

NORTHERN HARDWOOD CONFERENCE REPORT

A review of challenges and research priorities for northern hardwood forestry





Northern Hardwood Conference Report

Storm Robinson, Joey Volpé

Abstract

The Northern Hardwood Conference held in Fredericton in 2023 was an excellent opportunity to review challenges and research priorities for stakeholders in northern hardwoods management. The northern hardwoods forest has been changing and continues to change. Forest management and silviculture practices must adapt. We are facing issues with regeneration of limited species, a decrease in tolerant hardwood vigour and quality, climate change and multiple conflicting objectives such as market demand, increased demand for maple syrup production, and proposed increases in conservation land. Fortunately, the gathering of industry, business, and technology experts, researchers, and government at the Northern Hardwood Conference presents us with some opportunities and solutions. Since its existence, the Northern Hardwoods Research Institute has aligned its research and development operations to address current challenges of the entire forest products sector in the province of New Brunswick. In this report, we highlight the collective challenges in managing for tolerant hardwoods and we present NHRI's existing and future solutions to those issues that will guide our research priorities going forward. We propose three major focus areas in which to do so: Silviculture of northern hardwood and mixedwood stands, climate smart silviculture / adaptive management, and technology-based solutions to precision forest inventory and digitalizing the forest value chain. These focus areas will each include training, collaboration, adaptive management, and building the tools and technology to help inform practitioners and policymakers to move toward a more valuable northern hardwood forest.

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The northern hardwood forest is changing. Forest management and silviculture practices must adapt.

Northern hardwood forests occupy millions of hectares in the eastern United States and Canada, representing one of the most economically important and ecologically diverse forests in eastern North America. Northern hardwood silviculture is diverse and complex and has been the focus of extensive research for over 80 years. Today, managers continue to seek innovative sustainable management solutions to address the expanding challenges facing this forest type, including serious threats such as invasive species, inadequate tree regeneration and shifts in composition, degraded timber quality, herbivory, climate change, nitrogen deposition, and forest fragmentation.

The present may be challenging and the future uncertain, but it was encouraging to see so many great minds come together to discuss solutions to these issues during the Northern Hardwood Conference 2023 (NHC 2023) held in Fredericton, NB from August 1st to the 3rd.

Over 200 people came together to discuss solutions to some of the most issues facing northern pressing hardwood forests. Even more impressive was the great mix of industry, government, and academic representation. Having such a variety stakeholders from so of many jurisdictions at the same event is a rare opportunity to identify challenges, and more importantly, potential solutions regarding the management of northern hardwood forests.

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Beyond the issues affecting the forests, stands, and trees, stakeholders must also deal with a myriad of challenges that affect their ability to manage northern hardwood forests optimally. Governments are facing ever stronger pressure in terms of balancing an increase in the demand for our forests.

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A review of challenges and research priorities for northern hardwood forestry

Whether it be negotiating with Indigenous communities, conservation, recognizing traditional practices, recreational use, various economic pursuits (such as maple syrup production), or timber harvesting, the list of demands on our tolerant hardwoods is extensive, and striking the right balance between them remains an ongoing challenge. New questions such as the fate of ash trees not just for wood but for cultural value and forest structure are being posed by both Indigenous peoples and private woodlot owners. More crown land is being made available for maple syrup production, and more conservation is being set aside. Further, the aging work force is mentioned as a challenge in every part of the value chain; experienced and skilled workers are facing challenges in being succeeded by the new generation, mainly due to inadequate training and retention initiatives. This includes but is not limited to seed collection, nursery work, field technicians, trades people, machine operators, and millworkers. Moreover, the market demand for wood products is increasing with population and the move toward renewable energy.

The list of demands on our tolerant hardwoods is extensive, and striking the right balance between them remains an ongoing challenge.



The effects of climate change on regeneration, forest composition, stand vigour, and timber quality were also recurring themes heard throughout the conference. In particular, the future health and distribution of high-quality sugar maple / yellow birch stands is undeniably in question. There is mounting evidence that climate change, along with a host of other factors, is negatively affecting the health, vigour and regeneration of sugar maple stands at the northern end of its range.

Industrial forest managers are also facing a slew of emerging challenges. Most representatives of forest companies attending NHC 2023 presented on silvicultural solutions aimed at adapting silviculture practices to mitigate the effects of forest degradation in hardwoods. The consensus seems to be that silviculture regimes should be adapted, or new ones implemented to account for the fact that an increasing number of stands no longer meet the criteria for management under a system of single tree selection.

Depending on the region and previous management this could be due to past harvesting practices, increases in forest disturbances, or both. In most regions, we heard that northern hardwood stands are typically becoming more vertically and spatially heterogenous, and the traditional approach of the Uniform Shelterwood System is becoming harder to implement under those conditions. Many are looking for new alternatives and adaptations, like the various types of Irregular Shelterwood System, that allow for flexible sub-stand management, although changing the status quo comes with its challenges.

Optimizing supply chains through digitization was a central theme of the conference and the subject of the keynote address given by Doug Jones, CEO of Remsoft. The key going forward, according to Remsoft's president, will be the ability for systems and data to integrate seamlessly. Forestry was a front runner in adopting new technologies, like GIS, LiDAR and multispectral imaging, but adoption of management systems that can leverage that data to gain a competitive business advantage has been much slower within the sector. We heard a similar story from industrial forest managers. The consensus seems to be that there is a clear recognition of benefits of moving forward with the digitalization of the forest value chain, but progress is slow. Regardless of the level of difficulty of the challenge, or the speed of progress, managers can agree that digitalization of the value chain will be one of the most crucial tools for finding efficiencies going forward.

NHC 2023 was a rare opportunity to bring together expert practitioners, academia, and government officials to consider the challenges faced by northern hardwood managers, but more importantly to discuss potential solutions and tools needed to face those challenges. Everyone is working hard to adapt management and silviculture practices and to develop the required tools to ensure that northern hardwood forests remain ecologically and socioeconomically healthy for all.

In the following pages we offer a brief synopsis of the main takeaways of the conference. Three major themes were prominent during NHC 2023:



Forest Management and Silviculture: Balancing multiple objectives and shifting silviculture practices to address stand degradation and regeneration concerns.



Climate Smart Silviculture: Challenges and potential solutions in the face of a changing climate.



Technology Solutions: The connection between knowledge and optimizing operations.

In the last section, we address the knowledge and research gaps. As a small research center focused on northern hardwoods technology and management, we hope to assist practitioners in addressing these issues. Some of the challenges presented are already implemented into our Silviculture Prescription System and in our current best management practices. Others we hope to implement in the SPS version 3.0. New and existing projects will be adapted and managed using our adaptive management framework to stay current with ongoing shifts in silviculture and climate change research. This approach aims to keep our partners and stakeholders at the forefront of northern hardwoods research.

2.0 Forest Management and Silviculture

The reasons behind the current state of northern hardwood forests are multifaceted – site suitability and natural disturbance regimes, climate change, past land use such as agriculture, repeated harvesting that occurred without sufficient attention to residual stand condition, as well as a multitude of other challenges (Kern and Dickinson, 2023). However, it became clear during NHC 2023 that people throughout the range of northern hardwoods are facing similar issues and are working hard, but struggling, to develop the knowledge and implement the required policy and tools to address the challenges associated with the degradation of northern hardwood forests. On top of the ecological concerns facing northern hardwoods, the trend in management style and policy are facing changes as well.



2.1 Balancing multiple objectives

During the conference, we had the chance to hear from highranking public officials on the topic of management strategies that aim to satisfy stakeholders and their diversified objectives. Chris Ward (Assistant Deputy Minister, Forestry Division, NBDNRED) presented New Brunswick's forecasted hardwoods needs and production capacity and the governments' silvicultural strategies aimed at mitigating short term hardwood supply woes and increasing volume and quality into the future. New Brunswick's newly minted state of the forest report (NBDNRED1, 2023) and forest strategy (NBDNRED2, 2023) are a testament to the difficult juggling act facing many jurisdictions in Canada.

The hardwood industry in New Brunswick is expected to feed three hardwood sawmills in the northeast, four pellet facilities, two panel mills, and six pulp and paper mills. Yet, as far back as the 1970's, forest planners realized meeting the needs of the forest industry would need to be accomplished on fewer acres in the future because more land would be required for other forest uses. Although New Brunswick is excellent at forest inventory and planning, the hardwood timber consumption has grown substantially since the 1970's from 0.5 to ~4 million cubic meters per year and the global production of industrial roundwood is projected to continue increasing. The past reports and inventories dating back to the 1950's have painted an imperfect picture, and the gap in volume between immature hardwoods and mature hardwoods is of major concern to wood supply.

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Ward suggests that it's time to refocus on silviculture, specifically in tolerant hardwoods, to ensure that the future annual allowable cut can eventually meet the demand. This is crucial despite the existing gap and the increasing demands on tolerant hardwoods values.

These other values include the maple sugar industry which is forecasted to grow at a steady rate through 2030; a 6% per year growth in the North American maple syrup market. There is also the demand on increasing conservation areas from 23% to 30% on crown lands, including an increase in terrestrial protected areas such as old forest habitats, old communities, deer wintering areas, unique areas, water buffers and more. One solution Ward presents is to use LiDAR technology to overlap maple sugaries with conservation areas, and create sugaries from inoperable hardwood stands, while increasing zoning to manage tolerant hardwoods differently (more about these solutions in Section 5). The title of New Brunswick's forest strategy document is duly entitled "*Our Forests are for Everyone: A Long-Term Strategy for Healthy & Sustainable Forests*". A title that clearly outlines the balancing act required between the needs and objectives of many users and stakeholders (NBDNRED, 2023).

James Steenberg (Ph.D., Senior research and planning forester, NSDNR) presented on Nova Scotia's implementation of the Triad model of functional zoning (Seymore and Hunter, 1992; Ward and Erdle, 2015; McGrath et al, 2021). The model comes on the heels of a recent independent review of forest practices that has led to several changes to Nova Scotia's forest sector. Steenberg highlights issues of quality and access to good quality forest stands are the major concern for wood supply. Much of their sugar maple is stunted due to exposure and windstorms and yellow birch is found mostly on difficult terrain to access. This requires careful planning. A review of Nova Scotia's silviculture research trials dating back to the 1970's showed results that reflect a historical climate and conditions that are no longer present on the landscape and so new and adaptive methods are required. Like New Brunswick, there is an increasing demand for other objectives. Steenberg highlights restoring late successional species through crop tree release and "restoration shelterwoods". These fall in line with growing more sugar maple and yellow birch, but also in line with the Old Growth policy renewal in Nova Scotia. Steenberg is confident the changing forest practices combined with climate change will increase hardwood abundance within the province but unfortunately this will also increase management challenges.



The talk delivered by Nathan Christie (Escanaba Area Manager, Lyme Great Lakes, Michigan), outlined the fact that forestry decisions are often affected by the volatility of market demand, particularly from a species mix standpoint. According to Christie, there are many factors that affect the ability of silviculturists to manage northern hardwoods including forest composition, topography, soils, and weather. Additionally, local and regional forest product markets also play a critical role in the decision-making process. The topic of his presentation was to better understand how local sawlog, bolt and pulp markets shape future stand composition and forest management outcomes.

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There are many factors that affect the ability of silviculturists to manage northern hardwoods.

Amongst all the topics discussed during NHC 2023 one of the most common themes was the challenges associated with the degradation of northern hardwood forests. In essence, foresters are operating within a forest that is less than optimal from a commercial forestry standpoint – stands that are typically vertically and spatially heterogenous, poor composition and regeneration of desirable species, as well as stand health and tree vigour issues. Within this context, northern hardwood forests are likely to have reduced susceptibility to insects and diseases, less wildlife habitat diversity, reduced market flexibility, and reduced climate resiliency. These factors are often compounded by increased market pressures, thus creating a situation where matching forestry operations to market demands is becoming more and more difficult.

2.2 Regeneration

Laura Kenefic (Ph.D., Research Forester and team leader, U.S. Forest Service, Northern Research Station, Maine) presented strategies for managing compositionally degraded mixedwoods, including identifying limiting species and complicating factors, maintaining seed sources, manipulating regeneration substrate and microclimate, and controlling merchantable and nonmerchantable competition. Managing for mixedwoods is important in today's climate as their presence contributes to a landscape with higher resistance and resilience to pests and diseases.



They also provide wildlife habitat within hardwood stands, create a diverse product stream, and provide benefits for carbon storage. If managed correctly, mixedwoods can provide compatibility or adaptability with future conditions. The difficulties in managing for mixedwoods comes mostly from regeneration concerns.

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As these stands are born through previous harvest practices, there is usually a depleted seed source from past logging, as well as limiting species that require very specific substrates, such as yellow birch, red spruce, and eastern hemlock. Increased hardwood litter and deadwood from past harvesting makes those receptive beds more difficult to obtain for the seed. Hardwood competition from sprouting species such as American beech and red maple is a major concern for sugar maple, which also adds it to the limiting species list. For these reasons, silviculture systems must maintain seed sources, create a suitable microenvironment for seedling establishment, create suitable conditions for recruitment, and control competition through release. Competition from less commercially desirable species, particularly in the understory, was at the forefront of regeneration challenges being brought forward at NHC 2023.

To address these challenges, many are doing research on different variants of the irregular shelterwood (ISS) system. Managing for a species mixture with contrasting ecological objectives can be highly desirable from an economic and ecological perspective, especially when considering resistance and resilience to climate change. However, they are guite challenging to achieve in practice. A variety of ecological niches can promote a diversity of species, and irregular shelterwood is a good solution. It is different from selection cutting because you are not aiming for a continuous forest. The forest will be more than 2 age classes, but not the same over time. The Expanding Gap Irregular Shelterwood System is the first introduced by Patricia Raymond (Ph.D., Ministry of Natural Resources and Forests of Quebec), but there is still much debate on whether this is an appropriate strategy for many stands. Continuous cover irregular shelterwood is the second type Raymond introduces and variants of this method are currently promoted around the world as a good solution for ecological forestry (see Forest MOOC for change). The third type introduced is the extended irregular shelterwood which is much closer to the traditional shelterwood except you are extending the regeneration period and depending on your objectives, opting not to do the final removal to maintain cover. Patricia uses an example of a balsam fir - yellow birch stand to promote yellow birch, and in poor-quality yellow birch stands to increase the quality of the future stand, selecting retention trees of the highest quality. Tree marking was used in these stands and that led to the maintenance of legacy features for biodiversity which helped to maintain the other forest values while still harvesting timber and promoting a desired future stand condition.

Steve Bédard (M. Sc., Research Forester, Ministry of Natural Resources and Forests of Quebec) presented his research on ten-year response to Irregular Shelterwood in Québec. He agrees that the current selection system is not well-adapted to irregular and low-quality stands and mostly favours regeneration of shade tolerant species. On the flip side, the regular shelterwood system is not adapted to irregular stands that resulted from those selective cuttings (because there are valuable small and medium sized trees). Adapting silviculture to include irregular shelterwood systems recognizes the complexity and diversity inherent in promoting resilience to climate change.





His work compared hybrid single-tree and group selection cutting, which was the most prescribed treatment, with two novel variants of the Irregular Shelterwood System. These treatments were also coupled with mechanical understory American beech control, soil scarification and deer exclusion. His central conclusion was that despite high beech mortality, its abundant regeneration in the cutting treatments as well as in the control indicate that this species will probably dominate in the future to the detriment of sugar maple and yellow birch.

Thomas McCay (RPF, MFC., Chief Forester, Haliburton Forest & Wildlife Reserve) presented the current approach Haliburton Forest has taken to improve ISS outcomes at the stand and forest level. He argues disagreements in variations of irregular shelterwood are likely due to discrepancies for what is most appropriate for your region and your objectives. His efforts to develop, and improve, an alternative ISS are based on the operational reality that across central Ontario, an increasing number of stands do not meet the criteria for management under the preferred system of Single Tree Selection. These stands are typically vertically and spatially heterogenous, and the traditional alternative of Uniform Shelterwood cannot provide the required results under these conditions. Irregular shelterwood makes a very good alternative on paper, but it has problems of its own:

- How do you audit the tree marking (or in New Brunswick's case, the operator's decisions), or regeneration success?
- How do you forecast the next entry or make a schedule or put it into your growth and yield model?
- How do you ensure this is not just a disguise for high grading?

McCay argues there are no clear and immediate answers to those questions, so constraining is important. You need to know when you will be coming back. He states you need an effective stand inventory that can identify patch variation. He highlights how patch to patch variation can be much more important than stand metrics when evaluating these stands. Having a clear road map for the sequence of treatments in irregular shelterwood is so important. Rigorous prescription and treatment direction that will allow it to be audited.



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In the interest of promoting regeneration of desired species, Simon Bilodeau-Gauthier (Ph.D., Forest engineer and biologist, Forest Research Branch, MNRF, Quebec) presented on the subject of natural and artificial regeneration in northern hardwood stands in relation to harvest, browsing, and competition. According to Bilodeau-Gauthier, important challenges will affect northern hardwood stands in the near future, given that the main target tree, sugar maple, does not regenerate as easily as it did in the past. The sugar maple decline is not a new phenomenon, but increasing presence of American beech in the understory, higher levels of deer browsing, decreasing soil fertility, and environmental changes are cause for more than the usual concern.

> Mike Walters (Ph.D., Forest Ecologist and Associate Professor, Michigan State University) presented his work aimed at addressing inadequate stocking of desirable stems in sapling classes of northern hardwood forest in some regions of Michigan.

> The goal of his research is to identify combinations of silvicultural treatments that increase the diversity and density of sapling recruits over forested landscapes where deer-browsing pressure and other limiting factors are at play. His study is rooted in a 140-site evaluation of silvicultural alternatives to current management by selection silviculture. Walters concluded that deer use, high basal area, and lack of local seed sources were related to low regeneration density and diversity.

American beech is not the only understory competition managers are dealing with. Greg Edge (MS., Forest Ecologist/Silviculturist, Wisconsin Department of Natural Resources, Division of Forestry) presented an evaluation of the efficacy of high stumping as a mechanical treatment to control Ironwood. Ironwood is becoming increasingly common in the midstory and understory of northern hardwood forests in Wisconsin, particularly in degraded stands and areas subject to significant deer browse. The shade and competition caused by dense layers of ironwood saplings interfere with regeneration of other valuable northern hardwood species in the same way American beech does with our sugar maple in the Acadian Forest.

NHC 2023 also demonstrated that researchers are hard at work developing analytical tools aimed at forecasting regeneration within various scenarios. For example, Hugues Power (Ph.D., Researcher, Ministry of Natural Resources and Forests, Quebec) presented his sapling-based recruitment model for sugar maple dominated stands. His research efforts stem from the fact that over the last few decades, compositional changes have been observed in the sugar maple-dominated stands of southern Quebec. The module considers the number and size of saplings from the main tree species to predict the recruitment of new merchantable size trees.



The new recruitment module improves the precision accuracy of merchantable stem recruitment, and consequently, improves the prediction of future composition for sugar maple stands.

2.3 Vigour and Quality

The challenges associated with developing forestry systems aimed at stand improvement, and the closely related topics of tree vigour and timber quality have much in common with regeneration concerns and can be solved with many of the same management principles. The bulk of research presented at the NHC that directly relate to increasing stand vigour dealt with practical field research aimed at testing and developing tools for practitioners.

For example, François Guillemette (M.Sc., Forest Research Department of Ministère des Ressources Naturelles et des Forêts du Québec) showcased his work on assessing vigour when tree marking. The end goal of his work was to help tree markers better assess tree vigour based on the presence of individual defects. To accomplish this, he set out to empirically validate the classification systems used in the field. His study assessed tree vigour using repeated measurements collected as part of long-term silvicultural trials conducted in 615 permanent plots throughout the northern hardwood forest of Quebec, Canada. His results confirmed that crown dieback is by far the best indicator of tree vigour. They also showed that the rate that vigourous trees develop defects increased with increasing diameter. John Caspersen (Ph.D., Associate professor, Institute of Forestry and Conservation, University of Toronto) presented his comparative study of the potential advantages and disadvantages of a simplified tree marking system based mainly on crown dieback and stem defects over those currently used in the province of Quebec, which are based on a more complex set of classification criteria. He conducted tree marking simulation and value recovery assessments in 14 managed stands distributed across the northern hardwood range. His results confirmed that the simplified system not only facilitated stand improvement, but also significantly recovered more value (17 % on average) at the stand scale.



NHC 2023 was also an opportunity to shine a light on some of the great research work being done to improve outcomes further downstream of the forest value chain. Maximizing the value of harvested timber products is an essential component of managing northern hardwood forests sustainably. Several very interesting studies related to different stages of value maximization were presented. Filip Havreljuk (Ph.D., Researcher, Ministry of Natural Resources and Forests of Quebec) presented models developed to estimate log grade occurrence and volume of sugar maple and yellow birch in northern hardwood stands in southern Quebec. For each species, they used data from more than 2,000 trees harvested and bucked into logs at 30 sites across Quebec's hardwood forests since the early 2000s. Separate models were developed for each species by adding site predictors, such as climate and ecological variables, to tree-level variables, such as tree diameter at breast height and tree quality class.

Malcolm Cockwell (RPF, Ph.D.(c), Managing Director, Haliburton Forest) presented his research work on tree selection based on financial maturity. According to Cockwell, decisions about tree selection for harvesting and retention are typically guided by biological concepts related to the stocking level of forests. On the other hand, maximum diameter is an inherently economic concept that identifies the point of financial maturity. Previous assessments of maximum diameter of northern hardwoods focus on the rate at which trees increase in value due to growth and product development, but few also considered the risk of a tree declining, decaying, or dying between harvests. His analysis of long-term datasets provides a new operational perspective on maximum diameter, and therefore financial maturity, among northern hardwoods.

Caroline Bennemann (Ph.D. (c), University Laval) presented the preliminary results of her research work on tree bucking. Tree bucking is one of the most complex working steps during harvesting operations and particularly demanding in trees with complex architecture, which is very much the case for most northern hardwoods. Bennemann's research characterized the Acadian Forests in New Brunswick based on tree inventories made between 2012 and 2021. More than 250,000 trees were analyzed for this purpose. The objective of her study is to formulate enhanced bucking solutions, based on an increase of monetary value at the tree level, while maintaining a satisfactory harvesting productivity.

The forest being managed today is degraded and regeneration issues seem to be a reality in most jurisdictions, leaving the future even more uncertain. No matter the challenges, NHC 2023 was a reminder that people are working hard to find answers and knowledge all along the spectrum – from adapting forestry systems to a changing forest, to regeneration, increasing stand vigour and quality, adding value along the chain, and adapting to changing market demands. Quality research, actionable tools, and foresters who care about the future of the northern hardwood forests are, at the very least, an excellent starting point for addressing knowledge gaps.



2.4 Summary



Forest Management

New Brunswick Silvicultural Strategies: Chris Ward discussed New Brunswick's efforts to meet growing hardwood timber demands, emphasizing the need for improved silviculture, especially in tolerant hardwoods. They face challenges due to a gap in immature and mature hardwood volumes and increasing demands for other uses.

Diverse Demands in New Brunswick: New Brunswick's forest industry serves various sectors, including hardwood sawmills, pellet facilities, panel mills, and pulp and paper mills. Demands include maple syrup industry growth, conservation areas expansion, and increased zoning for tolerant hardwood management.

Nova Scotia's Triad Model: James Steenberg presented Nova Scotia's adoption of the Triad model for functional zoning. Challenges include quality and access to quality stands, stunted sugar maple due to exposure, and the need for new adaptive methods.

Market Demand Impact: Nathan Christie highlighted how market demand volatility, especially concerning species mix, influences forestry decisions. Factors such as forest composition, topography, soils, and weather, along with local and regional forest product markets, impact stand composition and forest management outcomes.



These presentations emphasized the need for adaptive strategies, balancing diverse objectives, and addressing challenges related to wood supply and market dynamics in managing northern hardwood forests.

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Silviculture

Challenges in Northern Hardwood Forests

Issues include spatial heterogeneity, poor species composition, and regeneration difficulties, compounded by market pressures lead to the need for evolving strategies in silviculture.

Strategies for Managing Mixedwoods

Efforts to address compositionally degraded mixedwoods involve identifying limiting species, maintaining seed sources, and controlling competition.

Stand Vigor and Timber Quality

Tree marking research suggests assessing tree vigor during tree marking and developing simplified tree marking systems for stand improvement.

Maximizing Timber Product Value

Studies on maximizing value aim to estimate log grade occurrence and volume, explore tree selection based on financial maturity, and improve tree bucking.

Silviculture Trends

Forest stands face degradation, no longer meeting the criteria for management under single tree selection. Challenges include limitations of cut-to-length systems, debates over continuous cover versus expanding gap, and other irregular shelterwood methods, constraining their application for specific objectives and regions.

Research Gaps

What does the future look like with more expanding gap variants of irregular shelterwood?

- Technology to increase accuracy of precision forestry
- More accurate models to predict the future forest when basal area removal is altered from traditional practices, region specific silviculture training
- Improved operator training or tree marking in hardwoods



3.1 Adaptive silviculture

Climate change introduces a suite of unknowns into conditions affecting forest growth, development, and health that affects the ability of northern hardwood forest ecosystems to continue to provide desirable ecosystem functions and socioeconomic services. The general takeaway from the conference was that forest managers need to develop strategies for retaining ecologically and economically productive forests in the face of climate change. The challenge is to maintain a forest composition that is resistant and resilient to change while preserving its ability to produce the timber quality needed for commercial species, essential to supply the forest industry. Cédric Albert (RPF, Ph.D. (c), Associate professor, University of Moncton) forecasts the changes in wood supply in New Brunswick using a more accurate method for parameterizing strategic planning models (Woodstock) using a spatially explicit individual tree-based model derived from PICUS. The model was then applied to the Gagetown forest located in southern New Brunswick and results showed that climate change could lead to a deficit of 10-40% of the available wood volume after only 80 years without any forest harvesting activities (Albert et al 2023).

The Adaptive Silviculture for Climate Change project (ASCC) showcased by Jessica Wikle (Ph.D. (c), Faculty member, Forestry Department and Manager, Research Forests, University of Vermont) is an international network designed to examine adaptation strategies to address changes related to climate through operational-scale treatments based on local expertise in forest management. The aim of the project is the development of strategies for retaining forest integrity in the face of climate change that are regionally relevant and can be incorporated into current silvicultural planning processes. This project follows the strategy and treatment gradient for potential responses to climate change that includes: no action (passive forestry), resistance, resilience, and transition. During NHC 2023, we heard researchers and practitioners discuss silviculture options all along that spectrum.

No action, or passive forestry, is letting nature dictate what species assemblage results from the effects of a changing climate. It may demand fewer resources than other approaches and is less prone to failure, but this is the strategy that may impact our wood supply and society the most. Less commercially desirable species may encroach on the niche currently occupied by highly valued species, and a highly competitive stand will require a higher water and nutrient uptake where soil quality and water availability are expected to decrease. For example, in the case of our hardwood species, sugar maple and yellow birch will most likely be the losers, making way for species such as American beech and red maple (Albert et al. 2023).

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These replacement species, although more resilient, are far less interesting economically, which means a potential decrease in volume and quality of timber. Silvicultural approaches that increase species, structural, and functional diversity allow managers to address the concerns associated with climate change by hedging their bets against multiple threats. The objective being to apply silviculture treatments that will increase resistance to stress and promote resilience.

Healthy and vigorous trees with good growth rates will withstand cumulative stress better than those already competing for resources. If we want to improve resistance to drought, the simplest method is to thin at different times in the lifecycle of the stand, reducing competition for key resources (Albert et al. 2023) Crowns develop more fully, enabling the tree to more effectively transform CO₂ into carbon through photosynthesis. Having fewer trees on one micro-site also reduces competition for water. Thinned stands will also reach economic maturity sooner, allowing for subsequent adaptation silviculture earlier in the rotation, to further reduce risk. This practice is well suited to most tree species.

Resilience is the capacity of an ecosystem to return to its initial state after being disturbed. For example, we can make a forest resilient to spruce budworm outbreaks by promoting healthy new cohorts of softwood and mixed species. The insect primarily attacks mature trees, thus allowing the existing regeneration to grow back more quickly. The forest will therefore return to its mature state more quickly than without the younger cohort. We can implement this approach by adopting silviculture regimes that encourage regeneration – such as shelterwood systems, irregular shelterwood systems, and uneven-aged management.

Most presentations aimed at the topics of improving resilience of northern hardwood and mixed stands dealt directly with practical silviculture options. One of the main takeaways that emerged was the fact that, in most jurisdictions and stands, foresters are moving away from more traditional northern hardwood systems like the Single Tree Selection System and the Uniform Shelterwood System. These forestry systems are proving more and more difficult to implement in the current context of climate change. While it is difficult to discern the effects of climate change from other factors – past land use and harvesting methods, disease, herbivory, insects, etc. – most researchers and practitioners seem to agree that climate change will bring further uncertainty and potentially accentuate many of these issues. The forecasted change in climate brings with it a sense of urgency that seems to be acting as a catalyst for adaptive silviculture and the trial and implementation of new, or hybrid, silviculture systems. As discussed in the section on promoting heathy regeneration, the study and implementation of various Irregular Shelterwood Systems (ISS) was the topic of several presentations. This is also extremely relevant to the climate change adaptation challenge we currently face.



3.2 Assisted migration

The breadth and scope of research work related to transitioning northern hardwood forests that was presented at NHC 2023 speaks volumes on the changes expected to be brought forth by climate change. Transition is the most radical, costly, and risky option within the treatment gradient. Forested assisted migration is a climate-adaptation strategy entailing the deliberate movement of individuals or genetic material from native source populations to locations either within or beyond their current ranges. Managers use this strategy to establish forests today that can thrive and sustain goods and services in expected future climate conditions. Assisted migration is mainly executed through artificial regeneration. It requires the knowledge of what tree species, or different genotypes of those species, we should be migrating. NHC 2023 clearly demonstrated that assisted migration and artificial regeneration are topics of interest as a potential solution to help our forests adapt.

Assisted migration is a climate adaptation strategy where we move species or genotypes to locations within or beyond their normal growing range in advance of climate change



The presentation delivered by Loïc D'Orangeville (Ph.D., Associate professor, Faculty of Forestry and Environmental Management, University of New Brunswick) was a case in point. He showcased the TransX project; a transborder climate gradient experiment that necessitates the creation of a network of provenance trials across eastern Canada and the U.S. that aims to test the warming vulnerability of northeastern tree species and their assisted migration potential. The network is composed of 12+ tree common gardens (provenance trials) where young trees composed of carefully selected natural and improved genotypes will be planted. Along with some softwoods, D'Orangeville is looking at five hardwood species including red maple, yellow birch, white birch, red oak, and sugar maple. Major issues in the project include lack of properly documented seed sources, with only a few reliable resources from the United States and Canada.

Another issue is survivability of the hardwood seedlings due to their specific site requirements and pressure from predators. Storm Robinson (MScF, NHRI Research and Development Forester) presented an update on an artificial regeneration of maple project (ARM) meant to explore these and other issues in artificially growing hardwoods and present current and future resources where practitioners can turn if they are interested in growing hardwoods artificially.



D'Orangeville hopes his research will lead to a better knowledge of the climate change vulnerability of temperate and boreal species, especially in the role of canopy and terminal growth phenology and the role of local adaptation (comparing genotypes) and the potential of each species for assisted migration. He also hopes to highlight the sensitivity of improved trees and the potential climatic risk of increased productivity on those sites—essentially, the potential trade-off between productivity and climate vulnerability.

The Desired REgeneration through Assisted Migration (DREAM) project, presented by Christel Kern, Ph.D., (Research Forester, U.S. Forest Service – Northern Research Station) is another great example of the work being done on the assisted migration front. DREAM is an international collaboration of researchers and managers that specifically seeks to address knowledge gaps and develop the necessary tools for successfully planning and executing forested assisted migration plantings (Royo et al, 2023). Although several assisted migration trials are underway, implementing this approach operationally is limited by major knowledge gaps and decision support tools. There is also no official U.S. policy in appropriate actions to take in assisted migration, and even the basic decision of whether to implement assisted migration, or to avoid it completely, is a difficult one (Williams and Dunroese, 2013). DREAM experiments and models and tools to target seed selection are underway in northern hardwood and temperate forests of Wisconsin and Quebec with aim of narrowing that knowledge gap.



3.3 Summary

Climate Change and Forest Management: The conference highlighted the challenges posed by climate change on northern hardwood forests and the need for adaptive strategies. Retaining productive forests while adapting to climate change is a central concern.

Strategies for Climate Adaptation: Presenters discussed strategies for adapting to climate change, including retaining forest integrity in the face of climate change. This involves considering passive forestry, resistance, resilience, and transition in response to climate-related changes.

Passive Forestry: Passive forestry allows nature to dictate species assemblages but may impact wood supply and society. Less commercially valuable species might replace highly valued ones, potentially leading to decreased timber volume and quality.

Silviculture for Diversity and Resistance: Silvicultural approaches promoting species, structural, and functional diversity aim to increase resistance to climate-related stress and enhance resilience. Thinning stands at different stages of their life cycle and encouraging regeneration are key practices for improving resistance to drought.

Transition and Assisted Migration: Transition involves moving forests to adapt to future climate conditions and is a costly and risky option in hardwood management. Assisted migration, through artificial regeneration, has become a mainstream topic in northern hardwood silviculture. The conference showcased projects like TransX, DREAM and ARM that focus on tree species' vulnerability and assisted migration potential.

The conference emphasized the urgency of climate change adaptation and the need for innovative silviculture approaches to maintain forest health and productivity.

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4.0 Technology solutions

During NHC 2023 technology, and more specifically the digitalization of the forest value chain, emerged as the thread that seems to hold the future of northern hardwoods forestry together. The conference showcased technology as one of its central themes, exploring various subjects during engaging workshops, enlightening scientific sessions, and an engaging field day. The event drew attention to the imperative need for the forestry sector to embrace digitalization to effectively tackle the forthcoming challenges, optimize resource management, and ensure sustainable practices.

The keynote address by Doug Jones (MF, President of Remsoft) shed light on the hardwood industry and forestry around the world. He states, "thinking about where we are at with hardwood management and what we are seeing around the world, hardwood often seems like a secondary thought." He says hardwood management is so complex but there's just something about it that pulls on your heartstrings. With 500 million acres under management, Remsoft is on the front lines of digitalizing the most complex supply chain that exists; dynamic markets, product variation, managing a natural environment, and imperfect information. Jones states it is data chaos that is holding us back, spreadsheets that are not connected or standardized should be a thing of the past. The other major issue Remsoft sees is the aging workforce. Attracting analytical foresters into this space is the biggest challenge and their solution is to take training into their own hands and plans are underway for a "Remsoft Academy".

4.1 Digitalization of the forest value chain

While the technology driven workshops and presentations certainly showcased the potential benefits associated with the digital transformation of the forest sector, much of the other research presented had strong technology components as well. The conference highlighted that today's forestry is defined by sophisticated technology and management systems – UAVs, mobile LiDAR, multispectral satellite imagery, GIS, Random Forest, forecasting models, AI, harvested head data, logistics and analytics software, and more. From data capture to analyzing mountains of data to gain a competitive business edge, and everything in between, highly sophisticated technology is now present at every stage of the forest value chain. The idea of the digitalization of the forest value chain, and the associated technology, are becoming an essential component of both research and forest operations.

Advances in drone technology include an increase from 15 km range to 500 m range. Line-of-sight laws are really the only hinderance to the distance we can fly. Kevin Toderal from RMUS says that as drones become more autonomous and safe, we should see changes in line of sight laws. He predicts possibilities for more autonomy to exist in about a three-year window. Along with changing line of sight policy, this can help with the aging workforce and shortage of foresters who have the skills to fly a drone.

Bastien Vandendaele of NHRI followed with a workshop on digitalization of trees for precision forestry using LiDAR, encompassing both mobile and UAV-based applications. Vandendaele says airborne LiDAR has its uses but falls short in capturing hardwood trunks and branches. Terrestrial LiDAR has been around for about 30 years, but it creates a very dense point cloud and is not easy to use in the field. Thanks to researchers like Vandendaele, we are learning the benefits of MLS (mobile laser scanning) in capturing individual tree metrics. Additional highlights include its ability to be used for ecological assessment, evaluation of competition, and regeneration assessments in gaps. It also serves to validate the accuracy of data captured in field collections. But the MLS research often encounters limitations in dense or complex forest measurements, and results may not be universally applicable. Initial investments and operational costs can be high, and the approach is generally restricted to small-scale applications, typically no more than a hectare at a time. Furthermore, there may be challenges in integrating data, but there are ongoing improvements in this field worldwide.

Jean Francois Prieur from CERFO discusses how Artificial Intelligence (AI) presents both significant potential and challenges in the realm of forestry research. One area of promise is the use of machine learning to predict dominant species within forests. However, a major challenge persists in achieving accurate species identification at an operational level. It is crucial to acknowledge that the initial enthusiasm surrounding Airborne Laser Scanning (ALS) for species identification has proven unwarranted, as there is no magic in a laser pulse capable of species identification.

The application of deep learning, while powerful, is hampered by its substantial data requirements. Current methods often demand tens of thousands of examples for each class, and obtaining such data can be a time-consuming and complex task. This leads to questions about the realistic level of species identification achievable, possibly limited to a plot level. Researchers are also exploring the combination of various imagery sources with PlanetScope data to label training pixels, aiming to enhance Al accuracy. However, it is important to consider the limitations imposed by external factors.

For instance, the worsening of wildfires can complicate satellite image acquisition, making the role of drone technology even more critical for data collection in these circumstances.

4.2 Challenges and solutions

Susan Willis's Digital Timberlands presentation starts with an analysis of New Brunswick's Enhanced Forest Inventory (EFI) metrics versus those collected on the ground, and the differences are significant, particularly in the context of hardwood species. The issues with overestimation of stems, underestimation of quadratic mean diameter, and volume overestimation can impact the accuracy of forest assessments.

Willis explains how the constraints of on-board computer data collection are also an issue in precision forestry. Continuous measurement interruptions due to forks are a common problem in hardwood species.

Addressing these challenges will require innovation and training. Developing more robust technology for data collection and refining measurement techniques can help improve accuracy. Willis states that investing in training programs to recruit and retain skilled workers, especially younger individuals is crucial for the forestry industry's future success. This will be important in adapting to changing wood products and ensuring the sustainability of forest management practices.

Today, many industries face the challenge of an aging workforce, and the forestry sector is no exception. This issue spans across the entire forest value chain, affecting areas such as tree nurseries, field technicians, and harvest operators. Research and development in technology play a vital role in addressing this issue. Enhancing bucking methods, automating and advancing machine processes, refining inventory precision, and providing improved training are all key processes that offer solutions to mitigate the effects of an aging workforce.

Data and systems must be aligned with management objectives, and not the other way around.

The conference brought to light the fact that more and more foresters are turning towards technology to find efficiencies all along the supply chain. The consensus seems to be that there is a clear recognition of the immense potential benefits of moving forward with the digitalization of the forest value chain, but progress is arduous and slow. There are challenges all along the chain – hardware and software standardization, data capture, data formatting and analysis, and more importantly, how to leverage that data most effectively from a forestry business perspective.

Most forest managers are finding it challenging to manage mountains of data of varying quality and finding the right ICT partners to implement, manage and extract value from these mammoth systems. According to Jason Killam, Chief Forester at J.D. Irving, Ltd., data and systems must be aligned with management objectives, and not the other way around. The emergence of such a wide array of technology solutions makes it more important than ever to have clear forest management objectives. The key going forward, according to Doug Jones, CEO of Remsoft, will be the ability for systems and data to integrate seamlessly. Data and analytics will be at the core of the digital transformation of the forestry sector going forward.

Hardwood Management: Keynote speaker Doug Jones of Remsoft Inc. emphasized that hardwood management often takes a back seat in forestry considerations, despite its global significance. This highlights the need for more attention and awareness.

Complexity of Hardwood Management: Jones stressed the complexity of hardwood management and the importance of sharing this knowledge with policy makers, as it has a unique and emotionally resonant dimension.

Data Chaos: The foremost hindrance to progress in the digitalization of forestry is the lack of standardized and structured data. Such data is deemed essential for effective forest management.

Complex Supply Chain: Forestry is considered one of the most complex supply chains due to dynamic markets, product variations, the influence of the natural environment, and imperfect information.

Aging Workforce: A significant portion of the forestry workforce is set to retire in the near future, posing a challenge in attracting new analytical foresters. Initiatives like the "Remsoft Academy" aim to address this issue.

Attracting and Retaining Talent: Attracting and retaining talent is a crucial concern, as the forestry industry evolves and becomes more digitalized, requiring a skilled and capable workforce to meet its demands.

Emerging technology trends: Dealing with mountains of data of varying quality, slow progress in integrating systems and data, finding the right ICT partners, optimizing bucking, digitalizing the entirety of the value chain, the power of AI.

Research gaps: Using technology to find more value through digitalization of the value chain, analytical tools aimed at forecasting regeneration, standardization of software and hardware that are forestry specific, standardization of data capture and formatting from a business perspective, training in AI and technology, improved on-board computer data collection, enhancement of precision forestry techniques.

5.0 NHRI's research priorities and solutions

NHC 2023 was an opportunity for our team to review our practices, talk to our partners, and rally our troops. More importantly, it served as a catalyst and a motivational boost to keep developing and improving. After ten years of working hard to improve the way forestry operations are conducted, and based on what we heard during NHC 2023, we are convinced now, more than ever, that our mandate is useful and that our organization has a central role to play in the future development of northern hardwood forestry. It was reassuring that the priorities of NHRI have been and continue being well aligned with those of the sector.

Like this report and based on our experience and our observations of emerging issues, we believe that our contribution going forward can be grouped into three closely interrelated themes – implementation of adaptive silviculture, digitalization of the forest value chain and northern hardwood silviculture training. Within those research and development themes we intend, as always, to keep the needs of our industrial forestry partners front and center. Our work is meant to be useful and used.

5.1 Forest management planning

To address hardwood management issues such as maintaining hardwood wood supply through increasing demand on other forest values, NHRI is committed to working closely with NBDRED to fulfill those demands. A big solution proposed by Ward was to get focused and implement zoning of our tolerant hardwoods to increase proper silviculture practices in those areas. One of our ongoing efforts to begin this process is through one of our graduate student partners, Elizabeth White. White presented her early research on mapping high quality sugar maple sites as part of the Lightning Round at NHC 2023. The objective of this research is to determine the factors that affect the abundance and productivity of sugar maple and other tolerant hardwood species across New Brunswick. The next step will be to use this process to determine future high quality potential sites to assist in zoning for future forest management plans. Our Silviculture Prescription System's automatic classification tool will assist in zoning as well. A prototype for this is already being tested, and with focused improvements, we know this will assist in the goal of zoning the silviculture of northern hardwoods.

5.2 Improving harvest-based silviculture

NHRI's Silviculture Prescription System (SPS) and the host of field tools stemming from it (worksheets, APP, tree classification system, etc.) is without a doubt our flagship product. It has now been implemented, field tested, and adopted on an operational level for several years. The extensive research and field work that has gone into the production of NHRI's SPS 2.0 makes us confident that it stands as a strong foundation to build on to operationalize adaptive silviculture principles within the northern hardwood forest. The built-in five-step process already addresses many issues presented in this report such as harvester training, change management, and silviculture recommendations such as the time of year harvest should occur to produce the right seedbed for limiting species. However, our constant drive toward continuous improvement leads us to believe it can still be honed, adapted, and perfected. For that reason, we intend to spend energy and resources into reviewing NHRI's SPS 2.0 in the coming months. One of the central goals of the review process will be to ensure it is well adjusted to the changing forest conditions currently faced by foresters, particularly when it comes to adapting to the effects of climate change. Over the next months we plan to run pilot studies to test the implementation, and results, of our current SPS 2.0. To validate our findings, we will create user groups that will recommend changes. Our next step will be to integrate the recommendations, test them through further pilot studies, and repeat until all involved are satisfied with the product. Once the process is complete, we will then be able to confidently roll out NHRI's SPS 3.0. Our goal from the onset is to produce a climate smart SPS 3.0 that can better integrate the effects of the changing climate on our northern hardwood forest. Through that work we firmly believe we can significantly contribute towards the implementation of adaptive silviculture by improving an already useful and effective tool that can be further integrated into northern hardwoods forestry operations.

Under the principles of adaptive management, the NHRI will re-visit previous harvest-based silviculture treatments to verify if new cohorts of regeneration are being established. In doing so, we will create a results-based framework and some technology tools to help practitioners conduct those tasks better.

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5.3 Tools and technology

The importance of digitalizing the forest value chain, and the applied research required to make it an operational reality, has also been part of our research agenda for close to a decade now. NHRI has always been at the leading edge of technological advancement in northern hardwood forestry.

Through the years we have been involved in research and development initiatives at various stages of the forest value chain. This has enabled our team to build a solid network of both ICT partners, and industrial forestry companies, willing to work with us towards the common goal of making the digitalization of the forest value chain a reality. The discussions we have had with experts and industry representatives through the years, and more recently at NHC 2023, have confirmed to us that we must continue playing a central role in developing and mobilizing the knowledge required to ready these tools for application at an operational level.

Our plans include developing a remote sensing-based tool to characterize regeneration before and after treatment – species, density, stocking, quality, health, browsing. To accomplish this, we are convinced we must leverage modern mid-high resolution satellite imagery. While we realize we may have to complement this data with UAV-based products when issues are detected, we remain convinced that the availability, and affordability of satellite imagery make them the technology of choice to fast-track operational implementation.

We also aim to develop sensing-based tools to determine tree and stand health, tree quality and product yield. For the same reasons as stated above, we plan to make satellite imagery the core technology within our development efforts. Our experience has convinced us that satellite imagery, coupled with mobile-laser technology when high accuracy is required, is the fastest, most accessible, and affordable way forward toward operational usefulness.

Developing tools, whether related to the implementation of adaptive silviculture or the digitalization of the forest value chain, is a very important step towards improving forestry operations in northern hardwood forests, but it is only the first. An undeniable fact our team has learned through experience, is that tools will never be leveraged to their full potential if not accompanied by well structured training.

5.4 Knowledge mobilization

Over the years our team has delivered hundreds of classes, workshops, and field days in a wide variety of settings – ranging from the inside of a harvester cabin and under forest canopies, to classrooms and board rooms, multimedia webinars, and everything in between. Another lesson we have learned is that actionable knowledge transfer, and convincing people to use the tools developed, is a hard business to be in. Through the years NHRI has developed a hard-earned reputation of always being there for our clients when they need training. We have never hesitated to invest time and resources, both financial and human, to help our partners assimilate the knowledge they need to improve their operational reality.

The knowledge shared may change over the years, but our dedication to sharing it and helping clients implement those changes remains the same.

Change management is a critical tool for organizations, including those in the forestry industry. Change management facilitates the smooth implementation of new processes, technologies, or strategies by effectively guiding teams and stakeholders through transitions. In forestry, it can be particularly valuable in adopting sustainable and environmentally responsible practices, integrating innovative technologies, and adapting to evolving regulations. By addressing resistance to change, providing clear communication, and fostering a culture of flexibility, change management helps ensure that the industry can navigate transitions successfully and remain resilient in the face of challenges, ultimately benefiting both the workforce and the environment.

Our mobilization products have the potential to significantly contribute to effective change management in the forestry sector. These products, tailored to the specific needs of the industry, can streamline various aspects of forestry operations.

They offer a centralized platform for real-time communication and coordination, facilitating the smooth integration of new technologies and practices. In the context of an aging workforce, they can serve as essential tools for knowledge transfer and training, ensuring that the skills and expertise of experienced workers are passed on to the next generation. Moreover, these products enhance overall efficiency, making it easier for teams to adapt to changing circumstances and remain competitive in the evolving forestry landscape. The five-step SPS process with it's instruction sheets and implementation checklists is an excellent example of how we help clients facilitate effective change management in silviculture practices, and we remain committed to help users through each step.

5.5 Training: bridging the gap between research and practice

One difference seen in other countries like Finland is the willingness to invest in training courses for specific skills in applied research. We are still missing an opportunity to train young people in technology, silviculture, and climate smart practices that provide real-world forestry solutions. It is difficult to recruit and retain skill-specific employees in the sector. Private training would increase our capacity and ability to perform at the level our stakeholders require. In the coming months, we plan to leverage our experience in knowledge transfer and training to begin developing three multimedia-based micro programs for forestry professionals, contractors, and forest workers. The themes chosen are aligned with what we perceive as being some of the most pressing needs within the forest industry. The first micro-program will deal with silviculture for mixed and hardwood stands, the second will be adaptive silviculture for a changing climate. The third program will revolve around the tools associated with precision forestry.

We plan to develop a host of training tools around those three themes, bringing silviculture and technology together and making them readily available. These training and mobilization products can be delivered in various formats and settings and adapted to a variety of audiences.

Our Silviculture Prescription System instruction sheets and future microprograms hold significant potential in addressing the challenges posed by conflicting multiple management objectives, an aging workforce, and promoting effective change management in the forestry sector. These tools provide a structured and accessible way to document and communicate best practices and guidelines. In the context of change management, they can serve as invaluable resources for training and onboarding new, younger workers, ensuring that the knowledge and expertise of the aging workforce are effectively transferred. Additionally, the integration of evolving technologies and sustainable practices within these resources can help bridge the generation gap and equip the industry with the latest tools and techniques.

5.6 Summary

NHC 2023 Reflection

The NHC 2023 conference provided an opportunity to assess existing practices, engage with partners, and boost motivation for further development. It reinforced the organization's belief in the value of its mandate in advancing northern hardwood forestry.

Three Key Themes

The organization identified three interconnected themes for its future contributions:

Adaptive Silviculture

Focus on implementing adaptive silviculture, addressing climate change effects, and honing their existing Silviculture Prescription System (SPS).

Digitalization of the Forest Value Chain

Pursue the digitalization of the forest value chain by developing remote sensingbased tools and leveraging modern technologies.

Northern Hardwood Silviculture Training

Develop training programs, including micro-programs, to bridge the gap between research and practice, particularly focusing on technology, silviculture, and climate-smart practices.

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Summary of NHRI Objectives

Developing Hardwoods Solutions

- Focus on growing more and better hardwoods
- Address the challenge of successful regeneration of desired species in northern hardwoods silviculture
- Highlight the importance of timing in harvesting

Improving Forest Value

- Increase timber value and production of knowledge
- Research and development opportunities in silviculture, forest management planning, and digitalization of the value chain
- Enhance sugar maple growth and promote intermediate treatments, including BMPs for intermediate treatments

Enhancing NHRI's SPS

- Run pilot studies with forest companies for validation
- Incorporate requirements for habitat and diversity
- Incorporate requirements for climate considerations
- Launch a beta version of SPS

Retrospective Study

• Conduct a retrospective study of recent cutovers for regeneration success

Knowledge Mobilization Activities

- Training and development initiatives
- Maintain the website, media presence, and publications
- Sustain partner memberships and customer relationships
- Develop adaptive silviculture guidebooks

Forest Management Planning

- Develop an adaptive management framework, including discussions with DNR and industry partners
- Determine the potential for high-quality hardwoods through zoning with DNR
- Develop tools for automatic assignment of harvest treatments

Digitalization

- Implement precision forest inventory, improving species predictions, and determining recent harvest activity
- Develop remote sensing-based tools for assessing tree and stand health, tree quality, product yield, basal area, and basal area growth rate
- Investigate the use of laser scanners for tree and stand metrics extraction, including the potential for operationalization and scalability
- Produce predictions for product, harvester productivity, and volume

Mobilization

- Create multimedia micro-programs with multiple modules
- Include 2-3 minute lectures in 6-12 modules
- Train all stakeholders in the forest value chain
- Provide operators and contractors with instruction sheets and instructional videos for effective implementation of prescriptions and best practices

These notes provide a comprehensive overview of the workplan's focus areas and strategies for NHRI's future endeavors.

Overall, NHRI's focus is on enhancing existing tools, embracing technology, and delivering effective training to advance northern hardwood forestry and address the challenges posed by climate change and changing industry needs.

6.0 Conclusion

The Northern Hardwood Conference 2023 was an opportunity for the NHRI team to confirm the usefulness our current work, and more importantly, to adjust our knowledge production and mobilization activities going forward. The information presented during the conference allowed us to identify knowledge gaps in the research applicable to northern hardwood forests. Our interactions with industry during the event gave us the opportunity to further understand their most pressing needs. From those experiences we are now in the process of adapting our strategic objectives, operational goals and workplans.

Whether it be the effects of climate change, forest degradation, regeneration and vigour issues, or the challenges of matching forest operations to market demand, it was clear during NHC 2023 that the northern hardwood forest is changing, and forestry practices must urgently find ways to adapt to this new reality. Time tested forestry systems must be adapted and the required tools to implement those changes, and measure the results, must be improved, or developed. In a nutshell, the need for applied research that aims to equip foresters facing those challenges has never been greater.

For over 10 years now NHRI's mandate has been to develop, field test, and help implement tools for foresters with boots on the ground and eyes on the canopy. Many issues that emerged during NHC 2023 have been part of our knowledge production and mobilization efforts since our inception. Adapting forestry systems to address the changing forest, addressing the effects of beech on sugar maple regeneration, integrating multispectral analysis into precision forest inventory workflows, collaborating closely with managers, technicians, and harvester operators to make knowledge useful and usable, and bridging the gap between ICT service providers and forestry departments these are just a few examples of the issues our team has been working on for a long time. Most of these challenges have now moved from the fringe to the mainstream, making it easier to convince partners to invest time and resources into dealing with them on an operational level. During NHC 2023, it was heartening to observe that we may not always do things perfectly right, but we are convinced, more than ever, that we are doing the right things. Our efforts seem to be aligned with the needs of industry, and thus, heading in the right direction.

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Northern Hardwoods Research Institute

www.hardwoodsnb.ca

1 506 737-4736

info@hardwoodsnb.ca

165, boulevard Hébert Edmundston, N.B. E3V 2S8