Eastern CANUSA Forest Science Conference 2018

9TH BI-ANNUAL
EASTERN CANADA – USA FOREST SCIENCE CONFERENCE

OCTOBER 18-20, 2018

UNIVERSITY OF NEW BRUNSWICK

FREDERICTON, NEW BRUNSWICK

ABSTRACTS

HARDWOOD CROP TREE RELEASE: MODELING A SPATIALLY HETEROGENEOUS TREATMENT WITH OSM, A NON SPATIALLY EXPLICIT TREE LIST MODEL

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Harvesting practices in hardwood stands of eastern Canada generate thousands of hectares dominated by non-commercial and low-value species with a low stocking of desired species. Releasing just the minimum number of crop trees to capture the stand's growing space at maturity, leaving non-interfering trees, may constitute a low-cost opportunity to restore the vocation of these stands for the production of desired species while maintaining non crop trees for other management objectives. Modelling the outcomes of crop tree release requires some acknowledgement of the heterogeneity of the release. This is not readily possible with commonly used growth and yield models which model average stand conditions. To acknowledge this heterogeneity, we present a two-step modeling approach where tree lists initializing simulations are separated into crop trees and non crop trees for the time where crop trees are assumed to be free to grow. The two-step approach was applied to a case study stand at the sapling stage from New Brunswick, Canada, tested with different lengths of free-to-grow periods and compared to the conventional modelling approach and to the conventional area-based pre-commercial spacing thinning. Simulation results show that the traditional modelling approach is not sensitive to CTR treatment effects. The two-step approach allows to easily induce a CTR effect without having to use a spatially-explicit growth model. However, the outcomes of the two-step approach are sensitive to the duration of separate modelling of crop trees and non-crop trees. Future validation will inform on the proper duration to use in simulations. Despite expected advantages of CTR, wide-scale adoption of this new silvicultural treatment is dependent on our ability to properly recognize the response in growth and yield models.

OLIVE-SIDED FLYCATCHERS (*Contopus cooperi*) IN FORESTED WETLANDS OF NB: ECOLOGICAL TRAPS AND THE ROLE OF HABITAT AVAILABILITY

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Ecological traps occur when a low-quality habitat is selected over available high-quality habitat, which results in negative fitness. This phenomenon typically results in a population sink and can occur when sudden changes to the environment disrupt cues individuals use that would otherwise allow them to reliably assess suitable habitat. Olive-sided Flycatcher (*Contopus cooperi*) is an aerial insectivore with a history of occupying ecological traps. Aerial insectivores are experiencing some of the steepest population declines among birds of North America. Olive-sided Flycatchers preferentially breed and forage in open forests, often near waterbodies. Within these sites, tall snags or trees are important for foraging and defending territory. Harvested sites provide adequate substrate for perching and nesting, although such sites are often ecological traps as they lack other requirements to maintain positive fitness. New Brunswick is an ideal location to study the effects of ecological traps on Olive-sided Flycatcher as harvested sites and natural patches are abundant. We will examine the degree to which habitat type acts as an ecological trap for Olive-sided Flycatchers in New Brunswick. A total of 15 habitat types in which Olive-sided Flycatchers have occupied are included. We will compare the diet, nest success, and time spent in a territory of 25 individuals in 48 sites (14 harvest sites, 34 natural patches). Overall, 96 invertebrate samples will determine the availability of a high-quality diet for 14 Olive-sided Flycatcher breeding sites. The presence of preferred food items and increased nest success are indicators of a high-quality habitat. Ultimately, we can estimate the role of habitat quality on Olive-sided Flycatcher population declines in New Brunswick.

SUSCEPTIBILITY OF SEEDLINGS TO MAMMALIAN HERBIVORES: CONSIDERING THE NUTRITIONAL VALUE AND DEFENCE COMPOUNDS OF PLANTS

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Mammalian herbivores, such as deer and hare (Cervidae and Leporidae), can negatively impact the growth and survival of tree seedlings, and can thus impede the regeneration of less resistant species in North America. Herbivore selection of plants is known to be influenced by plant nutritional value and traits that determine resistance (e.g., defense compounds). These chemical traits could be exploited to alleviate browsing pressure. For example, chemical analyses could be used to predict the potential resistance of planted seedlings. Our objectives are: 1) to determine which compounds are most consistently associated with plant resistance to cervids and leporids; 2) to evaluate the resistance potential of eight species (five conifer, three broad-leaved) translocated in an assisted migration study (Québec, Canada). For each species, three provenances were selected that represent current, mid-century (2050) and late-century (2080) climate projections.

To answer our first objective, we performed a systematic review of articles that evaluated the effects of defense compounds on herbivore plant selection. Our search uncovered 134 articles concerning this subject, 97 articles for cervids, 34 articles for leporids and four articles for both types of herbivores. Counter to expectations, our review found that tannin content was not a strong determinant of plant resistance. In contrast, we found evidence that resistance should rather be measured by the low-weight phenol and terpene content, ideally with measures of nutritional value (e.g. protein content).

For our second objective, we are reviewing the literature to determine the known chemical composition of the eight species. This search already highlighted the presence of geographical variation in defense compounds composition and concentration, for example, in terpene concentration within a species. Geographical variation in defense compounds could results in variable resistance potential for the three provenances in the assisted migration study. This hypothesis will be tested with chemical analyses for the 24 species-provenance combination in Fall 2018. Our results will help managers and researchers to design future studies on susceptibility to herbivores, but will also provide recommendations for species and provenances to favor when browsing is an issue.

WOULD COMMUNITY FORESTRY OR CO-MANAGEMENT HELP TO BRIDGE THE GAP BETWEEN INDIGENOUS INTERESTS AND INDUSTRY PRACTICES IN NEW BRUNSWICK?

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This research explores the relationship between the forest industry, and indigenous communities through the lens of community forestry and co-management. Specifically, the differences between indigenous-involved community forestry and co-management agreements with forest industry, and the associated consultation arrangements. While many provinces have consultation measures, Indigenous communities often find those carried out by the government and private industry to be unsatisfactory. This can be the result of Indigenous communities lacking forestry personnel to engage in these collaborations, or a lack of industry personnel capable of interacting effectively with Indigenous communities.

To remedy this many Indigenous communities across Canada have entered into co-management agreements, but this relationship has been unsatisfactory. These relationships have been unsatisfactory as it lacks Indigenous traditional ecological knowledge. This research will focus on bridging this gap by incorporating indigenous involvement in forestry in New Brunswick. Specifically exploring the importance of indigenous involvement in the forest industry by pursuing three goals: (1) to determine whether Indigenous community forestry or co-management agreements lead to better collaboration; (2) to evaluate the success of Indigenous community forestry across Canada; and (3) to provide insight for consultation practices and how Indigenous interests can be better integrated into forestry in New Brunswick.

The research will be completed through semi-structured interviews with 50 individuals. Individuals will be drawn from interest groups including academics working with Indigenous groups in a forestry setting, government or industry forestry workers, and Indigenous people in New Brunswick.

Results will provide insight for the forest industry and government about the importance of Indigenous community involvement in provincial forestry and build on knowledge on the inclusion of Indigenous forestry practices across Canada.

QUANTIFICATION OF FOREST CANOPY CHANGES CAUSED BY SPRUCE BUDWORM DEFOLIATION USING DIGITAL HEMISPHERICAL IMAGERY

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Effectively managing spruce-fir volume losses and tree mortality caused by spruce budworm (*Choristoneura fumiferana* Clem.) outbreaks requires current and reliable defoliation assessments of infested stands. Acquired defoliation information integrated into the spruce budworm decision support system and defoliation-based growth models enables forest managers to better develop forest protection strategies (e.g. aerial spraying of insecticide) and forecast stand responses. Current within-stand/tree-level branch and ocular defoliation assessment methods often used for calibrating aerial defoliation surveys are known to be labour-intensive and associated with a level of uncertainty. Our study investigated an alternative method utilizing digital hemispherical images of the forest canopy collected before and after defoliation quantifying the annual canopy foliage changes caused by spruce budworm defoliation for 75 plots in Gaspé Peninsula, Quebec. Gradient Boosting Machine analysis identified gap fraction change from May-October, gap fraction after defoliation, insecticide spraying, and % balsam fir (*Abies balsamea* (L.) Mill.) basal area as important explanatory variables of annual defoliation. Logistic Generalized Linear Model (GLM) and Random Forests (RF) models were trained on a random two-thirds of sample plots combining both years, and defoliation predictions were validated on the remaining one-third of plots. RF predictions consistently resulted in slightly higher correlations and lower root mean squared errors (RMSEs) than GLM predictions. Defoliation models including insecticide spraying, gap fraction change May-October, and % balsam fir basal area had RMSEs of 14–22%, whereas models excluding insecticide spraying had higher RMSEs of 18–24%. Model goodness-of-fit using two-sample Kolmogorov-Smirnov tests indicated that predicted and measured annual defoliation had similar distributions, with the exception of GLM and RF models excluding spray compared to measured ocular defoliation. Use of digital hemispherical images to quantify gap fraction change is a feasible, non-destructive, and objective method to assess canopy foliage changes caused by spruce budworm defoliation.

BOREAL FORESTS OF EASTERN CANADA: BENEFICIAL EFFECTS OF CLIMATE WARMING ON GROWTH MAY BE TRANSITORY

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Predicted increases in temperature and aridity across the boreal forest region have the potential to alter timber supply and carbon (C) sequestration. Given the high degree of inter- and intra-specific variation in climate sensitivity of boreal species to recent warming, there is an urgent need to develop species-specific predictive frameworks that account for local conditions. Here, we matched the growth of 270,000 trees across a 761,100 km² region with detailed site-level data to quantify the growth responses of the seven most common boreal tree species in Eastern Canada to changes in climate. Applying growth models to trees within the boreal region, we show that conifer growth is mostly limited by water scarcity in southern regions but constrained by excessive water in northern regions. In contrast, broadleaf tree growth is largely insensitive to climate. Our growth models indicate that in the absence of disturbance, overall forest productivity could increase by 13±3% with warming up to 2°C. Additional warming (3-4°C above ambient) could cancel this gain and lead to substantial declines reaching 12±3% under 5% reduced precipitation. Our results confirm the transitory nature of warming-induced growth benefits in the boreal forest and highlight the vulnerability of the ecosystem to excess warming and drying.

EFFECTS OF STAND HETEROGENEITY ON WIND LOADS IN A BALSAM FIR (*Abies balsamea*) STAND (POSTER)

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Windthrow is a common phenomenon in forestry. Wind and snow damage to stands can cause significant economic losses, affecting timber yield or access to forest plots. The major climate changes to come are likely to increase the occurrence of violent wind events and windthrows, making it important to improve our ability to estimate windthrow risk. At the same time, forest management is evolving to include practices that are more diverse. The purpose of this doctoral project is to model the risks of windthrow in complex stands, by addressing the problem at the individual tree scale.

Tree response to wind loading is a function of local competition from commercial-sized trees, sudden changes in competition following thinning or windfall events, and strong seasonal climatic variations. The main objective of this project is to quantify the impact of thinning on wind load on residual trees. The objectives derived from this project are to measure the effect of stand heterogeneity on wind load distribution at the individual tree level; to measure the impact of boreal climate on wind load distribution at the individual tree level; and to measure the immediate effect of partial cutting on the observed relationships.

Experimentation and stand: The study takes place in the Montmorency Forest, in a young heterogeneous balsam fir (*Abies balsamea*) stand originating from natural regeneration. Two anemometers record wind speed and direction around our stand to define a wind profile. The trees studied are equipped with strain gauges to measure trunk deformation during wind events. A calibration will make it possible to convert these measurements into applied load. To measure seasonal climatic variation, a set of four thermal sensors allows us to measure a temperature gradient from the top of the canopy to the roots of the trees, and two cameras allow us to evaluate the snow level on the ground and on the tree crowns.

SPATIAL TEMPORAL DYNAMICS OF POPULATIONS IN DISTURBED FORESTED LANDSCAPES

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Effective conservation and sustainable forest management requires planning and management at the landscape scale. Many species may use habitat patches that are widespread, and individuals move among different habitat patches creating a metapopulation in which multiple local populations in individual habitat patches are linked by dispersal. Forestry is a disturbance on the landscape, and an objective sustainable forest management is for forestry to mimic natural disturbances such that local disturbances do not have serious negative metapopulation consequences. When individual patches are disturbed there is an immediate impact on a local population, because individuals move among different habitat patches the local effect may be masked by immigration, or there may be broader metapopulation consequences as individuals no longer emigrate from that patch. In this context, conservation and sustainable forest management aim to limit local impacts, and when local impact occur ensure there are no serious metapopulation consequences.

Using spatially explicit population models I show that at the landscape scale, the location of the disturbance within the habitat network can determine the overall impact on metapopulation persistence. In the case of ecological traps, when there is a mismatch between environmental cues and habitat quality the consequences of disturbance can be greater than disturbance alone. Observed effects vary among types of habitat networks, with larger effects in dendritic networks (stream) than random networks (wetlands). Within a habitat network the location of the disturbance is also important, disturbances in peripheral populations have large local effect but small metapopulation effects, whereas disturbances in the centre of networks have small local and large metapopulation consequences. Empirical data from experimental wetlands is used to demonstrate how measured effects on individuals can be use to predict metapopulation consequences to validate the model.

Incorporating the spatial temporal habitat needs of species into forest management is critical for sustainable forest management as it provides a tool whereby managers can explicitly consider conservation goals in addition to existing targets.

INDIVIDUAL TREE SPECIES IDENTIFICATION USING LOW AND MID-DENSITY AIRBORNE LASER SCANNING (POSTER)

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The purpose of this study is to investigate the degree to which LiDAR pulse density affects species classification at the individual tree level. Thirteen tree species typical of the Acadian Forest Region of Canada, are being investigated to determine: 1) individual tree species prediction accuracy using discrete airborne LiDAR acquired at an average of 1 pulse per m^2 and 6 pulses per m^2, 2) the variability of prediction accuracy by species, genus and hardwood/softwood groups, and size classes, and 3) the most important features (variables from a Random Forests model) used for classifying individual tree species at 1 pulse per m^2 and 6 pulses per m^2 discrete return LiDAR. Species knowledge is an essential part of having an accurate inventory (current and future) of the forest resource. In addition to its economic importance, species distribution is an important factor for climate change, forest health, and ecological integrity. A greater understanding of species classification on the landscape will result in improved land use planning. Tree crowns were delineated using SEGMA® software followed by training and classification using a Random Forests model. Individual tree predictions will be summarized at the conifer/deciduous, genus and species levels for 1 pulse per m^2 and 6 pulses per m^2 LiDAR datasets.

AN ANALYSIS OF FACTORS AFFECTING SATISFACTION LEVELS OF DEER HUNTERS IN NEW BRUNSWICK

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Hunting is a popular activity in New Brunswick, providing many social and economic benefits, but the number of active deer hunters has declined over the last 30 years. We surveyed 401 hunters across the province to gather information about motivations for hunting and attitudes regarding management of hunting seasons and wildlife habitat and to assess hunter satisfaction with hunting. Hunters self-registered to participate in our survey with on-line, postal and telephone options. Focusing on the 345 deer hunters within this sample, we used factor and regression analysis to determine the importance of key elements that are likely to influence hunter satisfaction such as wildlife and habitat management, access to hunting territory or years of hunting experience. A better understanding of hunters' motivations and satisfaction can assist government agencies to refine hunting and wildlife management policies, help forest managers to improve practices and assist hunting associations to better understand the interest of hunters.

EVALUATION AND IMPROVEMENT OF TRAPPING FOR THE INVASIVE BEECH LEAF MINING WEEVIL, *Orchestes fagi* L., IN NOVA SCOTIA, CANADA

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The invasive beech leaf mining weevil, *Orchestes fagi* L. (Coleoptera:Curculionidae), is a common pest of beech trees in Europe that has recently established in Nova Scotia, Canada. Adults overwinter and emerge in early spring to feed on and lay eggs in beech leaves. Developing larvae mine beech leaves and cause significant defoliation when populations are high. Successive years of heavy defoliation by the weevil is killing native American beech trees (*Fagus grandifolia*) in Nova Scotia and the weevil is spreading rapidly. One of our main objectives is to develop survey tools to monitor the weevil's spread and detect new infestations as early as possible. By using bioassays, field trapping experiments, and electroretinograms, we will analyze the response of *O. fagi* to auditory, chemical, and visual stimuli to develop a multimodal survey tool. Results from field trapping trials in 2017 suggest that trap color and trap design significantly affected mean catch and trap height slightly affected mean catch. Overall, it was found that yellow sticky prism traps placed in the upper canopy of beech trees performed the best. 2018 field trials will explore interactions between trap color and beech leaf volatiles.

MANAGING NORTHERN CONIFER FORESTS FOR CHANGING OBJECTIVES

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In the past century, northern conifer forest management approaches and objectives have shifted frequently due to changing market conditions. Yet adapting long-range silvicultural practices to current markets can be like trying to hit a moving target. In addition, with growing value placed on non-timber products, foresters and landowners today consider additional outcomes above and beyond product value when comparing different kinds of management. This work uses data from a long-term U.S. Forest Service study (1950 to present) at the Penobscot Experimental Forest in central Maine, USA, where even- and uneven-aged silviculture and exploitative harvesting practices have been applied for more than 65 years. We examined effects of management on stand composition, structure, volume, past revenue, and current stumpage. Outcomes in terms of composition and financial return were assessed relative to the original treatment objectives, and in light of changing markets for species and forest products over time. Results suggested that while some treatments achieved desired objectives, changes in markets and growing awareness of ecological values (e.g. retention of large trees) affects contemporary assessment of their desirability. Changes in absolute and relative species values, for example increases in price for red maple pulp over the study period, negatively affected outcomes of treatments aimed at excluding hardwoods in favor of softwood pulp production. In addition, silvicultural treatments which included complete overstory removal or used risk of mortality to prioritize partial removals provided less desirable habitat for species requiring large trees and deadwood. These findings underscore that we must consider outcomes beyond short-term timber or pulp production, and may change how we interpret structural and compositional results.

DISTANCE OF CLEARCUT EDGE INFLUENCE FOR EPIPHYTIC CYANOLICHENS IN OLD, WET, MIXEDWOOD FORESTS OF NOVA SCOTIA: YEAR 1 OF THE L-ACER FIELD STUDY

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Old growth forested wetlands of Nova Scotia's Atlantic Coastal Plain are globally important hotspots of biodiversity, particularly for epiphytic cyanolichens. Several species are exceptionally rare or declining to the extent of warranting protection by both the Canadian federal government and the Province of Nova Scotia. The reasons for these declines are not entirely understood, but experts have attributed them (in part) to a combination of ecosystem acidification, due primarily to airborne sulphur pollution, and forest harvesting, which has increasingly targeted such forests for fibre in recent years. We established an 'edge-influence' study, which will (1) determine the minimum safe distance between clearcuts and at-risk lichens, and (2) examine whether this distance changes over a gradient of acidification. We sampled epiphytic cyanolichens in ten old, poorly-drained forest remnants with red maple in the canopy, that were at least 6 ha in size and adjacent to a recent clearcut. Lichens were surveyed on the lower bole of red maple trees in 5 × 50 m plots every 20 m from the forest-clearcut edge to 100 m, and compared with the forest interior at 150 m. Our results provide interim guidance on the minimum distances that should be left to ensure epiphyte community integrity at the stand scale, but require follow-up surveys to test for the possibility of a temporal lag.

LICHENS, ACIDIFICATION, AND CUT EDGE RESPONSE (L-ACER): FILLING THE KNOWLEDGE GAPS FOR EFFECTIVE MANAGEMENT OF AT-RISK LICHENS IN FORESTED WETLANDS (POSTER)

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Old growth forested wetlands of Nova Scotia's Atlantic Coastal Plain are globally important hotspots of biodiversity, particularly for epiphytic cyanolichens. Five species are declining or rare to the point of being classified as endangered, threatened, or of special concern by the Canadian federal government and the Province of Nova Scotia, with others currently being assessed. The reasons for these declines are not entirely understood, but experts have attributed them to a combination of ecosystem acidification (due primarily to airborne sulphur pollution), forest harvesting, which has increasingly targeted marginal or low-value forests in recent years, and increased grazing pressure from invertebrates, such as invasive Arion spp. Over the first two years of the project, we are testing these hypotheses using a combination of natural and manipulative field experiments, laboratory and mesocosm experiments, and modeling exercises. Our results should provide some of the necessary answers to mitigate additional losses of at-risk species in these ecosystems. In the mid-to long-term, our study will provide opportunities to explore the potential benefits of ex-situ conservation methods, facilitated migration or transplantation, and stand-scale remediation.

STAND DEVELOPMENT PREDICTION ACCURACY OF TWO INDIVIDUAL-TREE STATISTICAL GROWTH MODELS FOR THE ACADIAN FOREST REGION: FVS-ACD AND OSM-ACD

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The Acadian Forest has a long history of stand growth research and modeling; however, these efforts have generally been restricted within state or province, rather than across the extent of this forest type. Between 2010 and 2014, approximately 20,000 repeatedly measured plots from Maine, Nova Scotia (NS, New Brunswick (NB), and PEI were compiled and standardized from a combination of available government, industry, and local research datasets. This concerted effort was aimed toward developing statistical tree form, growth, survival, and regeneration models across the Acadian Forest. To date, two distinct empirical stand model programs have been developed to combine a number of new regional tree-level models together to predict historical forest development with and without silviculture interventions:

- FVS-ACD (Forest Vegetation Simulator – Acadian Variant) - developed by Weiskittel (UM) and Dr. J. Kershaw (UNB) and mostly used in Maine for private land forest management planning.
- OSM-ACD (Open Stand Model – Acadian Variant) - developed by Hennigar and primarily used in New Brunswick for Crown forest management planning.

Both applications are calibrated for use across the region, are open source, and can do batch run simulations using commands; however, the underlying application platforms, equations, and simulation routines have diverged considerably over the past five years. Here, we discuss these differences and compare stand-level net volume prediction performance (mean bias, root mean squared error) of these two models against observed stand development over a 10-50 year period in repeatedly measured plots in Maine, NB, and NS for a range of species, ecological conditions, stand development stages, and management types, including: unmanaged mature-old stands, partially cut hardwoods, spruce (*Picea* spp.) and pine (*Pinus* spp.) plantations, thinned, and naturally regenerating clearcuts. Areas of future refinement for each model application will be highlighted and discussed in this talk.

MAINE'S TREE GROWTH TAX LAW 1972-2016: A POLICY ASSESSMENT

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In 1972, Maine adopted a use value property tax program for forests, that was one of the earliest in the US. The program takes a slightly different form in the 10-million acre Unorganized Townships than in the more settled areas of the state. We analyze both. We report a policy evaluation of the program assessing trends in tax assessments, areas enrolled, new enrollments versus withdrawal. We then offer preliminary judgements of this program measured against classic tax policy criteria such as revenue adequacy, compliance burden, impact on allocation of resources, and vertical and horizontal equity. A key policy goal of any use value property tax program, however, differs from classic tax analysis: it is to deliberately affect resource allocation by retaining more land in forest than would be the case under market value property tax assessments. Assessing the effectiveness of a forest use value tax against this goal is elusive, but we offer preliminary observations. We also offer summary comparisons of the Maine Tree Growth Tax with nearby US and Canadian jurisdiction. We rely on data assembled for a legislatively mandated study of the program.

OPERATIONAL CONSIDERATIONS FOR LOWLAND NORTHERN WHITE-CEDAR: DEADWOOD, MICROTOPOGRAPHY, AND REGENERATION (POSTER)

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Northern white-cedar occurs throughout the Northern Forest region and has historically been cut opportunistically during harvest operations aimed at more abundant species on mixed-species sites. Recent management guidelines have presented information about silviculture for white-cedar as a minor species in mixed stands. Yet there is still little information about ecological characteristics of, or operational considerations in, white-cedar dominated lowlands. In order to better inform sustainable forest management on these sites, we have undertaken a study of stand and site characteristics in white-cedar lowlands in central Maine, USA. Preliminary observations suggest that high water table limits tree establishment and growth to elevated microtopographic positions such as those resulting from past tree fall, stumps, and buried roots. These small-scale topographic features likely serve as regeneration safe sites during periods of seasonal flooding. In addition, well-established competing tree species (e.g. balsam fir) and shrubs (e.g. alder) in the understory are likely to outcompete slow-growing white-cedar following release. Last, prevalence of asexual regeneration (layering) among advance regeneration of white-cedar on these sites raises questions about the viability of regeneration treatments that rely upon post-harvest establishment from seed. In light of these concerns, we recommend site protection measures during harvesting such as designating skid trails in areas with less pronounced microtopography, avoiding decaying deadwood, laying harvested wood from selected low-value trees in trails to minimize site damage, creating harvest gaps that release established white-cedar regeneration, and mechanical control of composition in the submerchantable classes to prevent site conversion.

CHALLENGES TO REGENERATING AND RECRUITING TEMPERATE MIXEDWOODS IN NORTHEASTERN AND CENTRAL NORTH AMERICA

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Mixedwoods are distinguished from other compositionally diverse forests by the presence of both hardwoods and softwoods in mixture. Such mixtures often result from harvesting or natural disturbances that create regeneration niches for early to mid-successional species of low to intermediate shade tolerance in forests otherwise dominated by late-successional, shade-tolerant species. Mixedwoods confer a number of ecological and commodity-production benefits, including but not limited to resistance to pests and diseases, wildlife habitat, climate change resilience and adaptability, and market flexibility. Yet many mixedwood forests are transitional in nature and cannot be sustained without deliberate efforts to regenerate and recruit species with differing silvical properties and functional traits. Research throughout the central and northeastern regions of North America on ecology and management of *Pinus* – *Quercus*, *Tsuga* – hardwood, *Picea* – hardwood, and *Abies* – hardwood forests reveal some commonalities, including the difficulty of establishing and recruiting desired softwoods. This presentation will review mixedwood forest types, the ecological and economic benefits of growing hardwoods and softwoods together, and the silvicultural and cultural challenges to perpetuating these mixtures. Our findings suggest that the limiting species across forest types are those with narrow regeneration substrate requirements, relatively slow establishment and subsequent growth, and/or vulnerability to damaging agents such as browsing. In contrast, species that tolerate a broad range of regeneration substrates with rapid growth and/or sprouting ability tend to become more dominant over time. Forest type-specific silviculture recommendations will be presented, including manipulation of regeneration substrate, competition control, and managing for a range of conditions within mixedwood stands.

LANDSCAPE CONFIGURATION INFLUENCES THE INTENSITY OF SPRUCE BUDWORM OUTBREAKS

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It is widely recognised that composition and structure at the stand scale influence tree vulnerability to spruce budworm outbreaks. Few studies have been conducted at the landscape scale despite the dramatic changes to landscape structure over recent decades. Our objectives were to evaluate landscape-level effects of forest management on spruce budworm (SBW) outbreak severity and duration for balsam fir and black spruce, to evaluate whether forest composition responds similarly to SBW outbreaks and to logging and to evaluate associational resistance and susceptibility across landscapes. Our results show that SBW and harvesting lead to different outcomes in terms of composition. We further show that large blocks of spruce are little vulnerable to SBW and could be a good strategy to reduce forest vulnerability but that although they are not vulnerable to SBW they are to forest operations. In mixed spruce-fir forests, associational susceptibility was observed at scales of multiple square kilometers. These results suggest large landscape level changes in forest contiguity and composition may have unintended negative effects on outbreak severity but that targeted interventions can have positive effects.

CANOPY COVER ESTIMATION FROM LANDSAT IMAGES: UNDERSTORY IMPACT ON TOP-OF-CANOPY REFLECTANCE IN A NORTHERN HARDWOOD FOREST

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Light availability is considered to be the main factor limiting seedling and sapling growth in northern hardwood forests. However, field measurement of light availability is time-consuming. Using random forest regression, we developed models to estimate canopy cover in a northern hardwood forest from a Landsat 8 OLI image. To assess the accuracy of model predictions, we used a canopy height model (CHM) derived from LiDAR data. We selected two threshold heights (1.3 and 5 m) to distinguish the understory from the overstory and to determine the impact of the understory on top-of-canopy reflectance. Our results show that the understory influences top-of-canopy reflectance. A 1.3 m height threshold provided the most accurate estimation of canopy cover. In contrast with studies conducted in softwood stands, we found no evidence that the shortwave infrared (SWIR1) band decreased the influence of the understory on top-of-canopy reflectance. In the northern hardwood forest, the estimation of canopy characteristics, such as canopy cover and leaf area index, should be focused on the green band, as it was least influenced by understory vegetation.

SPATIAL-TEMPORAL PATTERNS OF SPRUCE BUDWORM DEFOLIATION WITHIN PLOTS IN QUEBEC

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The objective of this study was to investigate the spatial-temporal patterns of spruce budworm (*Choristoneura fumiferana* [Clem.]; SBW) defoliation within and between measured plots during the current SBW outbreak in Quebec. Although the spatial-temporal variability of SBW defoliation has been studied at multiple scales, the spatial dependence between individual defoliated trees has not been quantified for SBW infestations, and effects of defoliation levels of neighboring trees were seldom covered. Using spatial autocorrelation analyses, spatial patterns at both global (plot) and local (tree) levels were characterized. At the regional level, we found that 45, 25, and 33% of plots had significantly clustered defoliation patterns in 2014, 2015, and 2016, respectively. Relationships between plots with significantly clustered defoliation among tree varied among years and overall defoliation level: 40, 53, and 14% of clustered plots had 61-100% defoliation in the three years. Approximately 60% of plots with clustered defoliated trees ranged from 31-60% defoliation in 2016. We also found that significantly clustered plots had higher average % basal area of black spruce (*Picea mariana* [Mill.] B.S.P.), and lower average % basal area of white spruce (*Picea glauca* [Moench] Voss) than in non-significant plots. At the local level, we detected and visualized the hot spots, cold spots, and outliers within each plot, to decompose the global statistics into the contribution by individual trees. We also created a tree-year-defoliation regression model to better understand whether defoliation of individual trees depended on mean defoliation or host species of surrounding trees. Knowledge of the spatial-temporal variability of SBW defoliation will benefit determining defoliation sampling techniques, forecasting defoliation at unsampled sites, and evaluating management alternatives.

EXOTIC LARCH IS EVERYWHERE (POSTER)

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Trials of exotic larch have been conducted since the late 1800's. Despite its obscurity, it has been used in trials across eastern US and Canada. Here we present a map of some of the many trials and their locations.

PATCHES AMONG GAPS: THE ENTANGLED DYNAMICS OF BOREAL OLD-GROWTH FORESTS IN EASTERN CANADA

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Gap-dynamics (i.e., continuous and low-scale mortality) is generally the process defining the old-growth stage in boreal and other forests. Yet, recent studies suggest that punctual and medium-scale mortality events (i.e., patch dynamics) might also play an important role in old-growth dynamics, but they have never been studied in Eastern Canadian boreal old-growth forests. Furthermore, changes in structure and composition resulting from the progressive disappearance of the first cohort could make the stands more sensitive to patch occurrence. Thus, we hypothesized that (1) gap and patch dynamics are both drivers of boreal old-growth forest disturbance regimes in Eastern Canada and (2) the balance between these regimes will change with the disappearance of the first cohort.

We tested these hypotheses using dendrochronological analysis in 20 boreal old-growth forests in Québec, Canada, representing a gradient of the old-growth stage, beginning from stands dominated by the first cohort and ending with stands where the first cohort was absent. We identified patch and gap creation by analysing stand level synchronicity of individual abrupt growth releases.

We found that along with gap-dynamics, patch dynamics are an important component of boreal old-growth forest disturbance regimes. Gap dynamics are initially the dominant process but patch dynamics become equally important with the disappearance of the first cohort. In addition, gap and patch creation vary strongly among decades, with peaks of mortality associated with recurrent spruce budworm outbreaks and climatic disturbances. Furthermore, Eurasian boreal old-growth forests presented secondary disturbance regimes similar to those observed in the study territory.

THE ROLE OF WETLAND BUFFER WIDTH IN MAINTAINING AMERICAN BLACK DUCK POPULATIONS IN NEW BRUNSWICK COMMERCIAL FORESTS (POSTER)

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Commercial forestry is an important industry in New Brunswick and should balance high economic yield with a strong environmental responsibility. One way to achieve this is to maintain forested riparian buffer zones (buffers) around waterbodies. Buffers are important to the industrial forest as they reduce the potential negative effects of land uses adjacent to aquatic systems. In New Brunswick, forestry operations must maintain ≥30m buffers around waterbodies. However, there has been little empirical examination of the response by non-fishes to this buffer requirement. Waterfowl are potential indicators of ecosystem health in eastern North America because they experience perturbations in both terrestrial and aquatic ecosystems. The American Black Duck ("black duck"; *Anas rubripes*) is a socially, economically, and ecologically important waterfowl species in New Brunswick. However, midwinter inventories conducted on black duck wintering grounds in the United States demonstrated a >50% decline in black duck populations from the 1950's to the 1980's. Management has increased black duck populations in some areas, except in the commercially forested region of interior New Brunswick where they exhibit notable local extirpations. We examine the role of wetland buffer width in the persistence of black duck populations. We used a geographic information system to overlay forest harvest data with georeferenced black duck observation data from 1996-2017 in 13 plots surveyed by the Canadian Wildlife Service. Plots are 25km^2 and surveyed in a rotational schedule (among years). Preliminary results suggest that a smaller mean distance to harvest from a wetland edge has a negative influence on the number of black duck observations. We will use these results to develop a dynamic model to determine the optimal buffer size to maintain black duck populations in New Brunswick.

ESTIMATING THE MITIGATION POTENTIAL OF CLIMATE CHANGE THROUGH AFFORESTATION AND REFORESTATION OF UNPRODUCTIVE LANDS (POSTER)

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The speed at which climate change is occurring today is alarming and strategies for adapting and mitigating these changes are at the heart of international debates. Emissions of anthropogenic GHGs, especially carbon dioxide, are one of the main causes of global warming. The role of forests in carbon sequestration is well known, and the addition of the substitution and sequestration effect of wood products helps to increase the amount of carbon sequestered and decrease the effect of carbon dioxide emissions. The forest sector plays a key role in mitigating climate change through forest management scenarios, such as afforestation scenarios, to increase forest sequestration capacity.

This project aims to evaluate the mitigation potential of climate change through afforestation and reforestation of unproductive lands such as open woodland, poorly regenerated burns and abandoned farmlands. Specifically, the amount of carbon sequestered by ecosystems will be modeled and the substitution and sequestration effect of wood products from harvesting forest stands will be added. The effects of climate change will also be included in the modeling to determine changes in carbon stocks in different pools over 2050 and 2100.

The modeling will be done using the Forest Carbon Accounting Model CBM-CFS3, created by the carbon accounting team at Natural Resources Canada's, Canadian Forest Service. The potential of mitigation of climate change of afforestation and reforestation of unproductive lands will be evaluate at a stand level scale. Secondly, this potential will be evaluated at the scale of the commercial forest area of the province of Quebec.

Expected results from modeling of afforestation scenarios will provide a better understanding of forest carbon interactions. Also, this study will verify the contribution of wood products and their substitution effect in the calculation of the total carbon budget in the context of an increase in forest area in the province of Quebec. The expected results will enable us to guide political institutions to better steer climate change mitigation measures and policies.

NORTHERN MIXEDWOOD FUELS-DEADWOOD STRUCTURE AND REGENERATION FOLLOWING REPEATED WHOLE-TREE AND STEM-ONLY HARVESTS WITH AND WITHOUT PRESCRIBED BURNING

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Given projected increases in summer drought frequency in Maine, current fuel loads and future deadwood contributions from natural disturbances (e.g., eastern spruce budworm, wind storms) suggest greater risk of frequent severe fire events in the future. With historically long fire return intervals in central and northern Maine, little research has examined the effects of burning and mechanical removal on fuel structure in northern mixedwood stands. The effects of fuels mitigation treatments on stand development also need study. On the Penobscot Experimental Forest (PEF) in Maine, USA, we have a unique opportunity to evaluate the effects of broadcast burning following stem-only harvesting (SOHB) relative to whole-tree harvesting (WTH) and stem-only harvesting (SOH) without burning on fuel structure and tree regeneration. Our objectives are to (1) compare fuel structure and fuel loads across WTH and SOH (addressing a knowledge gap regarding effects of treatments on fuel loads within northern mixedwood stands), and (2) compare softwood regeneration across WTH and SOH (addressing the softwood regeneration bottleneck in mixedwood stands). This study repurposes an older study conducted in 1964-65 which initially evaluated spruce-fir regeneration following three different methods of slash disposal. The site harvested in 1964 was re-harvested in winter 2018 with slash burns planned for fall 2018. Fine and coarse woody fuels, fuel height, and litter and duff depth were measured to determine if fuels differed between WTH and SOH areas. In addition, tree regeneration 15 cm in height to <1.3 cm diameter at breast height was measured. This study will provide novel insight into northern mixedwood fuel structure following harvest and regeneration following repeated WTH and SOH. Future work will involve re-measurement of both fuel structure and regeneration immediately following fall prescribed burns.

THE ATLANTIC FOREST RESEARCH COLLABORATIVE

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The Atlantic Forest Research Collaborative (AFRC) was founded on June 11, 2018 to address needs articulated by forest land owners and managers. The AFRC is a non-profit collaborative based at the University of New Brunswick in Fredericton on the traditional territory of the Wolastoqey Nation. The AFRC Vision is "Forests that are resilient, sustained and highly valued". Science-based, independent, and collaborative, the AFRC operates under established core values. The AFRC Mission is "To enhance collaborative forest research, public awareness, and professional capacity to advance adaptive forest management in the Atlantic Region." The Collaborative provides a coordinating, integrating, and some of the production functions needed to achieve its Mission. AFRC members and research associates create synergies by matching those with research needs and those with the capacity to fulfill them.

The AFRC is guided by a representative Advisory Board comprising UNB ForEM (academic), Mi'gmawe'l Tplu'taqnn and Wolastoqey Nation in New Brunswick (Indigenous), Nature Conservancy of Canada and the New Brunswick Federation of Woodlot Owners (NGO), J.D. Irving Ltd. and Forest NB (industry), New Brunswick Energy and Resource Development and NRCAN Canadian Forest Service (government). Advisory Board members contribute advice and may provide matching (in kind/cash) funding to support research, awareness and development activities.

Because it is housed at UNB, the AFRC is able to use the university's existing resources to facilitate its activities. The AFRC website is now active. The Board has articulated priority research questions such as adaptive management under climate change. These questions are being addressed under a defined work plan. We are working towards building respectful relationships between Indigenous and non-Indigenous forest stewards, and exploring Indigenous Knowledge and western science linkage. Outreach initiatives are underway including collaboration with the University of Maine Cooperative Forest Research Unit (CFRU).

EFFECTS OF SPRUCE BUDWORM OUTBREAKS ON BALSAM FIR REGENERATION IN MIXED BALSAM FIR-HARDWOOD STANDS (POSTER)

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Higher hardwood content in stands results in lower defoliation of overstory balsam fir (*Abies balsamea* (L.) Mill.) caused by spruce budworm (*Choristoneura fumiferana* Clem.). To determine whether higher overstory hardwood content also reduced defoliation and mortality of balsam fir regeneration of varying height classes during a spruce budworm outbreak, we sampled 36 plots representing three classes of hardwood content (0-25%, 40-65%, and 75-95%) across a gradient of fir-hardwood stands. Twenty-seven plots were sampled in nine stands near Amqui, Quebec in an early stage spruce budworm outbreak (3 years of defoliation), and nine plots were sampled in three stands in the North Shore of Quebec in a later stage budworm outbreak (7 years of defoliation). Linear mixed-effects models with repeated measures (years) were used to analyze differences in defoliation of fir regeneration as a function of hardwood content, six height classes, and three years (2013, 2014, 2015). In the Amqui plots, defoliation of fir regeneration was significantly related to all factors and interaction terms except for hardwood content, while in the North Shore plots, defoliation was significantly related to all factors and the hardwood content x height class and hardwood content x year interaction terms. Defoliation of balsam fir regeneration was 85% higher in softwood than in hardwood stands in 2013 and 2014 in the North Shore plots, when the budworm outbreak was severe. Defoliation was at least 10% higher on regeneration taller than 30 cm than on smaller regeneration in the Amqui plots in 2015 and over 15% higher in the North Shore plots. In general, balsam fir regeneration in softwood stands had higher levels of defoliation than in hardwood stands when defoliation was severe, and regeneration taller than 30 cm had higher defoliation than smaller regeneration.

BOREALIZATION OF THE NEW ENGLAND-ACADIAN FOREST: A REVIEW OF THE EVIDENCE

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The New England-Acadian Forest (NEAF) is a transnational ecoregion spanning over 24 million hectares of the northeastern U.S. and eastern Canada. The region is characterized as a transitional forest, or ecotone, naturally composed of both boreal and temperate species. However, the term “borealization” is often used to describe various processes driving the NEAF toward a more boreal character at the expense of its temperate forest species and ecological communities. That the NEAF has undergone significant landscape-scale change in the last four centuries since European settlement is well understood. The purpose of this study is to review the current literature to investigate whether past, current, and/or predicted future processes of change are indeed altering the forest toward a more boreal character, or whether these changes constitute something else entirely. To do so, we conducted a literature review on historical forest compositions, past and current land-use practices, as well as indirect anthropogenic changes that are predicted to influence future forest compositions of the NEAF. We reviewed over 100 peer-reviewed scientific journal articles and government reports related to this issue. We found ample evidence to suggest that, at the landscape scale, there has been widespread replacement of temperate tree species by boreal species since European settlement. While not inherently boreal in nature, the processes that have contributed to borealization within the NEAF have also contributed to declines in non-tree biodiversity, structural diversity, and an overall decline in mature, late-successional forest communities. Furthermore, the borealization of the NEAF is occurring in direct contrast to the predicted impacts of climate change. We encourage future scholarship to tackle these aspects of borealization in the NEAF, including its social, economic, and ecological implications.

N-ICE: A QUICK METHOD TO DELINEATE GROUNDWATER INPUTS IN RUNNING WATERS

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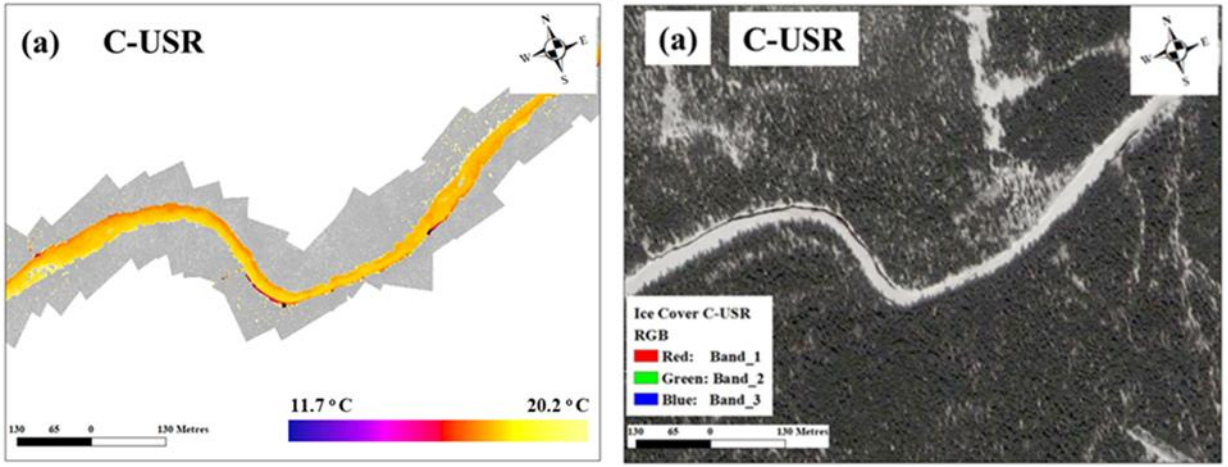
Groundwater can be important in regulating stream thermal regimes in cold, temperate regions and as such, it can be a significant factor for aquatic biota habits and habitats. Groundwater typically remains at a constant temperature through time, i.e., it is warmer than surface water in the winter and cooler in the summer. Small tributaries are often dominated by groundwater during low flows of winter and summer. We exploit these thermal patterns to identify and delineate tributary/groundwater inputs along a frozen river (ice-on) using freely available, satellite data, and we tested the findings against airborne, thermal infrared (TIR) data. The comparison confirms that groundwater inputs can be delineated using available satellite imagery. Our results also established the spatial extent and influence of tributary/groundwater inputs to streams through time. The thermal plumes for seeps and tributaries appears longer and narrower in the winter than summer. This is likely a function of horizontal stratification in the winter due to ice cover. The spatial extent in the summer is likely driven by diffusion and mixing between free-flowing surface water and the incoming, cooler flow. This method of establishing tributary/groundwater inputs and contributions to surface water thermal regimes is relatively simple, free, and can be useful for science and forest management as long as 'necessary ice condition exists' (N-ICE).



LANDSCAPE-LEVEL EFFECTS OF INTENSIVE FOREST MANAGEMENT

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The Black Brook District forest, located in northwestern New Brunswick (Canada), is intensively managed by J.D. Irving, Limited. The 187,000 ha continuous land base area ranks among the most intensively managed forests in Canada. The Black Brook forest has a long history of forest management with plantations established since the late 1950s. Plantation establishment is usually done within one year of final clearcut harvest. The landbase also includes large areas of shade tolerant, high-value hardwoods managed by single-tree selection or patch cuts, and non-harvested conservation areas.
Forest management activities, such as plantations as well as even-age and uneven-aged harvesting techniques, will directly alter stand type, age-class distribution, and within-stand structures. In areas where forest management has increased in intensity and extent, it is important to understand the role of landscape pattern in preserving, altering, or eliminating biological communities. If plantations continue to expand and to intensify, it will become increasingly challenging to maintain current levels of biodiversity. Ecological contribution of managed, including planted, forests to biodiversity objectives at the landscape scale needs to be better understood. This study will then identify similar areas of intensively managed landscapes in Maine and compare these landscapes to the Black Brook forest.

This project is addressing the question *How do forest composition, structure, and habitat differ between the current and projected Black Brook District in comparison to forest areas with less intensive management and to reserved landscapes?* Previous research by Etheridge et al. focused on the historical and projected influence of management at Black Brook, analyzing changes in landscape composition and stand structure. We are comparing key landscape and ecosystem metrics across a gradient of intensity of management in New Brunswick and Maine, with paired landbases including more intensively managed (Black Brook District and Irving Woodlands in Maine), less intensively managed (Crown Land in New Brunswick and Maine State Land), and unmanaged areas (Protected Natural Areas in New Brunswick and Ecological Reserves in Maine). Each landscape is being projected forward 50 years under four management scenarios, using the Remsoft Spatial Planning System (Woodstock): 'business as usual' existing management plans, varying severity of spruce budworm outbreaks, varying severity of windthrow, and climate change.

High-density LiDAR for each landscape is being used to generate key landscape, forest, and habitat metrics. Key landscape and forest metrics evaluated include species composition, age-class distribution, areas by silvicultural treatments, patch size and connectedness, areas by old forest habitat types, biomass growth index, and availability of key ungulate and avian species habitat.

SHORT- AND LONG-TERM COMPARISON OF A TREE-LEVEL AND A STAND-LEVEL GROWTH MODEL

Hugues Power and Isabelle Auger

Direction de la recherche forestière, Ministère de Forêts, de la Faune et des Parcs, Gouvernement du Québec

Many forest growth models have been developed over the past decade. In the province of Quebec (Canada) and in other parts of northeastern America, many models can now be applied to large parts of the territory. Often, more than one model is available to produce estimations for the same variables on a given territory, and choosing the right model for a given territory can be challenging. To help forest managers, we compared two forest growth models that can be used over most parts of Quebec's commercial forest: Artémis, a tree-level model, and Natura, a stand-level model. For our comparisons, we used measures from permanent sample plots located in six distinct territories across the province. Each plot was simulated with both growth models over a 50-year period. Both models produced consistent predictions, but their precision and accuracy varied among groups of plots and territories. Overall, Natura performed better than Artémis in the spruce–moss bioclimatic domain, while Artémis performed better in the balsam fir–white birch and the yellow birch–balsam fir domains. This may result from differences in model structure: the fact that Natura uses stand age could explain its advantage for even-aged stands, while the tree-level structure of Artemis could explain its superiority in bioclimatic domains where irregular stands are abundant.

DEVELOPMENT OF A SPATIALLY EXPLICIT FOREST GROWTH MODEL FOR QUEBEC'S MANAGED MIXEDWOOD STANDS (POSTER)

Hugues Power, Marcel Prévost, Patricia Raymond and Steve Bédard

Direction de la recherche forestière, Ministère de Forêts, de la Faune et des Parcs, Gouvernement du Québec.

In recent years, growth models have become recognized as essential forest management tools. They are useful to test stand responses to different silvicultural treatments as a complement to experimental designs, and thus contribute to refining silviculture. Mixed stands dominated by yellow birch and conifers are among the most common and economically important forest type in the balsam fir–yellow birch bioclimatic domain. They contain tree species with diverse ecological characteristics, particularly regarding their longevity and their needs for regeneration establishment. The development of a silviculture adapted to the mixed forest is still recent in Quebec, and current knowledge does not yet provide answers to questions about long-term effects. To address this, we intend to use eight studies distributed across the balsam fir–yellow birch and yellow birch sugar maple bioclimatic domains to develop a forest growth model that could forecast regeneration and residual tree responses to different cutting intensities and spatial patterns. This model will include modules for regeneration, diameter growth and mortality, and will be spatially explicit to take into account the influence of the spatial patterns on regeneration and residual tree growth.

EMPLOYERS ATTITUDES AND BEHAVIOURS REGARDING THE DIVERSITY OF THE INDIGENOUS WORKFORCE IN THE FORESTRY INDUSTRY

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The Forest Products Association of Canada anticipates that the Canadian forest industry will need to hire approximately 60 000 workers by 2020. Several Indigenous communities have young populations with high unemployment rates and could thus contribute to reducing worker scarcity. Despite various governmental, private and Indigenous initiatives to favor the participation of Indigenous people to the forestry workforce, there is a fundamental lack of knowledge about ways to improve recruitment, integration and retention of Indigenous workers. In a context of labour scarcity, the sustainability of the forest industry depends on its ability to be attractive to the growing Indigenous population.

We conducted semi-directed interviews with 22 leaders and human resources managers from non-indigenous (16) and indigenous (3) forest companies in Quebec (Canada) to determine what promotes Indigenous participation in the forestry workforce.

While conventional recruitment techniques are not always effective with Indigenous people, our results show that partnership and collaboration approaches with communities have proven to be an effective way to select and recruit Indigenous workers. Cultural training and awareness-raising on discrimination and stereotypes are essential to the establishment of a culturally-safe working environment.

Mentoring is well adapted to the hands-on approach to learning favored by most Indigenous peoples. Ultimately, companies adopting holistic diversity management practices improve their chances of success in training, recruiting, integrating and retaining Indigenous workers within their organizations. Our research provides culturally-relevant tools for governments, private companies and Indigenous communities to improve diversity management and enhance Indigenous participation in the forestry workforce.

SILVICULTURAL OPTIONS FOR REHABILITATING HIGH-GRADED MIXEDWOOD STANDS IN A HERBICIDE-FREE CONTEXT

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Prior to 1990, thousands of hectares of mixedwood stands in Quebec's boreal-temperate forest ecotone were harvested with unregulated methods such as diameter-limit cutting. By focusing solely on timber trees of economically valuable species, these cuts too often left stands with highly variable density and impoverished in terms of composition and wood quality. In many cases, the lack of care to the regenerating layer, combined to the ongoing spruce budworm (*Choristoneura fumiferana*) epidemic, caused regeneration deficiencies, especially on the most productive sites such as the ones supporting yellow birch (*Betula alleghaniensis*)-conifer stands. Many poorly regenerated stands were invaded by highly competitive noncommercial species and still require rehabilitation treatments to sustain wood production and other ecosystem services. Selection of regeneration methods should consider the low abundance of seed trees of desired species. Site preparation treatments should improve seedbed conditions and decrease interspecific competition without herbicides, banned from public land since 2001.

To overcome the lack of knowledge on rehabilitation methods, an experiment was established near LaTuque in central Québec in 2001. Selected stands were high-graded by a diameter-limit cutting in 1988 and still had low merchantable basal area in 2001 (MBA 10 to 12 m²/ha). The overstory was mainly composed of low vigor yellow birch, while the understory was dominated by noncommercial mountain maple (*Acer spicatum*) and pin cherry (*Prunus pensylvanica*). The experiment was made of 4 completely randomized blocks comparing 4 regeneration treatments, each one applied on 1-ha experimental units (EU): untreated (let grow), uniform shelterwood (50 seed trees/ha, MBA 3-4 m²/ha), strip clearcutting (20-m strips) and seed-treed clearcutting (10 seed trees/ha). Within each EU, 2 regeneration options were tested on 50 x 100 m subplots: natural regeneration and plantation. This study focuses on the natural regeneration option, whereas each subunit was furthered divided in 3 (50 x 33 m) to test site preparation treatments: no site preparation, mechanical raking and spot scarification (2 x 5 m, 400 spots/ha). This conference will present the natural regeneration outcomes after 15 years.

INTRODUCING MAINE'S ADAPTIVE SILVICULTURE NETWORK (MASN)

Brian Roth

Cooperative Forestry Research Unit, University of Maine

NORTHERN WHITE-CEDAR REGENERATION IN NATURAL AND MANAGED STANDS

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Northern white-cedar is a species with high value for both wood products and wildlife habitat. A general decrease in cedar abundance has been observed across most of its range, a situation that has been attributed to an increased white-tailed deer pressure and management strategies targeting other species when cedar is present in mixedwood stands. In order to better understand the regeneration processes of cedar, two studies were conducted in western Quebec. In the first one, 26 plots were sampled in forests containing cedar and having the main characteristics of old forests. Cedar sexual regeneration was positively associated with mounds and decaying wood. The abundance of seedlings taller than 15 cm increased with distance from deeryards. Saplings were almost absent in a region with a high deer density. Growth releases were associated with known spruce budworm outbreaks.

In a second study, cedar regeneration after operational selection cuts was studied in 70 paired treated/control permanent plots having at least 10% of basal area in cedar. On each site, regeneration inventories were conducted 15-20 years after cutting. Results indicate that selection cutting allowed the establishment of white-cedar when deer densities were low, which was the case on the study sites. The local abundance of seed trees, harvesting intensity, competition and the availability of establishment microsites influenced cedar regeneration. Seedling abundance was positively associated with mounds and decaying wood.

These two studies can provide guidance for cedar management in mixedwood stands. In old forests subjected to a high deer browsing pressure, banning harvesting may not be sufficient to permit stand regeneration. When selection cutting is applied without high deer pressure, stand prescription could be adjusted at a fine scale to ensure local regeneration of cedar. The effectiveness of selection cutting in conditions of high deer pressure however remains to be established.

A GROWTH SIMULATOR TO HELP MANAGERS ADAPT THEIR MANAGEMENT IN WHITE SPRUCE PLANTATIONS

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Since April 2013, all forest management activities in the public owned forests of Quebec must follow the principles of ecosystem-based forest management. This has led to certain modifications in the sylvicultural scenarios proposed for plantations in eastern Quebec. The existing tools to simulate stand development are however unable to take into account these modulations. A new individual growth simulator is thus proposed. Prior to simulation, the non-commercially sized trees are predicted if using standard forest inventory data. The position of each tree is also allocated using a spatializer model. The simulator can then run on 5-year steps with either spatially explicit or aspatial data. The version of the model using non spatial competition indices shows slightly better fit statistics. Using an external validation dataset, the validation RMSE on diameter at breast height tree increment was found to be 0.95 cm (6.2%) for the aspatial version and 1.04 cm (6.8%) for the spatially explicit version. At stand level, the validation RMSE on stand basal area was 1.27 m^2/ha (4.1%) and 1.51 m^2/ha (4.9%), for the aspatial and spatially explicit versions. No trends within the validation results were found. The model will help managers evaluate how the proposed ecosystem-based modulations impact forest growth and yield.

ECONOMICS OF HYBRID CLEAR-CUTTING SYSTEM INVOLVING AT-STUMP PROCESSING AND SOIL REINFORCEMENT STRATEGIES

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Maine consists of millions of acres of forest stands which are the main source of income for the economy. Economic as well as environmental feasibility of different harvesting methods is a widely researched topic in Forest Operations. Comparison of the productivity and other aspects of different harvesting methods is vital as harvest prescription is one of the key factors in regulating the cost of operations.

The primary objective of the study was to evaluate and compare Stem-only (SO) and Whole-tree (WT) harvesting statistically in terms of production and cost. Also, a comparison between at-stump and at-landing processing of logs. It will also discuss the importance of winter-harvesting and the extent to which it helps in mitigating the site disturbances caused during a harvesting operation.

The study site was a 26 ha mixedwood stand in the Penobscot Experimental Forest, Bradley, Maine. Out of the 26 ha, 6.5 ha was harvested during February and March 2018. Buffer zones were maintained during the harvesting which accounted for about 10.8 ha. The operation employed a ground-based harvesting consisting of a feller-buncher, de-limber, grapple skidder, and slasher/loader. The same machines and operators were engaged in all the sites. Blocks were subjected to clear-cut which followed either a SO or WT method. At-stump processing of logs was done by mobilizing a de-limber inside the unit in SO prescription blocks, whereas logs from WT blocks were processed at the landing. Slash from the SO blocks was retained in the unit and the slash from WT blocks was left at the landing. Sorting and loading were not differentiated for both prescriptions. Time and motion data were recorded for each of the cycle components along-with the predictor variables. Average delay free cycle time (DFC) was calculated for each of the machines for determining the productivity. Any evident signs of soil disturbances were noted.

As a part of preliminary data analysis, the DFC of different machines for the SO and WT blocks were calculated separately. The DFC (in secs) for SO blocks were found to be 62.8, 33.6, 193.8 for felling, processing and skidding respectively. Corresponding values for WT blocks were calculated to be 45.6, 25.0 and 247.8 secs respectively. DFC for sorting was found to be 30.2 secs. Each of the loading cycle had an average DFC value of 60.4 secs and the average time to fully load a truck was estimated to be 1549 secs. Additionally, the feller-buncher was employed in laying skid trails in the stands. Average DFC for establishing trails was found to be 73.7 secs. Regression analysis and machine rate calculation will be done for obtaining the overall cost of operation and for analyzing the productivity.

As the harvesting was done during heavy snowfall, ground was covered with almost 30 cm of snow which covered the soil profile and thereby, reduced potential soil disturbance.

Outcomes from the study should help forest managers, loggers, researchers and land owners in efficiently planning and executing a harvesting operation suitable for their respective regions.

PROOF OF CONCEPT: A CROP TREE RELEASE VARIANT OF PRECOMMERCIAL THINNING USING A SPACING SAW DESIGNED FOR TOP SPACING

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Although crop tree release (CTR) in hardwood stands is an accepted variant of precommercial thinning (PCT), the lack of an affordable and feasible method hinders its adoption. Crop tree release implies selecting between 150 and 500 trees·ha-1 when trees are between 7 and 12 m high and cutting only stems that compete with the target crop trees. We developed an approach for navigating dense stands with a GPS while selecting crop trees and performed a field trial of a crop tree release variant of PCT using the Husqvarna 535 FBx spacing saw in a 27.8 ha hardwood stand. A detailed time study was performed to document the trial over 13 days. Compared to conventional PCT that occurs earlier in the life of a stand, delayed CTR-PCT required cutting larger stems, which showed to be feasible and productive using the chain saw configuration of the spacing saw. Productivity exceeded four times that of a conventional PCT performed with a brushsaw. Although productivity could vary with stand characteristics and worker, this proof of concept trial demonstrates some of the potential uses that this new saw configuration offers and sets the basis for an eventual larger scale deployment of this treatment.

MITIGATING THE IMPACT OF THE EUROPEAN BEECH LEAF MINING WEEVIL, *Orchestes fagi*, ON AMERICAN BEECH IN CANADA

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The beech leaf mining weevil, *Orchestes fagi* (Coleoptera: Curculionidae), native to Europe, was discovered infesting American beech in Halifax, Nova Scotia, Canada in 2012, but had likely established 5–7 years prior to its discovery based on anecdotal reports of typical signs of damage to foliage. Data from fixed radius permanent sample plots show that >85% of beech trees died after several consecutive years of heavy infestation by the weevil (i.e., 70% of leaves with larval mines). Mortality of beech trees on residential properties in Halifax has been lower (40% as of fall 2016) but has cost residents with beech trees >$1000 on average for tree removal. Because adult weevils overwinter under bark scales on the trunks of trees, including spruce, beech and maple, the risk of human-assisted spread of the weevil via movement of logs and firewood is high. We present data from two approaches to mitigate the impact of the beech weevil in Canada: 1) protection of individual high value street trees from weevil damage with stem-injection of TreeAzin™ (produced from azadirachtin extracts from seeds of the neem tree); and 2) classical biological control. Stem injection of mature beech with TreeAzinTM in the fall or early spring significantly reduced larval survival and damage to foliage and emergency registration for its use was granted by the Pest Management Regulatory Agency in the spring of 2018. Extremely low–nil levels of parasitism of *O. fagi* have been observed in Nova Scotia, suggesting classical biological control may be a viable long-term strategy. We present early results from a two-year study initiated in 2018 to determine whether any parasitoids of the beech weevil in Europe are sufficiently species-specific to be considered suitable candidates for a classical biological control strategy.

DISENTANGLING FACTORS THAT INFLUENCE FOREST VULNERABILITY TO WIND DISTURBANCE ALONG CANADA'S COASTAL ACADIAN FOREST

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Wind is an important driver of forest dynamics along eastern North America's coastal forests, but also damages many commercially managed forests. Although the impact of wind on forests is well recognized, knowledge of the factors that predispose forests to wind damage is less known, especially in the context of large, powerful wind storms, such as hurricanes. This is of particular concern as climate change is expected to alter the frequency and severity of strong wind storms affecting eastern North American coastlines over the coming decades.

In this study, we used wide-scale forest survey data of wind damage, caused by Hurricane Juan, from Nova Scotia, Canada to investigate factors that influence forest vulnerability to windthrow. Juan made landfall as a Category 2 hurricane with sustained winds of 158 km/h and damaged over 600,000 ha of forest across central Nova Scotia. The damage zone was intensely surveyed using aerial photography and LandSAT satellite imagery and categorized according to level of wind damage at a 15 x 15 m cell resolution. We randomly selected 100,000 windthow and non-windthrow cells (i.e., forest sites) and used boosted regression tree analysis to explore the influence of various meteorological, topographic, soil, and forest structural variables on the presence or absence of stand-replacing (> 80% of all trees overturned) windthrow.

Our results show that wind speed and forest structure, specifically, stand height and tree species composition, were the most influential variables determining forest vulnerability to windthrow. On average, sustained winds of at least 95km/hr or gust of 130km/hr caused a >50% probability of windthrow. Taller stands were most vulnerable to windthrow, especially those dominated by spruce (*Picea* spp.) and balsam fir (*Abies balsamea*), while hardwood and pine dominated stands were less affected. Interestingly, topographical exposure, which takes into consideration the elevation, slope and aspect of a forest site relative to its surrounding topography and predominant wind direction, ranked low in overall influence; however, a clear relationship between high exposure and increased windthrow was observed. These results may be used to help evaluate forest vulnerability to windthrow during management planning activities and assess future risk from wind storms.

UNRAVELING THE MECHANISMS THAT DRIVE EARLY SUCCESSION FOLLOWING HARVESTING IN THE ACADIAN FOREST

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Successful implementation of sustainable forest management requires long-term, strategic planning, including the ability to predict forest succession. However, predicting succession is not a trivial pursuit and has remained a central challenge for ecologists and foresters for well over a century. Research has shown succession is not an orderly, stage by stage process, as traditionally considered, but follows multiple successional pathways depending on various ecological mechanisms. Historically, the task of predicting succession for management purposes relied on expert-opinion, but today's management challenges (e.g., climate change) demand a more empirical understanding of causal mechanisms.

In this study, we provide the first region-wide analysis of forest succession following commercial harvesting in Canada's Acadian Forest. Using repeatedly measured forest inventory data, we analyzed early succession on 52,000 forest stands across New Brunswick and Nova Scotia following clear-cut harvesting. Stands ranged in age between 10-30 years since harvest, representing the "stand regeneration" stage of forest development. The k-medoids clustering algorithm was used to classify all stands into discrete regeneration covertypes based on the most recent measurement of tree species abundance. Boosted regression tree analysis was used to explore the influence of potential variables on the probability of harvested stands succeeding into one of the discrete covertypes. Variables tested included climate, topography, soil and neighbourhood composition effects.

As expected, covertypes dominated by shade-intolerant, broadleaf species (e.g., birch, poplar, red maple) had the overall highest probability of regenerating following harvest; however, multiple successional pathways were observed and were mainly related to climate and neighborhood composition. Areas of higher summer precipitation and lower climate moisture deficit were more likely to regenerate as spruce and balsam fir covertypes, whereas warmer, dryer climates promoted regeneration of mixed-species covertypes dominated by shade-intolerant, broadleaves and non-commercial shrubs (e.g., pin cherry). Pre-harvest stand composition and the composition of neighboring stands had a strong, positive effect on post-harvest regeneration, promoting conspecific covertypes, supporting the "direct regeneration hypothesis" of succession.

Results from our study will help provide a more empirical underpinning of forest succession following commercial harvesting and may be used to help guide forest management planning. Further, the strong influence of climate detected suggests climate may play a more important role on forest regeneration than previously considered, which has important implications for forest management as climate change is expected to accelerate over the coming decades.

STRUCTURAL DEVELOPMENT PATHWAYS IN SECONDARY NORTHERN FORESTS INDICATE HIGH POTENTIAL FOR CARBON-BASED FOREST MANAGEMENT

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Currently, vast areas of secondary forests in the northeastern U.S. are recovering from past land-use. However, whether structural development pathways are converging or diverging from similar carbon storage outcomes remains uncertain. Here we aim to facilitate the ongoing debate about the most effective carbon forestry approaches to mitigate human-induced greenhouse gas emissions. In particular, our objectives were (i) to identify structural development pathways in secondary northern hardwood-conifer forests, (ii) to determine their effects on carbon storage, and (iii) to quantify the effect of structural drivers of carbon accumulation.

We conducted an intensive inventory of structural attributes at 45 mature, unmanaged mixed hardwood-conifer forest sites in Vermont. For these sites, we identified distinct structural development pathways using Agglomerative Hierarchical Clustering (AHC), and analyzed their differences in aboveground carbon storage. We employed a random forest algorithm to detect meaningful associations between carbon and structural attributes, and to derive the partial effect of each structural variable on carbon storage.

AHC suggested three different structural development pathways, including one softwood, and two hardwood-dominated clusters. Nine of the 19 variables investigated differed significantly between clusters. Among those were all variables related to the variability in tree dimensions and the heterogeneity of the canopy. The structural development pathways differed significantly in carbon storage with the highest amount of carbon stored in the softwood cluster. Nine variables were identified to be meaningful for carbon storage. Of those seven had a positive, one a negative, and one a bimodal relationship with carbon. The positive effect of structure was more distinct in hardwood compared to softwood-dominated forests. Live basal area dominated the effect of structural variables on carbon, followed by the heterogeneity of tree diameters, and the percentage of conifers.

The variability of carbon stored in hardwood-dominated clusters indicates a particularly high potential to increase carbon in these forests. Silvicultural systems designed to enhance stand structural complexity are likely most effective to optimize carbon storage in production forests. However our results suggest there are multiple options (i.e. flexibility) in directing stand development pathways to achieve carbon storage objectives.

TESTING THE EFFECTS OF CLIMATIC FACTORS ON THE EARLY GROWTH AND DEVELOPMENT OF SPRUCE SPECIES IN THE ACADIAN FOREST (POSTER)

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Climate change has the potential to drastically alter the dynamics, productivity and species composition of Canadian ecosystems. Recent climate model predictions show that an increase of 3 to 7 °C in mean temperatures across Canada's forests is quite possible by the year 2100. Individual tree species responses to shifts in climate may be independent of the surrounding ecosystem, which will lead to novel community types for which there is no current analogue. This is of particular concern along Canada's boreal-temperate forest ecotone, such as the Acadian Forest Region, where mixtures of cold- and warm-adapted tree species are currently already growing at their maximum southern and northern limits, respectively. Indeed, cold-adapted spruce species are predicted to decrease in growth and abundance according to modeling studies; however, many aspects of how climate will interact and affect the development of spruce species, especially during the early germination and seedling stages, remains unclear, calling into question the validity of modeling predictions.

In this study, we will be investigating the effects of climate change on the germination success and seedling development of black spruce (*Picea mariana*), red spruce (*Picea rubens*) and white spruce (*Picea glauca*) by exposing seeds and seedlings to several regimes of elevated temperature and carbon dioxide (CO_2). In order to observe the influence of increased winter temperatures and elevated atmospheric CO_2 on germination, seeds of all three species will be collected from northern and southern populations in the fall of 2018, randomly assigned to five separate stratification trials and, subsequently, germinated under ambient and elevated CO_2. To test the effects of increased summer temperatures and elevated atmospheric CO_2 on seedling growth and development, seedlings of all three species will be planted in open-top field test chambers of different temperature and CO_2 regimes and their growth and vigour measured after one growing season. The results of this study will help to improve our understanding of how these species, which are of great ecological and economical importance in the Maritimes and Canada, will respond to climate change throughout the 21st century.

WHITE CEDAR (*Thuja occidentalis*) REGENERATION UNDER HIGH BROWSING PRESSURE (POSTER)

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Eastern white cedar has seen a decline in abundance in much of its range over the last decades. This decline is thought to be in large part due to high white-tailed deer populations, as they increase browsing pressure on pre- and post-harvest cedar regeneration through preferential browsing and prefer cedar stands for overwintering. Cedar regeneration dynamics are also still poorly understood in relation to browsing, which plays a major but hard to predict role. Moreover, harvesting systems tend to focus on species with different needs than cedar, and therefore favor the regeneration of competing species at the expense of cedar. Supplemental feeding, known to have an impact on browsing behavior, is also common in many areas with problematic cedar regeneration.

This project aims to evaluate:
1) the reaction of cedar seedlings (in terms of growth and form) to browse intensity, frequency and timing under shade and light conditions;
2) the survival and growth of cedar seedlings after partial cuts under high browsing pressure;
3) the factors that influence browsing pressure on cedar seedlings after partial cuts; and
4) the impact of supplemental winter feeding on cedar selection by deer.

In an experimental plantation, we will simulate various browsing intensities, locations and timings on cedar seedling growth and form (objective 1). We are also monitoring browsing and growth on individual seedlings in partially harvested cedar stands (objective 2) and will link browsing pressure with stand characteristics (objective 3). We will lastly plant cedar seedlings along a distance gradient from supplemental feeding stations (objective 4). This project will improve our understanding of cedar regeneration in a context of high browsing pressure and of the influence of supplemental feeding on selectivity for a highly selected browse. It will also contribute to a better understanding of the factors affecting browsing damage and cedar vulnerability.

EFFECTS OF MANUAL DEFOLIATION TREATMENTS AND SITE TYPE ON YOUNG BALSAM FIR FOLIAGE PRODUCTION

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Defoliation levels and site types have been suggested as important factors influencing the response of trees during spruce budworm (*Choristoneura fumiferana* Clem.) outbreaks. We measured the number of shoots, shoot length, and needle length of sampled branches, and calculate foliage weight from 1992-1994 for 80 balsam fir trees of 7-10 years old, in four manual defoliation treatments (0% removal of current foliage, 50%, 100%, 100%+bud removal for all shoots per tree) and four site quality classes (dry/poor, dry/rich, wet/poor, moist/rich). The significance of effects of defoliation severity and site quality on foliage growth of balsam fir depended on the number of years of treatment. Trees on rich sites had 62% more shoots, 55% longer shoots, and 299% greater foliage weight than on poor sites in the second and third years of treatment. Defoliation treatments had no effect on mean shoot length and needle length, but defoliation for 2-3 consecutive years increased the number of shoots, especially on the dry/rich site, through epicormic shoot production. Thus, site quality, nutrition and soil moisture played an important role in the development of shoots and needles and the tree's ability to withstand defoliation. Defoliation for 2-3 years substantially decreased total foliage weight.

A REGIONAL APPROACH TO DEER RESEARCH AND MANAGEMENT

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White-tailed deer (*Odocoileus virginianus*) populations in northeastern North America (i.e., northern Maine, New Brunswick, Nova Scotia) have fluctuated dramatically over the last 100 years. Hypothesized causes for these trends relate to winter severity, arrival of coyote, hunting quotas, decrease in winter cover habitat, herbicide application, and plantation production. Deer movement and habitat use appears to be changing, with deer increasing in some suburban areas. A collaborative research and management group, Northeast Deer Research Partnership, with members from Maine, New Brunswick and elsewhere, was formed in 2016 in order to identify common issues, and attempt to understand deer populations at a larger, regional scale. Projects to date identify modelling historical trends, use of LiDAR for documenting food availability associated with forest management, habitat assessment at multiple scales, societal aspects of public winter feeding programs, and response by deer to mild and severe winter weather in northern Maine to southeastern New Brunswick.

EFFECTS OF HARDWOOD CONTENT ON BALSAM FIR DEFOLIATION DURING THE BUILDING PHASE OF A SPRUCE BUDWORM OUTBREAK

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Defoliation by spruce budworm (*Choristoneura fumiferana* Clem.) on balsam fir (*Abies balsamea* (L.) Mill.) is more severe in fir than in mixed fir-hardwood stands. Previous studies assumed that defoliation in fir-hardwood stands was reduced in proportion to percent hardwood regardless of outbreak severity. We tested the influence of stand composition on defoliation during the first 5 years of a spruce budworm outbreak near Amqui, Quebec, by sampling 27 fir-hardwood plots selected to represent three percent hardwood basal area classes (0%–25%, 40%–65%, and 75%–95%). Balsam fir defoliation was significantly lower ($p < 0.001$) as hardwood content increased, but the relationship varied with overall defoliation severity each year. Annual plot defoliation in fir-hardwood plots, estimated using: (1) defoliation in pure fir plots and the assumption that defoliation in fir-hardwood plots was reduced in proportion to percent hardwood; (2) a generalized linear mixed-effects model with defoliation in pure fir plots, percent hardwood, and interaction as fixed-effects; and (3) Random Forests prediction incorporating 11 predictor variables, resulted in $r = 0.77$, 0.87, and 0.92 versus measured defoliation, respectively. Average defoliation severity in softwood plots and percent hardwood content were the most important variables in Random Forests analysis. Data on average defoliation level in softwood stands, as an indicator of overall outbreak severity, improves prediction of balsam fir defoliation in mixed stands.

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