aboveground tree biomass, bole wood, branches and leaf biomass to dbh. Nutrient content and biomass estimations for these small trees can contribute to literature significantly, as most previous studies have focused on larger trees in older stands. However, many of the stands in the Northeast are developing and it will be useful for land managers to be able to estimate aboveground biomass and associated nutrient concentrations for trees of relatively younger age and size.

THE BEAR BROOK WATERSHED IN MAINE – DECADAL RESPONSES TO WHOLE FOREST ECOSYSTEM MANIPULATIONS

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The Bear Brook Watershed in Maine (BBWM) is a long-term, paired, forested, ecosystem study examining the effects of a changing physical and chemical climate. The East Bear watershed (11.0 ha) serves as the reference watershed. The West Bear watershed (10.3 ha) has been treated bimonthly with ammonium sulfate ($(NH_4)_2SO_4$) starting in November 1989 and continuing to the present. Granular $(NH_4)_2SO_4$ has been aerially applied at approximately 28.8 kg S/ha/yr and 25.2 kg N/ha/yr. The chemical manipulation is designed to investigate the effects of atmospheric deposition of N and S.

The BBWM is on International Paper land under a long-term agreement with The University of Maine. The study is a collaboration among the University of Maine, International Paper, the USDA Forest Service, the U.S. Geological Survey, and Plymouth State University. Continuous measurements of precipitation and stream hydrology and chemistry provide input-output budgets for the treated and reference watershed while studies of soil chemistry and biology, soil solutions, fine root dynamics, soil respiration, vegetation chemistry and physiology, litter and litterfall, and stream and sediment processes define mechanisms of ecosystem response. The study has resulted in over 100 scientific publications and is recognized internationally for its contributions to forest ecosystem sciences.

After 15 years of whole-watershed chemical manipulations treatments have resulted in soil base cation depletion and metal mobilization, developing N saturation, changes in forest physiology and chemistry, and progressive acidification of soils and streams. Mechanisms of response to treatments that emerge on a decadal time scale are different than those that were evident during the initial years of treatments, underscoring the critical importance of long-term research in defining forest ecosystem response to environmental stressors. The BBWM program of research also focuses on the response of the reference watershed to long-term changes in ambient atmospheric deposition, and the interaction between climate and biogeochemical processes in both the treated and reference watershed.

DISTURBANCE HISTORY OF OLD-GROWTH RED SPRUCE STANDS IN NORTHERN MAINE: LINKING TREE-RING AND STEM-MAPPED DATA

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The aim of this study was to reconstruct the detailed history of natural disturbance for three old-growth, mid-elevation red spruce stands in northern Maine. By linking dendroecological methods and stem-mapped data, we estimated the actual area encompassed by particular disturbance events, as well as their frequency and location within stands.

We conducted the work in the Big Reed Forest Reserve, which at *ca.* 2000 hectares is thought to be the largest remaining contiguous tract of old-growth forest in New England. Unlike many small, isolated old-growth stands that may not be representative of the surrounding landscape, the Reserve supports forest communities, soils, elevation ranges, and topographic settings typical of northern Maine. Thus, it affords a unique glimpse of forest structure, composition, and processes that represent what forests of this region might have been like in the absence of disturbances associated with European settlement and subsequent development.

Three 50-by-50 m spruce-forest plots from a larger study were selected for intensive sampling here. The X and Y coordinates were recorded for all living and dead trees (individuals ≥ 10 cm diameter at breast height [dbh]) and saplings (individuals ≥ 2 m in height but < 10 cm dbh) within each plot. For each living tree we recorded dbh, total height, height to base of the live crown, crown class (dominant, co-dominant, intermediate, and overtopped), and stratum. To determine canopy projection area for each tree, we measured the horizontal distance from bole center to the canopy drip line in four cardinal directions.

We found no evidence of stand-replacing disturbance in these three spruce stands. The disturbance dynamic appears to have two components: pulses of moderate-severity disturbances caused by host-specific disturbance agents (i.e. spruce budworm, spruce bark beetle) interposed upon a background of scattered small-scale canopy gaps, presumably from wind damage. Consequently, rates of disturbance fluctuated considerably over time; however, they rarely exceeded 35% of canopy area lost per decade. The overall mean decadal disturbance rate was 10.1%. Gap areas, even during peak decades of disturbance, were apparently too small or too densely occupied by advance spruce regeneration to admit shade-intolerant species, although at times they did admit mid-tolerant species. Spruce trees clearly benefit from relatively small canopy gaps scattered in space and time: 80.6 % of trees showed one or more releases before canopy accession. Thus, this pattern of disturbance maintains red spruce dominance of the canopy. Reconstructed gap areas reveal that, following budworm outbreaks, gaps were both larger and more numerous. Gap areas thus calculated were generally smaller (median 25.3 m^2, mean 46.7 m^2) than those from other *Picea* forests.

CHANGING LANDOWNERSHIP IN THE NORTHERN FOREST: EFFECTS ON BIODIVERSITY

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For most of the 20th century, private landownership in the Northern Forest of New York and northern New England was relatively stable. The roster of major owners included the leading forest industry companies in the Fortune 500, financially strong companies with leading positions in their industries. Indeed, these companies had been founded in this region, one of the culture hearths of modern papermaking in North America. Industry growth began to slow in the late 1980s and by the 1990s, the industry was facing slowing demand growth and stiff competition on all fronts. In a period of about two decades, the landownership picture in the Northern Forest has been dramatically re-arranged. As of early 2005, there remain no major U.S. publicly traded paper and wood products companies owning more than nominal acreages in this region.

This ownership shift gave rise to serious public concerns about the future of undeveloped landscapes across the region. One concern is the effect of new ownership conditions and management practices on biodiversity. Funded by the National Council on Science for Sustainable Forestry, we are conducting a preliminary study of this issue. We compiled a detailed database of land transactions larger than 5000 acres since 1980. We then interviewed sellers and buyers of a sample of properties to see how management practices may have changed.

Preliminary results are available. First, we recognize that the shifts in landownership may not yet be finished, and many changes in management occur slowly and are not yet visible. Also, many of the changes in use of properties, especially at the smaller end of the size spectrum, took place in response to growing demand for exurban lands, and would have occurred even had there been no change in ownership by the large companies. Mere totals of lands sold are misleading, because for many of the larger sales, only minimal changes in ownership and management occurred. Also, we are finding it difficult to devise a convincing classification of owners by economic situation and motives. The situation is often too ambiguous and fluid for that. Many of the largest ownerships consisted of clusters of towns in diverse areas and were not tightly blocked up. When the pieces are sold off to separate buyers, as occasionally occurs, actual fragmentation of contiguous tracts may not occur. Finally, the process of ownership change has led to significant gains in public ownership and conservation group ownership, especially for easements.

A STATE-WIDE ASSESSMENT OF THE ABUNDANCE AND DISTRIBUTION OF THE PEACH BARK BEETLE, *PHLOEOTRIBUS LIMINARIS* (COLEOPTERA: SCOLYTIDAE): A POTENTIAL THREAT TO BLACK CHERRY

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A survey was designed to assess the relative abundance and distribution of the peach bark beetle (PBB), *Phloeotribus liminaris*, across 100 northern hardwood stands in New York state in 2002 and 2003. A second study determined the within-tree distribution of overwintering PBB and relationships between density of external gum spots, number of overwintering galleries and number of emerging PBBs in order to develop a method for predicting PBB population density and trend. A third study assessed the crowns of black cherry as a potential source of brood material when black cherry slash is not available. A fourth study was initiated in 2004 that eventually will serve as the basis of recommending a time of year when cherry can be harvested and minimize the likelihood of a buildup in PBB populations.

PBB was distributed in every county surveyed in New York. Abundance was associated with the presence of recently created black cherry slash and increasing black cherry basal area. The Tug Hill and Catskill regions had the highest frequency of PBB. Overwintering beetles, though present throughout the tree bole, were concentrated on the lower half of a black cherry stem. There was a positive linear relationship between number of gum spots and number of overwintering galleries, but gum spot density and number of captured adult peach bark beetles were not related. The possible mechanisms driving the abundance and distribution of peach bark beetle at regional, stand and site scales are discussed.

REGENERATION OF NORTHERN WHITE-CEDAR FOLLOWING SILVICULTURAL TREATMENT: A LONG-TERM STUDY

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Northern white-cedar (*Thuja occidentalis* L.) is found on many different types of sites, both in pure stands and in mixture with other species. Common associates include spruce (*Picea* species), balsam fir (*Abies balsamea* (L.) Mill.), and yellow birch (*Betula alleganiensis* Britton). Unfortunately, the circumstances leading to the successful recruitment of northern white-cedar are poorly understood. Some studies suggest that regeneration is associated with small natural disturbances such as blowdown. However, silvicultural treatments imitating nature have had varying degrees of success with regard to northern white-cedar regeneration. Browsing has been identified as the main factor limiting establishment and sapling development in many regions, but some areas do not regenerate successfully even when fenced.

Concerns about sustainable forest management have motivated researchers to study the relationships between silvicultural treatments and northern white-cedar regeneration. Experiments have been planned on lowland areas in the Gaspé Peninsula, eastern Québec and on mesic sites in the Outaouais region, western Québec. Though these new experiments will enable us to better identify the conditions associated with successful regeneration, they will only provide a short-term perspective. Medium-term data will be provided by a retrospective study of partial cuts conducted 15-20 years ago. Fortunately, researchers at the Penobscot Experimental Forest in Maine have been collecting data on northern white-cedar regeneration and growth for over 50 years. The PEF experiment includes 10 replicated silvicultural treatments. These data will be analysed in order to determine if there are relationships between treatment and northern white-cedar regeneration, and the findings will be used to develop treatments for the Gaspé Peninsula experiment. Further analysis will be conducted in order to examine the interactions of treatment and site type on cedar regeneration and tree response to partial cutting.

The results of this study will provide us with a better understanding of northern white-cedar regeneration mechanisms, and will help us to identify silvicultural regimes that promote cedar establishment and growth.

REALITY CHECK: HAS THE MASSACHUSETTS CURRENT-USE TAX PROGRAM BEEN EFFECTIVE IN DETERRING FOREST PARCELIZATION?

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Residential and commercial development of forestland threatens to compromise the many environmental, economic, and social benefits provided by the forested landscape. Heightened demands for land accompanied by increased property values and escalating tax liabilities, have significantly pressured many private owners to sell off part or all of their forestland. The resulting parcelization and fragmentation of forests has been shown to undermine the integrity of wildlife habitat, and to compromise the fiscal vitality of nonindustrial timber harvesting.

Studies have indicated that landowners who actively plan and manage their forestland are better equipped to resist the financial pressure to develop. With this in mind, various policy instruments have been offered to provide landowners with tools and information to encourage long-term tenure and stewardship.

The Massachusetts forest property tax program, better known as Chapter 61, provides a 95% reduction in assessed property tax value for enrolled landowners. To be eligible for enrollment landowners must have a 10-year forest management plan approved by the state forester's office. In exchange for reduced tax payments to the town, landowners commit to keeping their property forested and to managing for timber production for the duration of program enrollment.

My study (to be completed by December 2005) will attempt to address the efficacy of the Chapter 61 program in deterring forest parcelization across the state since the mid-1980s. I will take advantage of the Massachusetts Department of Conservation and Recreation (DCR) database management system in addition to its comprehensive library of enrollee management plans. Enrollment data will be collected from these sources for a sample of predominantly forested towns and will be used in conjunction with spatial data to determine ultimate parcelization.

This study will also examine the rate of enrollees who obtain permanent protection for their forest land through conservation restrictions following initial program enrollment.

Preliminary research conducted in the summer of 2004 has suggested that the dichotomy between state approval and town implementation of program enrollment may complicate a statewide analysis. Although landowner management plans are filed with the state, subsequent changes in attributes of enrollment often fail to make it back there, suggesting DCR records aren't necessarily reflective of reality at the town level.

As a result my study will also seek to assess, characterize, and quantify the communication breakdown between towns and the state as well as the resulting gap in enrollment information.

LAND USE HISTORY AND FOREST SUCCESSION ON LONG ISLAND, MAINE

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Disturbance histories are important factors in determining the composition and structure of today's forests. Not least among these disturbances is land-use history, due to its widespread and long-lasting impacts. Land clearing for Maine peaked in 1880 at 6.5 million acres. This was almost half of Maine's forested land. The very first settlements in Maine were on the coastal islands due to their accessibility. Therefore, Maine's islands contain some of the longest-impacted areas of forest.

Long Island is located in Blue Hill Bay, west of Blue Hill and east of Mount Desert Island. It is 4.5 miles long and 2 miles wide at its widest point, encompassing 4,555 acres. It was first settled in 1779 and grew to a population of about 200 year-round residents. The primary occupation on Long Island was farming, which included raising livestock, mainly sheepherding. Lumbering, fishing and a granite quarry provided supplemental livelihoods. By 1920 all of the residents of the island had moved to the mainland, leaving only a few summer camps scattered along the coast. A limited-use easement on 4,312 acres was acquired by Acadia National Park in 1995.

The objectives of this study are to: 1) establish ownership boundaries and their respective land-use histories; 2) quantify vegetation coverage and variability for each property; and 3) correlate ownership boundaries and land-use histories with current forest succession patterns. These objectives are being accomplished by historical research and field studies.

Historical research consists of examining deeds from the Hancock County Registry of Deeds, various readings and publications, interviews and visits to historical societies in the area. Tentative boundary lines, based on the deeds were plotted with GIS software and loaded into a hand-held GPS unit. These were then taken into the field to help guide the search for physical evidence of the property lines and homesteads. Any barbed wire, rock walls, foundations and such were geo-referenced and compared to established properties. Thirteen adjacent properties were delineated using the deeds' metes and bounds descriptions. Cellar holes were found for each property, as were wells for all but one.

To obtain vegetation and information, a one-sided variable width transect with a BAF 75 prism was used. Species, DBH and condition class were recorded for all live trees larger than or equal to 0.5″ DBH. The species, diameter, transect line intersection and decay class were also recorded for all dead and downed trees with a diameter larger than or equal to 6". Coverage descriptions, including the presence of ledges, blow downs and fern patches, were recorded for every 100 feet of the transect. This information is being processed using FlexFIBER, an inventory and growth modeling software. Seventeen transects on ten properties have been completed, documenting dramatic transitions in vegetation, suggesting that this technique is useful and appropriate for this application.

STAND-LEVEL RESPONSES OF NORTHERN WHITE-CEDAR TO SILVICULTURAL TREATMENTS IN CENTRAL MAINE

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Northern white-cedar (*Thuja occidentalis* L.) is arguably one of the least studied commercial tree species in the northeastern United States and adjacent Canada. Many cedar-dominated stands are being harvested without understanding likely treatment responses. Few studies on stand-level cedar responses to silviculture have been pursued, most of which have been in the Lake States or the boreal forests and have limited relevance to the Northeast due to soil and climate differences. Previous research has demonstrated that cedar regeneration and sapling recruitment are problematic in stands where cedar sustainability is not the focus of silvicultural treatment.

The Penobscot Experimental Forest (PEF) in central Maine has 50+ years of stand-level silvicultural research in which northern white-cedar is a small, but important component of the species composition. Changes in the proportions of stand basal area (BA, expressed as m^2/ha, trees ≥1.3 cm dbh), density (number of stems ≥ 1.3 cm dbh per hectare), and volume (m^3/ha, trees ≥ 11.4 cm dbh) comprised of cedar were analyzed for nine treatments, including selection cutting, modified and fixed diameter-limit cutting, shelterwood, and commercial clearcutting. There were no significant differences between treatments in the magnitude of change in the proportion of cedar density ($p = 0.30$) or volume ($p = 0.22$) during the first 45 years of the study. There were, however, significant differences among treatments in the magnitude and direction of the percentage of cedar BA change ($p = 0.02$). The percentage change in BA was significantly different between the fixed diameter-limit (2% increase) and 5- and 20-year selection treatments (9% decrease) ($p= 0.03$), and between the modified diameter-limit (<1% decrease) and the 5-year selection treatment ($p = 0.09$). Other treatments did not differ from one another, and had a mean cedar BA decrease of approximately 4%.

Though the percent volume change was not statistically significant among treatments, this may be due to high within-treatment variability and low statistical power (only two replicates of stand-level treatments). In general, treatment prescriptions that ignored cedar have resulted in increases in mean volume of that species over time, whereas treatments that discriminated against cedar have decreased its volume. There has been a consistent decline in cedar density on the PEF in the past 45 years, although BA has remained fairly constant. This suggests existing trees are increasing in radial increment with little to no sapling recruitment. Browse effects on regeneration have not yet been evaluated on the PEF, though herbivory likely affects recruitment. Future research will address cedar growth patterns, age structures, regeneration and recruitment dynamics, and the impacts of site.

ECOLOGY AND SILVICULTURE OF NORTHERN WHITE-CEDAR

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Northern white-cedar (*Thuja occidentalis* L.) is an important ecological and economic component of northern forest ecosystems throughout northern New England and eastern Canada. In addition to its commodity value as shingles, posts, boat-building lumber, and mulch, it is an important source of winter forage and habitat for white-tailed deer (*Odocoileus virginianus*). Despite its utility and value, there has been little research on the ecology and management of this species. Most studies of cedar have been conducted in the Lake States, where forest type, soil condition, climate, and disturbance history vary greatly from the forests of the Northeast. We have a limited ability to predict cedar growth in northeastern forests, especially in response to silvicultural treatments, and know little about its regeneration and early development.

Though foresters generally associate higher stem quality in cedar with upland seepage forests, these ideas have not been substantiated through data in any meaningful way. Cedar is often a minor component of mixed-species stands and is harvested opportunistically in the course of managing for more dominant species. Foresters interested in managing for cedar are handicapped by a lack of knowledge of cedar silviculture. Recruitment into sapling and pole stages is often problematic, and managers have expressed concern about the sustainability of the cedar resource. Further research into cedar ecology and response to silviculture is critical for sustainable management.

We propose to: 1) develop methods to predict stand- and tree-level growth of northern white-cedar in response to silvicultural treatment and site quality; 2) estimate rotation ages needed to attain various diameters; and 3) quantify sapling recruitment and growth patterns during early stand development. These objectives will be accomplished by conducting stem analysis on cedar trees in managed upland and wetland stands in central and northern Maine, and from a Maibec Industries millyard in Quebec, in order to assess age/size relationships and growth rates. These data will be supplemented by those collected on the USDA Forest Service silviculture experiment on the Penobscot Experimental Forest in central Maine, and in old-growth stands in the 5000-acre Big Reed Reserve in northern Maine.

We anticipate this study will provide data needed to improve our understanding of northern white-cedar ecology, and to develop effective management guidelines for cedar in the mixed-species northern forest.

COMPETITIVE POSITION OF THE MAINE PAPER INDUSTRY: BENCHMARKING AGAINST COMPETING REGIONS

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The North American paper industry has endured a painful period of restructuring since the late 1990s. Global economic forces, such as emerging production in tropical regions, adverse shifts in exchange rates, and maturing markets in North America and Europe, have prompted mill and machine shutdowns, investments to improve quality and shift grades, and significant industry consolidation. Despite rising demand until the late 90s, the U.S. industry ceased to build new mills a long time ago. The last greenfield papermill based on virgin fiber was started up in the South in the late 1980s. Just last year, the first newsprint mill built in the South (1939) was shut down.

As one of the original centers of modern papermaking in North America, Maine has a long history in this industry. Local forces have been at work as well. Maine mills went through a major period of reinvestment during the late 1970s through the early 80s. As machine sizes and speeds in world class new mills increase, Northeastern mills fall slowly behind the mills at the low end of the cost quartiles for their grades.

What are the implications of this situation for Maine? How is its competitive position changing? As one contribution to this question, with a U.S. Forest Service grant, we are exploring the issue in some detail. This poster offers a preliminary report. We are benchmarking the Maine industry against Quebec, Wisconsin, and Georgia, which produce large volumes of competing paper grades.

One major challenge is that complete data on the fiber balance of the paper industry by state or province does not exist. We can identity wood and chip usage fairly well, but market pulp and recycled fiber data are not available. Further, determining delivered prices for the major fiber sources is next to impossible. As a result, a precise accounting for differences in fiber cost between competing regions is elusive. We are comparing fiber supply expansion potential between these areas, and find that in both Georgia and Wisconsin, ability to expand supply significantly at recent cost levels is minimal, though this could change in coming decades in Georgia. Quebec is expected to see a significant decline in harvest levels on its Crown lands, though precise numbers are not available.

We are also comparing labor costs, power costs, and other cost elements as part of our analysis. At present, it appears that the most significant competitive threats will come from upgrading machines in Quebec and Georgia to produce printing and writing grades, and from imports.

HABITAT FEATURES THAT INFLUENCE THE PREVALENCE OF INVASIVE SHRUBS IN EARLY-SUCCESSIONAL HABITATS: THE ROLE OF SPATIAL SCALE

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Alien plants have invaded nearly all regions of the world. In the United States, approximately 5,000 species of alien plants have escaped into native communities. These introductions have resulted in a range of community- and ecosystem-level effects. Among terrestrial communities, invasive plants can out-compete native plants and alter community characteristics. The profound effects that invasive organisms are having has caused ecologists to consider their spread as second only to habitat destruction as a threat to global biodiversity. The establishment of an invasive plant is dependent on three factors: availability and transport of seeds, life-history characteristics of the alien plant, and the susceptibility of a habitat to invasion. Among the factors influencing susceptibility is the frequency and intensity of physical disturbance that removes native vegetation.

In New England, early-successional habitats are becoming increasingly scarce and may require active management if they are to be present at levels sufficient to support the diverse groups of plants and animals that are dependent on them. Early-successional habitats require some form of disturbance to maintain them (e.g., timber harvests, mowing, or controlled fires); thus, these habitats may be especially vulnerable to encroachment by invasive plants. Additionally, some invasive shrubs (e.g., autumn olive, multiflora rose, and honeysuckles) were intentionally planted in these habitats as a way to enhance food and cover for game animals. As a result, early-successional habitats may be disproportionately colonized by invasive shrubs in comparison to other terrestrial habitats. In response to this concern, we are investigating habitat features and land use characteristics at three spatial scales (landscape, local, and site) to determine their influence on the vulnerability of early-successional habitats to exotic plant invasions.

We examined the abundance of invasive plants in 58 early-successional sites in southeastern New Hampshire. At the landscape scale, we inventoried road and river density (potential corridors for seed dispersal) within a 1- km radius of the study sites. At the local scale, historic use of each site was determined by examining aerial photographs taken in 1962, 1974, and 1998. Current land use and time since disturbance were determined during site visits while soil samples were collected to determine pH, texture, and nitrate content. We will present preliminary results that identify which features may be most important in ranking the vulnerability of a site to plant invasions. Such information should affect management activities in these habitats.

INVESTIGATING THE ONSET OF RADIAL GROWTH REDUCTION CAUSED BY BALSAM WOOLLY ADELGID DAMAGE ON BALSAM FIR IN RELATION TO CLIMATE USING DENDROECOLOGICAL METHODS

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Balsam woolly adelgid (BWA) (*Adelges piceae)* was first identified in Maine in 1908 and spread throughout the lower half of the state by 1950. Isolated patches of infestation occurred as far north as Westmanland in northern Aroostook County. After 1950, chronic infestations remained in coastal areas of Maine, while further inland damage became sporadic and widely scattered. Within the last decade, however, damage has increased in interior portions of the state with the worst damage in central Hancock and Washington Counties.

We are testing the hypotheses that reductions in radial growth of BWA infested balsam fir (*Abies balsamea*) in central Hancock and Washington counties was initiated within the last decade, and that distinct weather patterns such as warm winters and/or drought are associated with infestation changes. We are also confirming whether damage severity varies with soil drainage class and other stand parameters.

Circular, 0.08-hectare (1/5-acre) study plots were established in the area east of the Penobscot River where recent reports of BWA damage have originated. Twenty-nine plots, stratified by climate region and soil drainage class, were established on sites capable of commercial production of balsam fir. Several site and tree measurements were recorded on each plot and increment cores were taken from at least 12 host and 12 non-host trees. Measurements were taken as described in the Forest Inventory and Analysis Field Guide (USDA Forest Service 2003).

Chronologies will be developed from the increment cores for balsam fir and non-host species. These chronologies will be cross-dated, standardized, and compared with each other to remove stand-wide effects on growth patterns in an attempt to single out BWA effects on balsam fir. This examination will show whether reduction in radial growth of adelgid-infested fir is a recent event. The onset of growth decline will be compared with climate records to evaluate relationships between minimum temperatures, drought (as indicated by precipitation and stream flow), and BWA signals in fir chronologies. Relationships between soil drainage class, other stand parameters, and severity of BWA symptoms will be quantified using multivariate analytical techniques. The study's results will indicate if climate can explain the recent increase in BWA damage in Hancock and Washington Counties and how severity of BWA damage varies by drainage class and with radial growth reductions at DBH.

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FACTORS INFLUENCING THE GERMINATION, EMERGENCE, AND EARLY SURVIVAL OF NATIVE AND NON-NATIVE TREE SPECIES IN THE ACADIAN FOREST

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The Acadian forest forms the transition zone between the eastern temperate and the boreal forest. With the possibility of a changing climate, it will be important to predict how increasing temperatures and changing patterns of precipitation may influence the distribution of important native and exotic tree species. Although climate may act to limit the geographic distribution of a tree species at any of several points during its lifecycle, the influence of temperature and moisture on the sensitive early life stages may be particularly important. In addition, understanding how other factors such as seed predation, herbivory, plant competition, and season of dispersal can influence whether a seed is able to germinate, emerge, and survive the first year will help determine the relative importance of climate on these life stages.

The objectives of this study are to: 1) examine the effects of different temperature and moisture regimes on the germination success of important native Acadian tree species and exotic tree species; 2) quantify the effects of seed predation, herbaceous competition, overstory, and sowing date on the emergence and first-year survival of important native Acadian tree species and exotic tree species; and 3) determine if silviculture can be used to mitigate possible negative effects of global climate change on soil temperature and moisture to encourage the germination and establishment of desired Acadian forest species. These objectives are being accomplished using both growth chamber and field studies.

The growth chamber study is examining the germination patterns of nine tree species, representing boreal, (balsam fir, trembling aspen, white birch) temperate (eastern white pine, red maple, red spruce) and exotic species (hybrid larch, Norway maple, Norway spruce), under three temperature and moisture regimes in a factorial design. Moisture levels in the germination media were controlled using polyethylene glycol 8000 solutions with potentials of 0 Mpa, -0.6 Mpa and -1.2 Mpa to simulate wet, moderate and dry conditions, respectively. Temperature regimes included the 30 year average for Bangor, Maine from 1971-2000 [June high (23.5°C) and low (11.8°C)] and plus and minus 7.5°C from this baseline. This experiment provided control over temperature and moisture conditions, as well as observation of the timing of germination that is generally not possible in the field.

The field study includes seed of the same nine species in a 2^4 factorial design, and is examining the influence of: 1) sowing date (fall vs. spring), 2) overstory canopy (overstory vs. no overstory), 3) vertebrate predator protection (cage vs. no cage) and 4) herbaceous plat competition (grass vs. no grass) on emergence and early survival. Emergence, mortality and cause of mortality, were tracked weekly during the first growing season in 2004. General patterns of soil temperature and moisture also have been monitored.

SAPLING RECRUITMENT AND GROWTH DYNAMICS IN MULTI-AGED NORTHERN CONIFER STANDS: A 20-YEAR STUDY

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It has long been recognized that sustainable multi-aged management relies upon defining and attaining specific stand structural goals. These goals are typically defined in terms of residual basal area, maximum diameter and number of trees per size class. Most assessments of multi-aged stands focus on these attributes, i.e. the structure and growth of the merchantable classes. However, the amount, species, growth and mortality of the sapling classes have important implications for long-term sustainability.

The USDA Forest Service Northeastern Research Station established a long-term silviculture experiment on the Penobscot Experimental Forest in Maine in 1952. Treatments are replicated at the stand level and include selection cutting on 5-, 10-, and 20-year cycles (SC05, SC10, and SC20, respectively) as well as modified (MDL) and fixed (FDL) diameter-limit cutting at 20-year intervals. A subsample of trees 0.5 inches and larger in diameter at breast height have been numbered and followed individually since 1975, with measurements taken before and after treatment and at 5-year intervals between treatments.

Preliminary analysis of sapling ingrowth data from year 25 of the study to the present revealed high within-treatment variability. The amount of ingrowth recorded in a single inventory varied temporally within treatments by as much as tenfold, and spatially (between replicates) by twofold. Values ranged from as low as 109 stems/acre over a five-year inventory period in one of the SC05 stands, to 1918 stems/acre in one of the SC20 stands. The mean rate of ingrowth over the measurement period differed only for SC05 (53.7 stems/acre/year) and S20 (240.6 stems/acre/year). Species composition of sapling ingrowth did not differ by treatment.

Individual tree dynamics were evaluated using the sapling ingrowth in year 25 of the study, and following that ingrowth "cohort" over time. Twenty years later the proportions of this class that had died, remained saplings, and reached the poletimber did not differ by treatment. On average, 50% of the "class of 25" ingrowth had died, 48% remained sapling size, and 2% reached the pole classes. Principal cause of mortality differed between the 5- and 10-year selection (residual stand damage) and 20-year selection (suppression). There were no other treatment differences in amount or cause of sapling ingrowth mortality.

Rates of sapling diameter growth at the time of ingrowth did not differ by treatment and averaged <0.1 inch per year. This slow rate of sapling ingrowth diameter growth, combined with high mortality, suggests problems with subsequent merchantable ingrowth and long-term sustainability of structure and production in the multi-aged stands. Future work will address merchantable ingrowth dynamics.

DYNAMICS OF TREE GROWTH AND COMPOSITION FOLLOWING PARTIAL CUTTING IN AN OAK – PINE FOREST IN MAINE

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The Holt Research Forest in Maine is an early 1900s origin even-aged second-growth forest. Common tree species include eastern white pine, red maple, and red oak in mixture with other softwoods and hardwoods. In 1987 ten 1-ha blocks on the forest were partially harvested to initiate a long-term study of ecosystem response to silvicultural treatment. Since that time, data from treated blocks and untreated controls have been used to assess changes in stand structure (density and volume), species composition, growth, mortality, and snag dynamics.

Objectives of the treatment were to increase structural diversity, regenerate a new cohort, and improve stand quality, growth, and composition. White pine and red oak were favored, as were good form yellow and paper birch, red spruce, and eastern hemlock. Grey birch, mature balsam fir, poor vigor red spruce, and trees > 50 cm dbh (primarily white pine "wolf" trees) were removed. These objectives, and the low-impact partial harvesting applied, are consistent with the objectives and forest management preferences of small landowners in the region.

There were no pre-treatment structural or compositional differences between harvest and control blocks (for species > 5% of BA). Inventory data collected post-treatment indicated fewer trees and less volume in the harvest blocks, as would be expected. Total stem density no longer differed between treatments nine years after harvest, apparently due to the combined effects of higher ingrowth in the harvest blocks and higher mortality in the control. Volume remained lower in the harvest than control blocks. Species composition did not differ between treatments, either immediately or one decade after harvest, despite attempts to improve composition. Net growth was also not differentiated by treatment, with the exception of higher medium-large sawtimber growth in the control due to greater stocking in those classes.

Post-harvest inventory revealed that the harvest blocks had fewer snags, despite no pre-harvest difference in snag density between treatment areas. Though the number of snags increased in both the harvest and control blocks over the next decade, greater snag recruitment (a function of mortality) occurred in the control. Partial cutting thus decreased both the number of snags in the residual stand and the rate of snag formation, resulting in increasing between-treatment differences in snag density over time.

FIELD EFFICIENCY AND BIAS OF METHODS FOR SNAG AND CAVITY TREE INVENTORY

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Snags and cavity trees are important to the structure and ecological function of forest ecosystems, yet due to operational sampling difficulties and limited resources snags are often not included in forest inventory. This study tested N-tree distance sampling as a new time saving device for snag assessment and compared N-tree distance sampling to fixed area sampling and modified horizontal line sampling (MHLS). Also presented is a novel modification of N-tree distance sampling that limits the area an observer must search to find tally trees. Results show N-tree distance sampling to be quick yet generally biased with high variability in snag inventory. Based on our inventory and time trials of all above-mentioned methods, we give recommendations on operational snag inventory in similar forest types.

P.O. SERIES – STAND DYNAMICS

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The Permanent Observation (PO) series of plots were established in the fall of 1924 with the object of capturing a continuous record of regeneration. All plots experienced a recent cutting of spruce and fir to a 6″ diameter limit, i.e. commercial clearcut. These plots located in the Penobscot River watershed on the Great Northern Paper Company ownership, were periodically remeasured up through 1994, and have more than met the original objective.

The 70 years of remeasurement data, photographic documentation, and graphical analysis encompass two major dynamic developments:

- Through the 1960s, the stand maturation response following the 1910 - 1920 spruce budworm epidemic and the circa 1920 harvest, and
- Then the stand degradation process from the mortality impacts of the 1970s - 1980s era spruce budworm epidemic.

Five plots (PO – 2, 3, 5, 6, and 10) can be characterized as representing a spruce flat development type, with equal representation of spruce and fir, moderate to poor drainage, and associated species of red maple, yellow birch, and white birch. In 1924, at a derived spruce-fir stand age of 10; these plots averaged 13,000 seedlings, 97 saplings (1 – 6″ dbh class), and 50 merchantable size trees per acre. The merchantable basal area was 53 ft^2/acre and the merchantable volume was estimated at 12 cords per acre, 95 percent of which was post-harvest residual yellow and white birch.

For the 25 year period (stand age 24 - 49), spruce-fir ingrowth averaged 0.51 cords per acre per year, with fir ingrowth concentrated early in this period and spruce tagging along later. At the 1963 data collection cycle and at a stand age of 49 years, spruce-fir periodic accretion peaks at 1.29 cords/acre/year. Ten years later, the mean annual increment of spruce-fir peaks at 0.52 cords/acre/year. At a derived stand age of 59 years, the average merchantable stock and stand values per acre are 630 trees, 167 ft^2 of basal area, and 32 cords.

The next 10-year period encompasses the recent spruce budworm epidemic and how it impacts these plots:

- 1974 - 1978, the plots average an estimated -2.04 cords/acre/year in mortality, resulting in an estimated net growth of -2.01 cords/acre/year. There was no measurable accretion!
- 1979 - 1983, the plots average an estimated -1.72 cords/acre/year in mortality, resulting in an estimated net growth of -1.72 cords/acre/year. Again, there was no measurable accretion.

In 1983, the average merchantable stock and stand values per acre are now 217 trees, 70 ft^2 of basal area, and 14 cords. The four remaining unharvested plots continued to decrement in volume and net growth through the last measurement period of 1984 - 1994, even as the next stand of seedlings/saplings started to express their development.

LONG-TERM EFFECTS OF LIMING ON SOIL CHEMISTRY IN NORTHERN HARDWOOD FORESTS

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Most studies on forest liming and soil acidity deal with short-term (<10 yrs) effects (Johnson et al. 1995). The few that have revisited limed sites after longer periods of time (e.g. Persson et al. 1995) suggest that while pH effects from liming may dissipate relatively quickly, other effects—changes in base saturation, exchangeable cations, distribution of organic matter—can be more persistent. Since these properties are normally related, this uncoupling suggests that in the long term, liming causes fundamental changes in the chemical properties of the treated soil.

In order to characterize these long-term effects, I located four previously established liming experiments in northern hardwood or mixed hardwood stands across the northeast. In all cases, lime or dolomite had been applied to mature stands; application rates ranged from 1.1 to 6.9 T/ha. The oldest experiment is in the Bartlett Experimental Forest in Bartlett, NH, and is part of a fertilization study that was put in place in 1963. The next oldest is located in the Harvard Forest near Petersham, MA, and was initiated 1984-85. The third experiment is at Woods Lake, part of the Integrated Lake-Watershed Acidification Study initiated in the early 1980s to address the acidification of lakes in the Adirondacks; the lime application was done in 1989. The fourth and youngest experiment is located at the Proctor Maple Research Center, near Burlington, VT, and was limed in 1990.

Samples of organic horizons and of the top 15 cm of the B horizon were taken from treatment and control locations at each experiment during the summer/fall of 2004. Horizon depths were measured at the time of sampling as well. The long-term effects of liming on pH, organic carbon content, exchangeable cations and acidity, effective and total CEC, and organically bound Al will be presented; initial analysis of horizon data indicates that liming resulted in an increased occurrence of A horizons and a decrease in the depth of Oe horizons.

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SIMULATING REHABILITATION TREATMENTS IN NORTHERN HARDWOOD STANDS FOLLOWING DIAMETER-LIMIT CUTTING

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Exploitive cutting practices, such as high-grading and diameter-limit cutting, are common throughout the Northeast. The primary focus of such practices is timber extraction. Unlike silvicultural treatments, they do not attempt to deliberately regenerate or tend residual trees. These practices are popular because, by removing the largest and most valuable trees, landowners and/or loggers generate immediate and relatively high financial returns. However, studies have shown that the benefits of repeated diameter-limit cutting are limited to the initial harvests. Short-term benefits are offset by long-term ecological and economical costs. Adverse effects may include residual stands with poor quality and low vigor trees, less commercially valuable species, and variable stocking and crown cover. Although the negative effects of diameter-limit cutting have been documented, research addressing rehabilitation options is scant.

The purpose of this study is to identify silvicultural strategies for managing northern hardwood stands, with a focus on overstory dynamics, following diameter-limit cuttings. Data were obtained from well-stocked, even-aged northern hardwood stands in Maine. Exploitive and silvicultural treatments were simulated over a 50-year period using a USDA Forest Service growth and yield model (NE-TWIGS variant of the Forest Vegetation Simulator). Six scenarios were explored including moderate and intensive rehabilitation treatments as well as no treatments, followed by one and two 12-inch diameter-limit cuttings. Moderate and intensive treatments differed in terms of the amount of basal area retained in each stand following rehabilitation treatments. Stand data were evaluated using the Stand Product Optimization Tool which attempts to determine an optimal mix of products for a stand based on user-provided merchantability standards, product values and sampling data (McConville and Svitak 2004). Species composition, merchantable volume by product class, and net present value were evaluated and compared across scenarios and between stands. Net growth will also be evaluated.

Preliminary results suggest that intensive rehabilitation treatments were most successful in improving species composition compared to moderate rehabilitation treatments and no treatments. Net present values were also generally highest for the intensive treatments and lowest for no treatments, when evaluated at the end of the 50-year modeling period. Moderate rehabilitation treatments were typically constrained by the species composition and density.

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MAINE'S COMMERCIAL THINNING RESEARCH NETWORK: A LONG-TERM RESEARCH INSTALLATION DESIGNED TO IMPROVE OUR UNDERSTANDING ABOUT HOW FORESTS RESPOND TO THINNING

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Maine's Commercial Thinning Research Network was established in 2000 to develop a better understanding about stand responses to commercial thinning in the state's forests. Initial efforts by the network are divided into two phases. Phase I developed a set of interim guidelines for commercial thinning through the development of a software product called ThinME. Phase II, representing most of the effort, has involved establishing a statewide network of research sites to address specific questions about commercial thinning. Data from Phase II will help further refine the thinning software developed in Phase I, improve regional growth and yield models related to thinning responses, and address other silvicultural questions of interest. The plot network is currently focused on answering two key questions about commercial thinning in spruce-fir stands across the state: (1) For natural spruce-fir stands that have not received pre-commercial thinning (PCT), what is the influence of (a) method of commercial thinning and (b) residual density on subsequent stand response? (2) For natural spruce-fir stands that have received previous PCT, what is the influence of (a) timing of first commercial thinning entry and (b) residual density on subsequent stand response?

Twelve study sites have been established across the state of Maine. Six sites have previously received PCT and range in age from 25 to 40 years old. The other six sites have never received PCT and range from 40 to 70 years old. At each site, seven 0.37 ha (61 m x 61 m) treatment plots have been established. Commercial thinning treatments in stands that have not received PCT include a factorial combination of thinning method (low, crown, or dominant) and level of relative density reduction (33 percent or 50 percent). Commercial thinning treatments in stands that have received PCT include a factorial combination of timing of first commercial thinning (now, delay 5 yrs, or delay 10 yrs) and level of relative density reduction (33 percent or 50 percent). The thinning treatments, which used single-grip harvesters and forwarder trails spaced 30.5 m apart, were applied from fall 2000 through fall 2002. Four 0.02-ha (15.2 m x 13.3 m) measurement plots were placed at the center of each treatment plot. All plots have been measured before and after thinning. Regular post-treatment measurements are being collected from permanent tagged trees. Measurements include species, DBH, tree location, total height, and height to live crown.

THE PACK FOREST PLAIN: ONE OF NORTH AMERICA'S OLDEST FOREST FERTILIZATION EXPERIMENTS

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In 1928, Svend Heiberg—one of the first foresters and soil scientists to practice, teach and conduct research on forestry in the United States—led the establishment of a series of conifer plantations that have been regularly used for scientific inquiry of forest nutrition, stand development, biogeochemistry, and silviculture. The 50-hectare collection of plantations— mostly red pine (*Pinus resinosa* Ait.) located on a glaciofluvial outwash sandplain ("The Plain") on the Charles Lathrop Pack Demonstration Forest in the southeastern Adirondacks of New York—were amended with organic matter or fertilized with various amounts and combinations of N, P, and K from 1935 to 1956, making the site one of the oldest forest nutrition trials in North America. Early on in the research, The Plain was discovered to have severe K deficiencies for growing red pine and other species, so studies focused on K nutrition and its interaction with other site resources, including water and light. Some of the first practice and theory papers on forest fertilization in North America were produced by Heiberg and others, including many of today's top soil scientists who worked on The Plain as students in the 1940s-1960s. In the 1970s and 80s, the long-term research sites were used by Heiberg-descendants (including Drs. Al Leaf and Ed White) to study biogeochemistry in association with plantation development (aggradation) and concern for acidic deposition effects in forest ecosystems. Results are featured in Brady and Weil's seminal textbook on soils ("The Nature and Property of Soils", 12th and 13th editions). Research work has continued to present with a growing record of information on changes in tree communities and soil chemistry. Future research will hopefully continue along these lines of inquiry, and would focus on sustainability of conifer plantations, site amelioration of degraded soils using plantations, acidic deposition and its changing influence on site quality in the Adirondacks, and plantation forestry as related to long-term carbon dynamics.

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LAND-USE HISTORY AS A DRIVER OF CURRENT ECOLOGICAL PROCESSES

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The forests of the northeastern United States present a history of almost continual change, albeit change that has varied greatly in scale, rates, and causes through time. The importance of human disturbance relative to natural disturbance has steadily increased, most rapidly and dramatically following European settlement. Legacies from clearing and plowing, grazing, burning, and cutting from the 17th through 19th centuries strongly influence most ecological processes in the region today. Harvard Forest has been investigating these influences for nearly a century, as exemplified by the famed Land-use History dioramas in the Fisher Museum at Harvard Forest (Foster and O'Keefe 2000) and, more recently, through its research as a National Science Foundation (NSF) Long-Term Ecological Research (LTER) site.

We have used a variety of data sources including proxy data such as pollen in sediments, historical maps, survey data and records, physical evidence on the landscape, and long-term plots and experimental treatments to investigate these changes. Virtually every ecological process studied reflects a legacy of land-use history. The dramatic cover changes during the last 150 years and the resulting successional patterns influence current plant species abundances (less beech and hemlock, more birch and red maple now than pre-settlement) and distributions. Moreover, these impacts typically vary with scale: homogenization at the broad landscape scale, but a mosaic of persistent patches at the local scale. Wildlife species have responded strongly to these changes and patterns. The landscape's ability to store carbon (approximately 2 metric tons/ha/yr) and its response to nitrogen deposition also reflect land-use history.

Separating human and environmental drivers of ecological change requires much work and at least a millennial perspective. It is critical that environmental decision-making begin with a knowledge and appreciation of the history and dynamic nature of our landscape.

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EFFECTS OF SILVICULTURAL TREATMENTS ON COARSE WOODY DEBRIS IN THE CATSKILL REGION

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Coarse woody debris (CWD) is an important component of forested ecosystems that requires increased attention with changing demands on forest management. CWD can be an important component of aboveground carbon and nutrient storage, but the variety of silvicultural treatments applied makes it difficult to predict.

This study was conducted to determine the effects of silvicultural treatments and harvesting practices on CWD biomass, nutrient capital and carbon content. The research plots were located in two of four model forests within the Catskill/Delaware watershed of the New York City (NYC) water supply system. The NYC watershed model forests offer an opportunity to demonstrate how the balance between a working landscape and water quality can be maintained while providing a practical means of studying and monitoring the effects of forest management on ecosystem functions and water quality. Information on CWD was collected by using the modified planar intercept method at the Lennox Memorial Model Forest with a variety of silvicultural treatments and the Mink Hollow Model Forest in the Catskills. We collected subsamples 15 cm in length by species and 4 decay classes to determine their density and nutrient concentration.

The biomass of CWD in control, crown thinning, high-grade harvesting, shelterwood cut, and patch clearcut is 10, 23, 39, 40, and 48 megagrams/ha respectively. Biomass of CWD depends on the degree of decay class of wood and the selected treatment. High-grade harvesting and light crown thinning did not produce much large CWD (> 20 cm). As expected, the proportion of low decay class in the treated sites was greater than in the control. The proportion of well-decayed CWD is highest in the control and high-grade harvesting sites. The density of CWD decreases as it falls to the ground and decays. Change in density on aboveground (D_a) and downed CWD (D_d) can be obtained from D_a = - 0.05 × (Decay class) + 0.47 (R^2 = 0.36) and D_d = -0.08 × (Decay class) + 0.46 (R^2 = 0.60).

Nitrogen concentration consistently increased as decay progressed in all species, but P, K, Ca, and Mg were less predictable. Nutrient content of CWD was the lowest (37, 2, 5, 30, and 3 kg/ha for N, P, K, Ca, and Mg respectively) in the control and the highest in the patch clearcut (109, 7, 40, 363, and 21 kg/ha for N, P, K, Ca, and Mg respectively). The carbon storage of CWD remaining on site is 5, 11, 19, 19, and 23 ton/ha for control, crown thinning, high-grade harvesting, shelterwood cut, and patch clearcut treatment respectively.

This study shows that silvicultural methods can significantly influence the amount of CWD and nutrient, especially soon after cutting. This study will provide valuable information in selecting treatments to accommodate non-timber values such as wildlife habitat, nutrient cycling, and carbon storage.

EARLY DEVELOPMENT OF GAP ORIGIN NORTHERN CONIFERS: DO MODEST SIZED CANOPY OPENINGS PROVIDE FOR TIMELY RECRUITMENT OPPORTUNITIES?

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One of the greatest challenges faced by forest managers interested in transitioning from single to multi-aged stand structures is the establishment and timely recruitment of new age classes. The Acadian Forest of central Maine, characterized by long-lived shade-tolerant species that regenerate reliably, provides an ideal backdrop for identifying viable strategies. To that end, this study presents a retrospective analysis of the height growth of gap origin saplings in a mature single-storied northern conifer stand transitioning into the understory reinitiation stage of stand development. The tallest individual saplings of each of the three most common species [*Tsuga canadensis* (EH), *Picea rubens* (RS), *Abies balsamea* (BF)] were harvested from each of six densely regenerated canopy gaps of varying size (gap fraction range=0.19 to 0.33, roughly corresponding to the removal of 1-2 main canopy trees). Sapling age, measured at the root collar, averaged 29 yrs (range=19 to 46), and average total height was 4.9 ft (range=1.7 to 11.9), when sampled in 2004. Species composition of the overstory was dominated by EH (60% of total stand basal area which was 165 ft^2); RS (28 ft^2) and BF (10 ft^2) were also represented in the overstory. The average breast height age of main canopy trees on the margins of the studied gaps was >100 yrs.

In general, the radial growth patterns exhibited by these saplings did not indicate distinct periods of suppression and release, but rather suggested accelerating growth in response to increased resource availability in the gaps and their increasing capacity to utilize them. Further, radial growth patterns of the surviving overstory trees surrounding the gaps showed little evidence of enhanced increment in response to the vacated growing space, perhaps due to their advancing ages and/or current social position within the stand. Seventy-four percent of the variability in recent sapling height growth could be accounted for in a linear model including species (P=0.026), gap fraction (P=0.006), and relative sapling height (P=0.047) as inputs; means separation indicated that on average EH grew faster in height than either BF or RS under these conditions. Current rates of height growth among these leading saplings does not appear to be sufficient to ensure their timely recruitment into the main canopy layer (EH=0.48 ft/yr, BF=0.31 ft/yr, RS=0.15 ft/yr), with the possible exception of EH. Our findings highlight a potential bottleneck when converting single-cohort stands to multi-aged structures. In fairness, the modest sized canopy gaps represented in this study may have been too small to promote thrifty height growth, even among these shade-tolerant species. Observation of gap origin saplings within openings more typical of group selection cuttings (up to 0.5 ac) may lead to a different conclusion.

SOIL CHARACTERISTICS 30-YEARS POST-HARVEST ON MAINE SPRUCE FLATS: PRELIMINARY RESULTS

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The objective of this retrospective study was to quantify the effects of tree harvesting on spruce flats in northern Maine, 30 years post-harvest. Spruce flats are dominated by shallow-rooted species and, therefore, nutrients vertically redistributed in the mineral soil following disturbance may be biologically out of reach. In order to test this hypothesis we selected stands cut 30 years ago representing three harvest intensities (30%, 50%, and 80% removal) and two unharvested reference sites. Samples from the O and B horizons were collected from pits excavated near each of ten mature red spruce selected at each site. These samples were analyzed for C, N, exchangeable cations, extractable P, pH, and exchangeable acidity. O horizon soil moisture was calculated from samples collected during the summer of 2004.

Preliminary results indicate that a threshold exists between 50% and 80% removal-by-volume beyond which the impacts on the soil are noticeable, 30-years post-harvest. Beyond this threshold, the O horizon is significantly thinner and has a lower C:N ratio. Total C and total N in the mineral soil were highest in the 80% harvest. This indicates increased leaching of dissolved organic matter from the O horizon post-harvest. The mass of extractable P and exchangeable K in the O horizon was significantly lower in the 80% harvest, while concentrations in the B horizon of the three stands after 30 years were indistinguishable. Phosphorus and K were not adsorbed by the upper 20 cm of the mineral soil and likely were leached below the sampling depth or from the system. Conversely, the mass and concentration of exchangeable Mn were higher in the O horizon of the 80% harvest.

A threshold exists between 50% and 80% removal beyond which nutrient dynamics are adversely impacted. In these shallow-rooted systems, some limiting nutrients likely are redistributed to locations where they are unavailable to trees. This can impair the fertility and productivity of these stands. The results from this study can help foresters implement management plans that will help maintain the integrity of the region's spruce-fir forests.

PATTERNS OF ABOVEGROUND BIOMASS ACCUMULATION IN A NORTHERN TEMPERATE FOREST

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Current detailed understanding of the role forest ecosystems play in the Earth's carbon budget is often limited to small areas and short time spans. In order to better understand the role that these forest ecosystems play in the global carbon budget it is necessary to understand the dynamics of biomass accumulation and the patterns of change that occur through time and arising from both anthropogenic and natural disturbances. Here we present preliminary results of an analysis of patterns of change in standing aboveground biomass across a broad spatial (1050 ha) and temporal (>75 years) scale for the Bartlett Experimental Forest, located in White Mountain National Forest, New Hampshire, USA.

RECONSTRUCTING THE INTERACTIONS BETWEEN *ACER RUBRUM*, *BETULA LENTA* AND *QUERCUS RUBRA* IN A MIXED-SPECIES FOREST IN CENTRAL MASSACHUSETTS: REVISITING THE EARL STEPHENS PLOT

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In 1952 Earl Stephens clearcut and meticulously reconstructed the history of a 0.36 ha plot on the Harvard Forest in Petersham, MA. It was found, and later presented in paper by Oliver and Stephens in 1977, that the forest developed from allogenic processes, rather than the continuous recruitment of shade tolerant species through autogenic processes. Since that initial study little has been done to investigate the development of the plot. The plot was revisited in the fall of 2004 to measure and inventory the species present. The data will be used to determine how the forest initiated and how the species present on the site interacted with each other after the clearing in 1952.

These interactions between northern red oak and red maple have been documented (Oliver 1977), but little has been done to try and understand the dynamics between black birch and red maple. This study focuses primarily of the relationships between these two species with and without the presence of northern red oak. Ten percent of the 0.36 ha plot was sampled; the plot was divided into the original 9.3 m^2 subplots from the 1952 reconstruction. Increment cores, canopy dimensions, diameter and height information were collected for each tree within the sampled subplot.

The purpose of this study is to provide information on how black birch and red maple interact with each in a mixed-species forest in central New England. Knowledge of such interactions will construct a better understanding of forest dynamics in central New England.

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SILVICULTURE OF NORTHERN WHITE-CEDAR IN MIXEDWOOD FORESTS

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Concerns have been expressed regarding a decrease in the abundance of northern white cedar over a large part of its range. Possible reasons for a decrease include poorly controlled harvesting and an increase in deer browsing. Cedar can be the main species on some sites but it is also a companion species in mixedwood stands. In these stands, productivity and stem quality can be very good, making it an important resource for the forest industry. However, cedar response to silviculture in such stands remains poorly documented so that the selection of silvicultural treatments is largely based on the silvics of other associated species.

In order to assess cedar response in these stands, a study was initiated in western Quebec, Canada. The study addresses two aspects of cedar response: regeneration establishment and residual tree growth response. It comprises three sub-projects. The first one consists in an experiment where short-term seedling establishment and development will be put in relation with level of cutting, seed rain, seedbed type, browsing pressure as well as light, nutrient and water availability. The second sub-project consists in a retrospective study in which regeneration and residual tree response will be examined in relation with the type of cutting, the local skid trail network and the local growth environment. The last sub-project will use long-term data from the Penobscot Experimental Forest (Maine) to look at the combined effect of site type and silviculture on the growth and regeneration of cedar. Together, the information gathered will make it possible to provide management recommendations for cedar management in mixedwood stands.

SILVICULTURE AND WILDLIFE IN BOREAL IRREGULAR FORESTS: A COOPERATIVE RESEARCH INITIATIVE

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It is generally assumed that fire is the dominant natural disturbance of boreal forests. This assumption might promote the current extensive use of the clearcut system. However, there are portions of the boreal forest receiving abundant precipitations. The interval between successive fires may then be longer than the lifespan of individual trees. Tree mortality creates openings in the canopy, and stands become characterized by an uneven and more diversified structure. Eastern Canada provides an example of balsam fir and black spruce forests having an irregular structure. The biodiversity characterizing the irregular boreal forest appears to stand out from the rest of the boreal forest, but information remains limited. If forest management is to be adapted to stand structure in a way that emulates natural disturbance patterns, alternatives to the clearcut system must be developed.

In 2003, a research program was launched to develop silvicultural systems suitable to maintain the biodiversity and ecosystem function in irregular boreal forests. This research conducted in Eastern Canada involves financial participation from provincial and federal governments, as well as the forest industry and wildlife agencies. The initial five-year research program focuses on three axes. Each of these axes incorporates wildlife and forest components so that integrated scenarios can be developed. The first axis will characterize the ecology of irregular forests by using specifically adapted descriptors. While building on this information, the second axis will define and compare various silvicultural treatments. Some of these treatments will be implemented from an operational point of view. Finally, the third axis will transpose the results of the first two at the landscape level so as to integrate the spatial distribution of stands and silvicultural treatments in terms of forestry operations. This will make it possible to evaluate the impact of the proposed silviculture on ecosystem processes acting at the landscape scale.

DOCUMENTING THE ECOLOGICAL EFFECTS OF NEW SILVICULTURAL SYSTEMS IN MAINE'S ACADIAN FOREST

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The Forest Ecosystem Research Program (FERP) was initiated in 1993 on the Penobscot Experiment Forest in Bradley, ME. Using current information about natural disturbance regimes in the Acadian Ecoregion, an expanding-gap silvicultural system with permanent reserve trees was developed. Based loosely on the German "Femelschlag" system, the treatment prescriptions include: a) 20% canopy removal on a 10-year cutting cycle (creating 0.2 ha openings) with 10% of the basal area remaining in permanent reserve trees, and b) 10% canopy removal level on a 10-year cutting cycle (creating 0.1 ha openings) with 30% of the basal area remaining in permanent reserve trees. Changes in baseline data, including measurements of overstory trees, tree regeneration, understory vegetation, snags and downed woody material, are being monitored on a periodic basis. The large size of FERP plots has been designed to facilitate interdisciplinary investigations and include projects: 1) establishing the relationship between light intensity and the diversity of herbaceous vegetation in harvest and natural gaps; 2) determining the influence of natural and harvest gaps on forest amphibians; 3) describing the influence of both gaps and DWD distribution on forest insects, specifically parasitic wasps and click beetles; 4) quantifying the nutrient content of DWD; and 5) modeling the effects of harvesting on vertical and horizontal forest structure.

LARGE AREA COMPARISONS OF FOREST MANAGEMENT PRACTICES (1951– PRESENT)

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Species composition, tree quality, and growth and yield were the primary response variables of interest when this study was established in 1951 on the Fernow Experimental Forest in West Virginia. Silvicultural treatments include single-tree selection, diameter-limit harvesting, patch cutting, and unmanaged reference areas replicated on three northern red oak site index classes (24, 21, and 18) on 280 ha. To date, designated treatments have included nearly 70 individual timber harvests totaling approximately 98,000 m^3 (7 MMBF) conducted by a Forest Service logging crew. The successful bid for the 712 MBF scheduled for harvest in FY 2005 was over $500,000. In addition to the original objectives, portions of the study have been used to evaluate epicormic branching, logging safety, aesthetics, forest hydrology, water quality, forest operations, economics, tree grade, regeneration, cull management, gap dynamics, and woody and herbaceous species diversity, and most recently, management implications of two endangered species. The study area virtually surrounds a winter hibernacula of the federally endangered Indiana bat and is the site of the second largest known population of the federally endangered running buffalo clover. Numerous scientists spanning three generations have been responsible for about 60 publications emanating from aspects of the overall study. Hundreds of camera points were established during the early years and recently thousands of photographs from these camera points have been digitized, providing time lapse imagery spanning four decades of forest management. Environmental Impact Statements, consultations with the U.S. Fish and Wildlife Service, NEPA, Monongahela National Forest Planning documents, incidental take permits, and state required BMPs are all part of the increasing administrative requirements that must be addressed to continue this study that did not exist when the study was initiated. This study provides an outstanding example of the challenges and benefits of long-term silvicultural research.

USING CALICIOID LICHENS AND FUNGI TO ASSESS ECOLOGICAL CONTINUITY IN THE ACADIAN FOREST

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Using lichens to assess ecological continuity in forest ecosystems was pioneered by Francis Rose in the British Isles. Rose established that oak woodlands in Britain, which have retained some degree of long-term ecological continuity, support significant lichen assemblages, which are absent or poorly represented in woods where disruption to ecological continuity has occurred to a greater or lesser degree. He concluded that these species represent a "relict flora" and developed the concept of their use as "indicator species" for grading woodlands on a scale of increasing or decreasing levels of past disturbance. Reasoning that the methods of Rose could also be used to assess the continuity of forest ecosystems in northeastern North America, old-growth indicator lichens were identified and indices were developed to assess the ecological continuity of northern hardwoods and spruce-fir stands in the Acadian Forest Ecoregion.

Given the wide variety of potential microhabitats that characterize aging forests, and the fact that an analysis of ecological continuity using the methods of Rose is only as valid as species inventories are complete, such investigations are often as daunting as they are time consuming. A more efficient method is suggested in the conclusions of Selva (1994), who showed that, not only do epiphytic lichen floras become richer over time—with older stands harboring more rare species—but the total number of calicioid lichens and fungi collected at a site is, itself, an indicator of continuity. With calicioid taxa found growing in more forest microhabitats than any other group of species, it is argued that an assessment index based on the total number of calicioid species collected at a site provides a more accurate assessment of continuity than an assessment following the methods of Rose. The higher the number of calicioid species collected at a site, the more ancient the site, and vice versa.

Commonly called the "stubble lichens" because of their small size, the calicioid lichens and fungi are an assemblage of saprophytic, parasitic and lichenized fungi that can be distinguished, in part, by their tiny (1-2 mm tall) stipitate apothecia. They colonize a variety of substrates including the bark and lignum of numerous angiosperm and gymnosperm species. Most species show clear substrate preferences, with many of the rarer calicioid species restricted to old-growth and ancient forest sites. Once established—and because dispersal is limited—these ancient forest indicators require ecological continuity of mature trees and a constant supply of substrate in various stages of decomposition to persist.

To date, the ecological continuity of 78 northern hardwoods and spruce-fir stands in the Acadian Forest Ecoregion have been assessed using this calicioid species index, 17 of which are considered ancient forest sites.

FORTY YEARS OF PARTIAL HARVESTING IN MIXED NORTHERN CONIFERS IN MAINE: RESULTS FROM THE PENOBSCOT EXPERIMENTAL FOREST

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A long-term experiment on the Penobscot Experimental Forest in east-central Maine was designed to provide information on the best silvicultural practices for managing stands of mixed northern conifers. We evaluated growth and yield and changes in species composition, quality, and structure during the first 40 years of the experiment (Sendak et al. 2003). Replicated treatments include the selection system, uniform shelterwood, unregulated harvesting, and diameter-limit cutting. We examined results of partial harvests: selection treatments at 5- (S05), 10- (S10), and 20-yr (S20) cutting cycles and fixed (FDL) and modified (MDL) diameter-limit cutting on a 20-year harvest interval.

The selection stands were managed under the *BDq* method, where *B* is residual basal area, *D* is maximum residual DBH, and *q* defines the number of trees in each diameter class. The selection stands had species composition targets and received timber stand improvement. Under FDL, all merchantable trees of desirable species exceeding the diameter limits were removed. Under MDL, trees above more conservative specified limits were sometimes left as a seed source and for wind protection, and high-risk trees of desirable species below the specified limits were harvested to capture mortality. Undesirable species, culls, and all or most desirable trees below minimum diameter limits were retained in both diameter-limit treatments.

Between-treatment differences in net and gross volume growth and treatment yields were not statistically significant, nor were net and gross volume growth for the selection versus diameter-limit cutting. For all treatments, mean annual net growth was 37.2 ft^3/ac and mean volume harvested was 2,454 ft^3/ac. The spruce component increased as a percentage of basal area over the 40-yr period in the selection compartments and MDL but decreased in FDL. Fir increased in FDL, remained about the same in S05 and S20, and decreased in S10 and MDL. Hemlock decreased in S20 and FDL, increased in S05 and MDL, and was unchanged in S10. Growth and regeneration of hemlock is encouraged by relatively light partial harvests and where hemlock stocking was initially high, such as in S05. Hardwoods decreased in S05, remained about the same in S10 and MDL, and increased in S20 and FDL. Volume in cull trees, used as a measure of stand quality, decreased in the selection treatments to about 1 percent of total volume but increased in MDL and FDL to about 12-13 percent of volume.

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ASSESSING CHRISTMAS TREE RESPONSE TO N FERTILIZATION

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Fertilizers are often used in Christmas tree production to increase tree growth and quality. The capacity to detect nutrient deficiencies that constrain tree growth and quality is an important component of an effective Christmas tree management program. Ammonium nitrate (AN) and chicken manure compost (CMC) were applied to five Christmas tree species commonly grown in New York State at 11 sites in the spring of 2003. Foliage was collected the following fall and analyzed for total nitrogen (N) and needle mass. Basal diameter current annual increment (CAI) was used as a response variable. Across all sites, AN treated trees had significant increases in CAI and needle N concentration relative to controls. There was no significant effect of CMC on growth in the first season following fertilization for any of the species. Vector analysis results corresponded with first year growth response approximately 65% of the time. However, there were distinct differences between species with correspondence rates ranging from 83% to 44%. Based on these first year results, it appears that tree response to fertilizer application can potentially be diagnosed with the use of vector analysis. Longer-term response assessment will clarify the overall usefulness of vector analysis in making fertilizer recommendations for Christmas tree production.

LONG-TERM RESEARCH ON THE USFS KANE EXPERIMENTAL FOREST IN NORTHWESTERN PENNSYLVANIA

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The Kane Experimental Forest was established and dedicated to research use in March, 1932. Scientists of that time, led by Ashbel Hough, designed studies to assess the long-term growth and development of mixed hardwood stands just growing back after the heavy industrial revolution logging that had nearly cleared the Allegheny Plateau between 1890 and 1930. In this paper, we will provide an overview of the results of four early studies, including lessons learned for design and implementation of long-term research. We will also provide an overview of more recently installed long-term studies on the Kane Experimental Forest.

One of the early studies focused on what was then called weeding, but we would call cleaning today—a replicated series of treatments in young stands to influence species composition, with full controls. This study has yielded important results about the role of pin cherry in stand development in the Allegheny hardwood forest type (Ristau and Horsley 1999), as well as important information about the response to these early interventions. A second study—or demonstration—examined the response of young stands to different strategies after a 1936 ice storm. A third was designed to provide input to yield tables, and a fourth examined thinning strategies. All of these relied on small treatment plot sizes – around 0.1 acres.

Studies installed in more recent times have used larger treatment plot sizes, ranging from 2.0 acres through 4.9 acres. These include additional studies of thinning strategies including tests of residual density, residual structure, and styles of thinning (crop tree vs. area-wide) (Marquis and Ernst 1991, Nowak 1996, Stout and Nyland 1987), and tests of different silvicultural systems, including even-, two-, and uneven-age systems. Most recently, a 2003 wind event has created opportunities to study recovery from natural disturbance on the Kane Experimental Forest.

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ACADIA RESEARCH FOREST: A LIVING LABORATORY

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The Acadia Research Forest (ARF) is located approximately 25 km (16 miles) east of Fredericton, NB where the main office of the Atlantic Forestry Centre (AFC) is situated. It is the AFC's outdoor forestry facility and it comprises about 9000 ha (22,230 acres) of softwood, hardwood, and mixed forests of both the Grand Lake and Eastern Lowlands ecoregions. Since its establishment in 1933, many different experiments, studies, and projects have been conducted in various research disciplines or themes. The original purpose of the research forest was to research and demonstrate good forest management for greater productivity, sustained yield, and economic benefit (Place 1992). Sustainable forest management has been actively practiced and demonstrated since the founding days of the AFR. In the early 1930s, Canada's Department of the Interior used it for unemployment relief projects and the National Forestry Program to set up and establish long-term silvicultural experiments and demonstrations (Thompson 1955, Place 1992). During the early 1940s, many long-term silvicultural experiments and demonstrations were established by internees of a World War II internment camp that was set up at the ARF by the Department of National Defense. In the 1950s and 1960s, concerns about clearcutting resulted in the establishment of a number of long-term alternative silvicultural studies. Tree improvement experiments were established in the 1960s and 1970s. Since the 1980s, several experiments and studies have been established at the ARF to respond to environmental policy concerns over air pollution, global change, carbon sequestration, and biodiversity. This poster illustrates some of the past and current long-term experiments conducted in the ARF; it supplements the oral presentation.

More information is available at the following website:
http://www.atl.cfs.nrcan.gc.ca/index-e/who-e/role-e/role-e/acadia-e.htm.

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THE COOPERATIVE FORESTRY RESEARCH UNIT: A PARTNERSHIP BETWEEN MAINE'S FOREST MANAGERS AND THE UNIVERSITY OF MAINE SINCE 1975

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Maine's large forest landowners have long recognized the need to support a strong research effort as part of their managing Maine's forests. In 1975, a small group of visionary forest industry leaders and representatives of the University of Maine formed the Cooperative Forestry Research Unit (CFRU). It is now one of the oldest industry/university forest research cooperatives in the United States, and continues to serve as a model of joint leadership and cooperation between Maine's largest industry and the University of Maine.

The CFRU is composed of about 24 private and public forestland management organizations from across the state that guide and support research on key forest management issues facing Maine's forest landowners and managers (www.umaine.edu/cfru/). The mission of the CFRU is to *"conduct applied scientific research that contributes to the sustainable management of Maine's forests for desired products, services, and conditions."* The CFRU has been generously supported for 29 years through the voluntary financial and in-kind contributions of its members.

During that time, the CFRU has researched and solved a number of crucial issues facing Maine's forest managers. In recent years, the CFRU also has become the primary research and development effort supporting third-party forest certification in the state. CFRU research has had two primary objectives: 1) develop information and tools to improve the efficiency and productivity of forest management and 2) provide science-based information about the ecological effects of forestry practices.

Research focusing on the ecological effects of forestry practices has allowed the CFRU to provide scientific information that has been instrumental in helping the forest industry meet the requirements of certification by the Sustainable Forestry Initiative and Forest Stewardship Council. In addition, this research has provided key information for policy makers addressing a number of important forestry issues in Maine and elsewhere. Current CFRU research continues this tradition with a focus on improving silviculture in the Maine forest and improving our understanding about the influence of forest management on wildlife habitat and conservation of biodiversity.

In addition, CFRU-sponsored research on the University of Maine campus has provided scores of undergraduate students, graduate students, and faculty in forestry and wildlife with the opportunity to learn about and help solve some of the most important problems facing forest managers in the state. This investment has provided a wealth of expertise that has been drawn upon by forestry organizations, government agencies, and the public when information and advice was needed about key sustainable forestry issues. The CFRU has had a positive and lasting influence on the forestry culture at the University of Maine by providing a direct link between the university and the people managing Maine's forest land.

INFLUENCE OF SILVICULTURAL INTENSITY AND COMPOSITIONAL OBJECTIVES ON THE PRODUCTIVITY OF REGENERATING FOREST STANDS IN MAINE

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Millions of acres of northern Maine's Acadian forest are in a relatively young condition following clearcut harvesting. Although natural hardwood and softwood regeneration can be abundant, the species composition of this regeneration is often not what landowner's desire. Tremendous opportunity exists to improve the composition, quality, and growth rates of these stands while they are in an early successional stage. Many landowners question whether it is better to start over, or to work with what is there and make the best of it?

The intensity of silvicultural treatments and compositional objectives set by forest managers largely determine the long-term outcome of stand development. Silvicultural intensity is determined by the degree of investment in vegetation management, artificial regeneration, and thinning. Compositional objectives determine whether particular species of conifers, hardwoods, or a mixture of conifer and hardwood species are desired in the final stand.

In 2004, we established a long-term study on the Penobscot Experimental Forest near Bradley, Maine that seeks to: (1) quantify the growth and development of early successional stands to varying intensities of silvicultural intervention and compositional objectives, (2) document ecophysiological mechanisms affecting the dynamics and productivity of young forest stands, and (3) compare the energy requirements and financial returns associated with early intervention in young stands.

The study site is an 8-yr-old naturally regenerated stand of aspen and red maple with an understory of balsam fir and red spruce. A 3 x 3 factorial design plus an untreated control (10 treatments) is being used. The treatments include three levels of silvicultural intensity (low, medium, high) and three compositional objectives (conifer, mixedwood, hardwood). Levels of silvicultural intensity are defined by the degree of control over (1) species colonization (tree planting), (2) relative species performance (control of competing vegetation), and (3) spacing among desired trees (thinning). A stratified, random experimental design with 4 replications is being used. Treatment plots are 30 m x 30 m (0.09 ha) in size and include a nested 20 m x 20 m (0.04 ha) measurement plot. Tree species planted in the medium and high intensity treatments include improved white spruce and four clones of hybrid poplar (D51, DN10, DN71, and NM4).

All crop trees (natural and planted) were selected or planted in summer 2004. The initial height, diameter, crown length and radius, and health condition of all trees also were measured. The amount of energy input from human labor, petroleum, and herbicides needed to establish the 10 treatments also were recorded.

INFLUENCE OF DISTURBANCE ON INGROWTH IN HARDWOOD FORESTS: THE OLD-SERIES PLOTS – 1927-1997

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The four Old-Series plots track 70 years of succession in unmanaged central Connecticut hardwood forests (Ward and others 1999). These plots have experienced three distinct disturbance regimes. Thus, the long-term impact of different disturbance regimes on ingrowth (forest regeneration) could be examined. Three plots had several episodes of moderate to severe defoliation (>25%): 1961-63, 1971-1972, and 1981. By contrast, moderate to severe defoliations at the fourth plot were limited to single year episodes: 1964, 1972, and 1981. A summer wildfire burned approximately 40% of the fourth plot in 1932. The burned area was inventoried in 1934. Areas adjacent to roads, trails, and other human disturbance were excluded from this analysis.

Study plots were established in 1926-27. All trees with a diameter of at least 0.5 inch have been mapped and measured at 10-year intervals, except during the 1940s, using 16.5-foot-wide strips through the forests. We now have records on 43,357 stems distributed on nearly 60 tree and shrub species. Soil drainage classes were classified according to the Soil Survey Manual. This analysis examined trees on very poorly soils and poorly drained soils (1.8 acres). Ingrowth is reported as stems/acre/decade (SA^{10}). Only the ingrowth of species capable of reaching the upper canopy in a mature forest is reported.

Ingrowth on the plot that had minor disturbance (single-year defoliations) has steadily decreased from 99 SA^{10} between 1927-37 to only 26 SA^{10} between 1987-97. Maple has been the predominant ingrowth species – accounting for 38% of stems. Oak ingrowth (<3 SA^{10})has been negligible since 1957. By contrast, ingrowth increased markedly on the plots that experienced multi-year defoliation episodes. Ingrowth rose from 52 SA^{10} between 1957-67 to 240 SA^{10} between 1967-87. Birch has accounted for 59% of stems during this twenty-year period. The wildfire on these moist sites was not as hot as on adjacent drier soils. Nevertheless, one third of all stems were top-killed by the fire. A dramatic increase of ingrowth, 288 SA^{10}, was noted during the 1957 inventory. Nearly 30% of the new stems were oak. The pulse of ingrowth has subsequently subsided and only 26 SA^{10} were observed between 1987-97.

These distinct disturbance regimes have resulted in real differences in species composition. In 1997, maple accounted for 50% of all stems on the lightly defoliated plots. Birch was the most common species on the multi-year defoliation plots, 52% of all stems, while oak accounted for <4% of stems. More than 14% of stems on the burned plot were oak.

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Ward, J.S., Anagnostakis, S.L.; Ferrandino, F.J. 1999. **Seventy years of stand dynamics in Connecticut hardwood forests - the Old-Series plots (1927-1997).** The Connecticut Agricultural Experiment Station Bulletin 959. 68p. http://www.caes.state.ct.us/Bulletins/1990s/1999/b959.pdf

ELEMENTARY SILVICULTURE: PRESENTING FOREST SCIENCE TO CHILDREN THROUGH THE NSF'S GK-12 FELLOWSHIP

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The National Science Foundation's GK-12 Fellowship Program provides a link between science education at the graduate and primary/secondary school levels. The program grants 12 fellowships to University of Maine graduate students in a variety of science or math departments. Fellows each work with three or four local teachers in grades 3-12 to design and implement demonstrations, laboratory projects, and field trips. Fellows use their areas of expertise to demonstrate the scientific method, the use of specialized equipment, and the fun and excitement of science.

This program, and others like it (there are 73 similar programs at other universities in the U.S.), provide an excellent opportunity for forestry education. The future of Maine's forests depends on an informed and scientifically literate public. As an NSF fellow, I will be able to work with schoolchildren to create an awareness of the importance and complexity of forest ecosystems. I plan to accomplish this by focusing on four main themes throughout the school year: diversity, growth, competition and change. I hope that my participation in this program will both facilitate science education and inspire young students to pursue careers in science.

EFFECT OF HARVEST INTENSITY ON SOIL PHYSICAL PROPERTIES AND SITE PRODUCTIVITY IN RIPARIAN MIXEDWOOD FORESTS

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Networks of perennial and intermittent streams and rivers cross Maine's private and public forest land. Among the functions provided by these riparian forests, water quality has received considerable attention. Impacts of harvesting practices are an important concern and stringent water quality standards have been established. Preserving riparian forests is an essential part of compliance with those standards. However, changes in riparian function associated with various harvest intensities are poorly understood.

Our objectives include (1) determining impacts of varying harvest intensities on soil physical properties, forest structure, and site productivity in riparian mixed-wood forests, and (2) relating terrestrial impacts of harvesting to observed in-stream changes. We propose to meet these objectives through a study of harvest blocks of varying intensities (from clearcut to no cut) along forested streams in Maine.

This project will complement an ongoing Agenda 2020 study of harvest intensity, soil productivity, and growth response (Reinmann et al. 2004), as well as headwater streams research conducted by the Manomet Center for Conservation Sciences (Wilkerson et al. 2004). We anticipate that this research will facilitate the identification of key associations within the aquatic-terrestrial interface in landscapes managed for timber production. This information will provide the basis for assessing the sustainability of managed mixed-wood riparian ecosystems, and for developing and improving management guidelines.

Literature Cited

Reinmann, A.; Kenefic, L.; Fernandez, I.; Shortle, W. 2004. **Preliminary results from a retrospective study of harvest intensity, site productivity, and red spruce growth.** In: Ward, J.; Twery, M., eds. Forestry across borders: proceedings of the 84th winter meeting of the New England Society of American Foresters. Gen Tech. Rep. NE-314. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station: 28-29.

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LASTING EFFECTS OF HURRICANE DISTURBANCE ON LONG-TERM FOREST DEVELOPMENT AT THE HARVARD FOREST

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Central to the Harvard Forest research mission is examination of natural disturbance and anthropogenic stress. Hurricane blowdown is a major natural disturbance process in New England, and has been studied at Harvard Forest through large-scale manipulation, historical reconstruction and modeling. Permanent plot data allow us to expand our understanding of long-term hurricane effects on forest dynamics; here, we use permanent plot data to illustrate the persistent effects of hurricane damage 30-60 years after the great hurricane of 1938. A 7-acre hardwood forest plot was established in 1969 at Harvard Forest. All living and dead trees were censused in 1969, 1975, 1987-92 and 2001. Based on distribution of windthrown stems and damage boundaries delineated immediately after the 1938 hurricane, the site was divided into severe (91-100% damage, 0.7 acres), moderate (51-75% damage, 2.2 acres) and low (11-25% damage, 4.2 acres) damage areas.

Intensity of hurricane damage continues to shape forest development, 30-60 years after the initial disturbance event. Stand development in the severely damaged area lagged about 30 years behind the low and moderately damaged areas. There were also marked differences in species composition between the severely damaged area versus the less-damaged areas. Red oak dominated basal area in the low and moderately damaged areas, whereas red maple, birch species and white pine were collectively more important in the severely damaged area. The different areas did not converge over time; black and yellow birches became more important in the severe area over time, whereas a growing number of later-successional species (beech, hemlock and sugar maple) recruited into the low and moderate areas. This case study shows that forest recovery following hurricane disturbance is a gradual process extending beyond the timeframe of most studies and allows for a better understanding of the long-term role of hurricane disturbance in the New England landscape.

LONG-TERM STUDY OF A PINE – OAK FOREST ECOSYSTEM: HOLT RESEARCH FOREST

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The Holt Research Forest (HRF) was established in 1983 on a 120 ha (300-acre) parcel in Arrowsic in mid-coastal Maine. A 40-ha study area was established with half to be used as an experimental area and the other as a reserve. Research and management protocols were established by Hunter and Kimball for two broad goals to direct the activities at HRF. One is research based: undertake long-term research to understand the structure and dynamics of an oak-pine forest ecosystem. The other is management based: develop a demonstration forest where state-of-the-art multiple use management techniques can be presented to the public. Long-term baseline data has been collected on many components of the forest including woody and herbaceous vegetation, birds, mammals, salamanders, seed and fruit production, and soils.

The study area is bisected by the property line of two old farms and the current condition of the vegetation has been significantly influenced by the past land use. The northern farm was abandoned in the 1930s and the forest canopy is dominated by white pine, while the southern half has longer history as a woodlot and is more mixed. Several forest floor species of plants show distributions that are linked to the land use history as well. The importance of land use history in determining the present biodiversity of a parcel should not be underestimated.

A group-selection harvest in 1987/1988 in 10 ha of the experiment area resulted in removal of 42% of the basal area and created canopy gaps ranging in size from 25 to 3000 m^2. This harvest provided the opportunity to measure the impacts of the harvest on growth rates of adjacent trees, tree regeneration, understory plants, birds, small mammals, salamanders and a host of other components. The direct impacts of the harvest resulted in some significant changes in plant species composition and created fluctuations in bird species composition and abundance. Changes on the overall structure of the forest as a result of this low-impact harvest have been minimal.

Overall, the study has shown the importance of long-term studies for giving us a better understanding of the temporal changes in populations. The relative stability of some populations becomes more apparent while other species populations are cyclic and others seemingly fluctuate randomly. Understand these populations, in relationship to forest harvesting, has become of critical importance as we incorporate ecological integrity into our management systems.

TREE REGENERATION AT HOLT RESEARCH FOREST: IMPACTS OF RED MAPLE REMOVAL AND WHITE-TAILED DEER BROWSING

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Tree regeneration was measured at Holt Research Forest in 1997 and 2002 to assess the response to a group-selection harvest in 1987/1988. Circular 25m^2 (0.006 acre) plots were located in canopy openings of three types (harvest gaps, ledge gaps, and tree-fall gaps) and in control areas with intact canopy. All trees >0.5m in height and less than 9.5cm DBH were tallied by species and damage by deer browse or white pine weevil were evaluated. Data was used to assess the differences between gap types and intact canopy, the changes in densities between sampling period, the effectiveness of a 2001 removal of red maple stump sprouts, and damage affecting the development of the regeneration.

In all gap types, white pine was the dominant species with densities of 780 to 2000 stems/ha. Yellow birch densities were high in harvest gaps (1800 stems/ha) but low in ledge gaps and nonexistent in tree-fall gaps. Balsam fir (986 and 795 stems/ha) and white pine (679 and 826 stems/ha) were the dominant species in intact forest. Red maple densities were high in all locations except ledge gaps and seed generated and stump sprouts were of equal density in 1997 in the harvest gaps.

In the harvest gaps, all hardwood species, except witch hazel, declined while white pine, red spruce, balsam fir, and hemlock all increased. The combination of a TSI and natural mortality resulted in a 69% reduction in red maple density. Our objectives were to reduce the red maple component to allow other species a chance to become established. No detectable response attributable to the TSI was expected in the first year. Densities remained relatively stable in other gap types and the intact canopy with no dramatic changes except decreases in red oak in tree-fall gaps and intact forest.

Noticeable damage due to white pine weevil was present in 4% of stems in 1997 and 27% in 2002, as the white pine ages it becomes more susceptible. Damage due to deer browse was detected in over 60% of red and white oak stems while in other hardwoods the rates were 3% or less in 1997. In 2002, these numbers remained about the same for oaks while deer increased their browsing on other hardwood species significantly. As red and white oak densities were reduced from 1997 to 2002, most likely because of browsing induced mortality, deer were forced to rely more heavily on other species. Deer populations have been shown to be steadily increasing over the last 10 years so these impacts will continue and the difficulty of establishing oaks will likely become more problematic as has been the experience in areas south of Maine.

Kenefic, Laura S.; Twery, Mark J., eds. 2005. **Changing Forests – Challenging Times: Proceedings of the New England Society of American Foresters 85th Winter Meeting.** Gen. Tech. Rep. NE-325. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 85 p.

Contains abstracts from 32 oral presentations and 53 posters presentations at the 85th annual winter meeting of the New England Society of American Foresters, in Portland, Maine, March 16-18, 2005.

Key words: forestry; sustainability; tree growth; New England; vegetation dynamics; silviculture; forest health.



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