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NORTHERN HARDWOODS RESEARCH INSTITUTE'S MONTHLY NEWSLETTER

THE LEAFLET

HARVEST KNOWLEDGE, **PROMOTE** GROWTH

SPECIAL EDITION

FOREST REGENERATION

Managing for tomorrow's forests… today!

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SPECIAL REPORT ON REGENERATION

MANAGING FOR TOMORROW'S FORESTS… TODAY!

Establishing forest regeneration is the act of growing back the forest by natural or artificial means after harvesting trees. Forests will also regenerate following natural disturbances such as fire, insect infestation, disease outbreaks and weather events.

The amount of forest regenerated, and the success of regeneration activities tell us how well the forest is being renewed and is an indication of forest sustainability. Managing hardwoods requires well-planned treatments that not only tend and improve existing trees but also regenerate desirable species.

Hardwood-dominated forests continue to be an important part of Eastern Canada's economy, providing saw logs and pulpwood, as well as non-timber forest products. They also play an important role in terms of wildlife habitat and biodiversity, as well as carbon sequestration and climate-change mitigation. Considering their importance, it is critical to ask ourselves tough questions regarding the management of our hardwood resource, and more importantly the results of those efforts. Just how well are our hardwood dominated forests doing in the Atlantic region?

Our research seems to point to some worrying trends. A review of 20 years of inventory data and re-measurements of permanent sample plots in the Maritime provinces shows that:

- ⇒ **The proportion of large trees and sawlogs is declining;**
- ⇒ **Poor quality trees have less sawlog recovery (30%);**
- ⇒ **Sugar Maple proportion is declining (- 20%);**
- ⇒ **Many treated areas (>50%) in the past fail to meet regeneration expectations in the short term;**
- ⇒ **Less than 25% of the plots studied meet expected stocking of desirable species (Sugar Maple and Yellow Birch);**
- ⇒ **There is significant uncertainty regarding the expected future growth and regeneration.**

Based on theses results it seems that, at least from a timber production standpoint, our hardwood forests are not doing that great. However, the good news is that through silviculture, these problems can be controlled, mitigated, and even eliminated. Our research has brought to light certain issues with hardwood forest management, but more importantly our work is pointing towards some promising solutions.

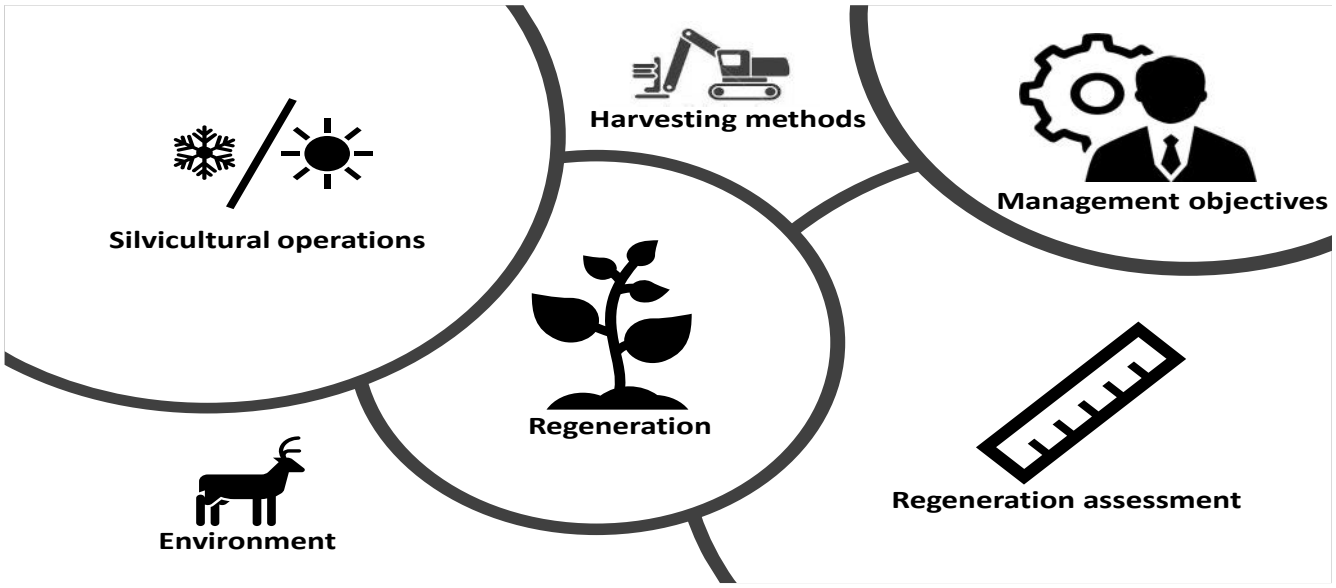
In this special issue of The Leaflet we present our readers the work we've done on northern hardwood forests regeneration in the past, the projects we are currently working on and what we are planning for the future. We hope that you will find this special report interesting, and more importantly, that it will convince you to join us in our quest to identify, develop, test and implement solutions to the many challenges facing the northern hardwood forest and the valuable resources it contains!

For more information on northern hardwood forest regeneration see:

Gaetan Pelletier, "Recruitment drive: : Hardwood management must reverse encroachment by low value species", Atlantic Forestry Review, January 2019, p.17. **[LINK]**

FACTORS THAT IMPACT REGENERATION

DOES THE RIGHT TREATMENT ALWAYS EQUATE WITH GOOD REGENERATION?



Several biotic and abiotic factors can influence regeneration following a silvicultural treatment, some factors are related to 1) land management, 2) silvicultural operations, 3) harvesting methods, 4) regeneration assessment and 5) environment . **(More Information: LINK)**

Management Objectives will influence regeneration following a treatment by dictating the goals of the silvicultural treatment. For example, if the objective of the silvicultural treatment is to increase the amount of biomass available for browsing, you will not necessarily invest in a soil preparation to favor Yellow Birch establishment and accept to have a greater proportion of non-commercial species. On the other hand, if you manage your land to increase gross merchantable volume, you will probably invest in additional resources to increase the regeneration density of commercial species if needed.

Silvicultural operations factors are linked to the conditions in which the silvicultural treatment is done, such as season of harvest and weather conditions. Due to greater soil compaction following a treatment done during summer, regeneration can have difficulties to establish and grow. On the other hand, if not enough soil disturbance is made during a winter harvest, some species such as Yellow Birch will have trouble establishing.

Harvesting methods also influence regeneration through factors like trail networks, treatment type and harvesting systems. Regeneration dynamics following a treatment is influenced by the intensity of the treatment. A low treatment intensity will tend to have less pioneer species right after the treatment and will favor the regeneration of shade-tolerant species. Nonetheless, if not enough canopy opening is done, regeneration will not be encouraged. Furthermore, research done at the Northern Hardwood Research Institute suggests that a low intensity partial cut is positively related with Beech dominance and that high intensity treatment decreases Beech dominance. **(More Information: LINK).**

Regeneration assessment is currently done through plot-based field surveys which is a time-consuming method with limited spatial extent. Due to certain limits in terms of assessment methods, regeneration following a treatment can be falsely estimated. The timing at which the assessment is done can also alter results. For example, if the inventory is done two years after a clear-cut the dominant species in the regeneration strata should be mostly non-commercial species while an assessment done 10 years after a clear-cut should have more commercial species present. **(More Information: LINK).**

Environmental factors such as soil and light availability influence regeneration the most, but other factors such as topography, browsing pressure, climate and surrounding vegetation are also important. Research done at NHRI suggests that Yellow Birch tends to favor sites having fine soil texture, a pronounced slope and poor quality while Sugar Maple will favor high quality sites. **(More Information: LINK).**

The Northern Hardwoods Research Institute (NHRI) felt that there was a need to perform a synthesis of the body of knowledge on the topic of regeneration response and dynamics of commercial species after silvicultural treatments. The following annotated bibliography gathers information about regeneration processes in hardwood stands, but also serves as a list of references for future studies on post-harvest regeneration.

ANNOTATED BIBLIOGRAPHY

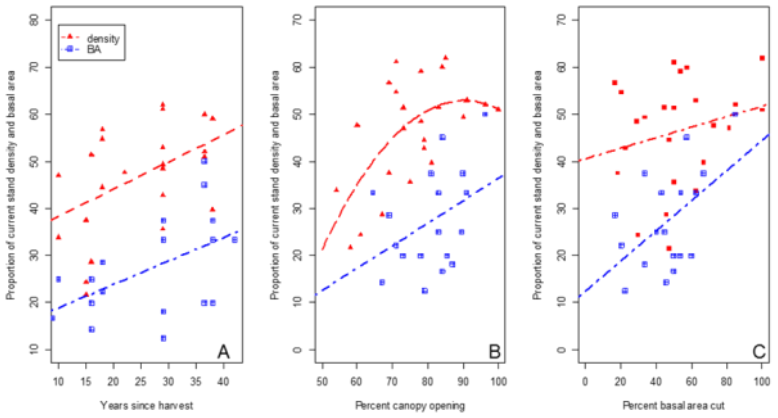
REGENERATION AND STAND HISTORY

THE ROLE OF ADVANCED REGENERATION ON STAND DEVELOPMENT

Partial harvesting is a family of treatments used to sustain the production of high quality sawtimber in northern hardwood forests sometimes when the quantity of advanced regeneration is generally adequate to regenerate stands. Knowledge of silvics and site conditions are considered to determine the intensity and method of harvest. For example, larger gaps are created to regenerate mid-tolerant species while smaller gaps are created to regenerate shade-tolerant species. Partial harvests consider advanced regeneration and new recruitment to regenerate stands . Our knowledge of the appropriate cover to retain for successful canopy recruitment and the role that advanced regeneration play in stand development following partial harvest in northwestern New Brunswick is still limited.

Our research suggests that harvest intensities based on the dominant advanced regeneration composition and harvesting systems that minimize the risk of physical damage to advanced regeneration are required to achieve partial-harvesting objectives.

Figure 1: The proportion of seedlings and saplings of Yellow Birch, Sugar Maple and Red Maple (referred to as TOHW-regeneration) in the current overstory density and basal area, as functions of years since harvest (A), percent canopy opening (B) and percent basal area removal (C).



Research Highlights

- Harvest re- entry cycles of less than 20 years can ensure advance regeneration recruitment into merchantable diameter classes.
- Protection of advance regeneration during harvesting will ensure enough recruitment into merchantable diameter classes.
- Maintain at least 20% canopy cover, especially in a two-aged stand, to reduce the risk of regeneration mortality and improve stand quality over time.

MORE INFORMATION

"Our research suggests that harvest intensities based on the dominant advanced regeneration composition, and harvesting systems that minimize the risk of physical damage to advanced regeneration, are required to achieve partial-harvesting objectives."

MANAGING REGENERATION

TRADITIONAL SILVICULTURE SYSTEMS

Northern hardwood forests of eastern Canada have become more heterogeneous mostly as a result of past partial treatments that have left a mosaic of structural and compositional conditions. Different silvicultural systems that attempt to integrate management objectives such as timber and regeneration of the next cohort are currently applied in this region. The objectives of the silvicultural systems that are applied in all forest types are to create environmental conditions favorable for the establishment of desirable regeneration. However, most systems are poorly defined and/or are generally applied in stands that are not suitable. Below, we offer readers a brief review of our research on some of the best-known silviculture systems.

SEED-TREE SILVICULTURAL SUB-SYSTEM

In the seed-tree sub-silvicultural system, a few live trees are retained on the cut block to provide seeds for forest regeneration. This method is thought to be an economical option for forest renewal. One concern of this approach of naturally regenerating forest stands is the longevity of the retained trees and interference from non-commercial vegetation. We have investigated the seed-tree approach to naturally regenerated stands in hardwood stands in New Brunswick. Our analysis confirmed that the proportion of Yellow Birch seedlings was generally increasing up to 40m away from a seed tree and declined thereafter. The optimum distance between seed trees for Yellow Birch seedling recruitment ranges from 30m to 40m. However, relative density of Yellow Birch seedlings was negatively influenced by competition from non-commercial tree species within each plot (Figure 2) (link to tech. note).

Research Highlights

- Distance to a seed tree had a significant effect on the relative density of Yellow Birch and indicates that seed dispersal range is crucial for successful recruitment of Yellow Birch.
- A best practice is to leave at least 10-20 evenly spaced mature Yellow Birch trees per hectare that are capable of producing seeds.
- After seedlings establishment, competition will become the next important factor.

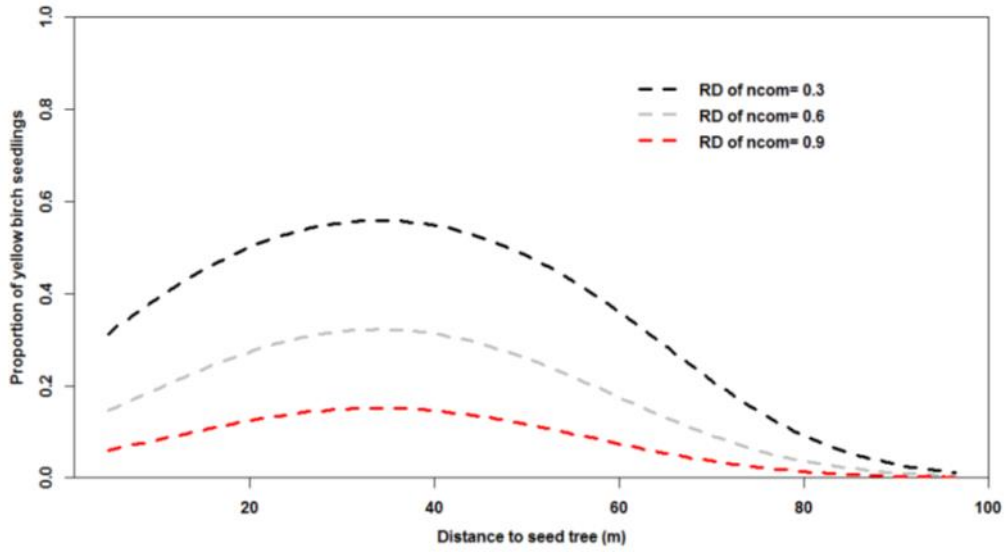


Figure 1. The predicted proportion of Yellow Birch seedlings as a function of distance to seed tree and competition from non-commercial tree species.

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MANAGING REGENERATION
TRADITIONAL SILVICULTURE SYSTEMS

Shelterwoods and two-age sub-systems

In these silviculture regimes forest managers use partial harvesting that emulates small to medium scale disturbance in order to increase residual stands regeneration and productivity. In fact, when large-scale disturbance cycles are long, small-scale disturbances that create canopy gaps within a forest landscape become an important mechanism for generating opportunities for changes in forest composition and structure. These small–scale disturbances can affect forest regeneration in markedly different ways depending on large-scale disturbance legacies of the forest (Baral et al., 2016). Since the results of studies on the effect of gap dynamics on forest regeneration are rarely transferable between forest types and even between regions of the same forest, this study aims to assess the temporal response of the regeneration and production of residual hardwood forest after partial harvesting with different intensities on different stands characteristics. Obtaining such evidence is critical for policy, management and land planning to exploit hardwood forests in sustainable ways.

Research Highlights

- Northern hardwood forests of New Brunswick respond positively to partial harvest by increasing over time both sapling and tree recruitment.
- The response of merchantable tree basal area increment to the different types of partial harvesting is species-dependent with the majority of species responding positively by increasing merchantable tree basal area over time.
- The basal area increment of merchantable trees is faster in stands with low residual basal area than stands with high residual basal area.
- All stem risk classes, and stem form classes of residual trees respond positively to partial harvest by increasing over time the basal area of trees from the different stem risk classes and stem form classes.

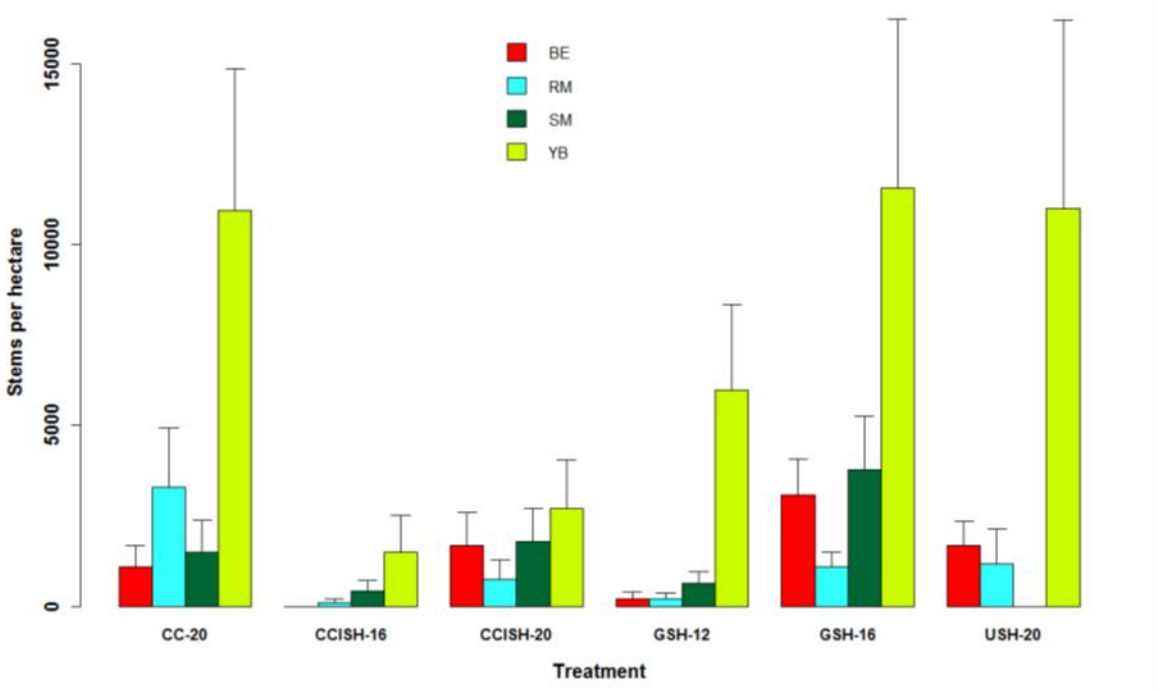

Figure 2: Tree seedling densities across different treatment combinations. CC-20, overstory removal (status quo) with 20m trail spacing; CCIS-16, continuous cover irregular shelterwood with 16m trail spacing; CCIS-20, continuous cover irregular shelterwood with 20m trail spacing; GSH-12, group shelterwood with 12m trail spacing; GSH-16, group shelterwood with 16m trail spacing; and USH-20, uniform shelterwood with 20m trail spacing.

MORE INFO
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MANAGING REGENERATION

TRADITIONAL SILVICULTURE SYSTEMS

COMMERCIAL THINNING TREATMENTS (CT)

In even-aged silviculture, thinning is often carried out to promote diameter growth of desired species and to improve stand composition and quality. While not the original intention, thinning in tolerant hardwood stands often allows new cohorts of trees to establish and shift the structure towards two-aged and eventually multi-aged stands. This has the potential to transform even-aged stands to uneven-aged stands if adequate space and time are provided for regeneration establishment and recruitment into the canopy layer. The composition of the new cohort depends on the magnitude of the removal and the local ability for species to get established. Different thinning intensities are expected to cause different species regeneration and recruitment. For example, low thinning intensities that enhance the availability of light to the stand much less than heavy thinnings may favor the regeneration of shade-tolerant species such as Beech and Sugar Maple. On the other hand, heavy removals may promote the regeneration of mid– and shade-intolerant species. The composition and density of the new cohort of trees following thinning treatment in even-aged stands are important factors that may influence future management options. This treatment has a very high potential to reverse the current negative trend for key sppecies.

Research Highlights

- Beech density decreased while Sugar Maple density increased with thinning intensity, showing opposite response to the treatment.
- The density of Sugar Maple seedlings was higher than all other species across the treatment.
- Higher basal area of dead trees increased the density of Sugar Maple but decreased the density of Beech seedlings.
- Thinning can be used to control density of the regeneration of desired or interfering species

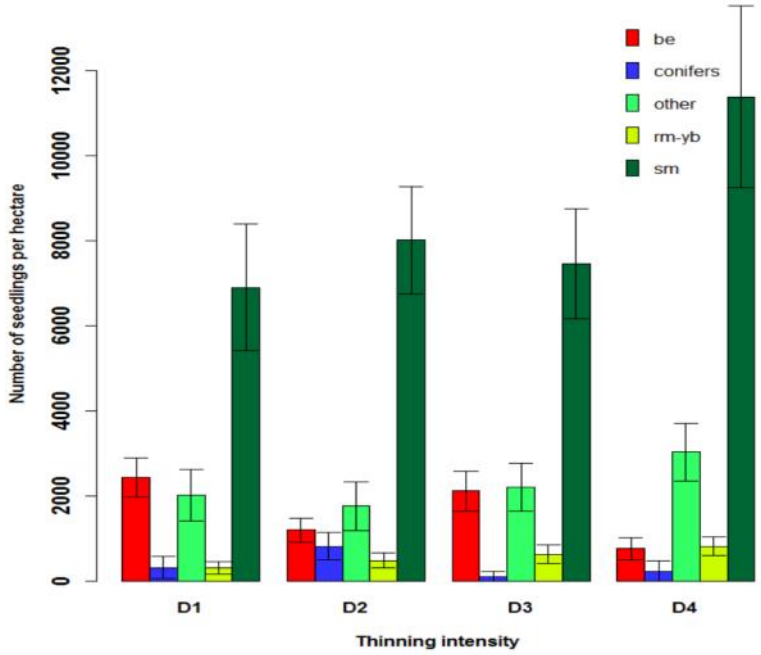

Figure 3: Tree seedling density of Beech (BE), conifers (BF, BS, SW), other (MM, STM, PCH), Red Maple-Yellow Birch (RM-YB) and Sugar Maple (SM) across different intensity of thinning. D1 = Control; D2 = 20% removal; D3 = 30% removal and; D4 = 40% removal.

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NHRI'S SILVICULTURE PRESCRIPTION SYSTEM
A PROMISING TOOL TO IMPROVE REGENERATION

SILVICULTURAL PRESCRIPTION SYSTEM (SPS)

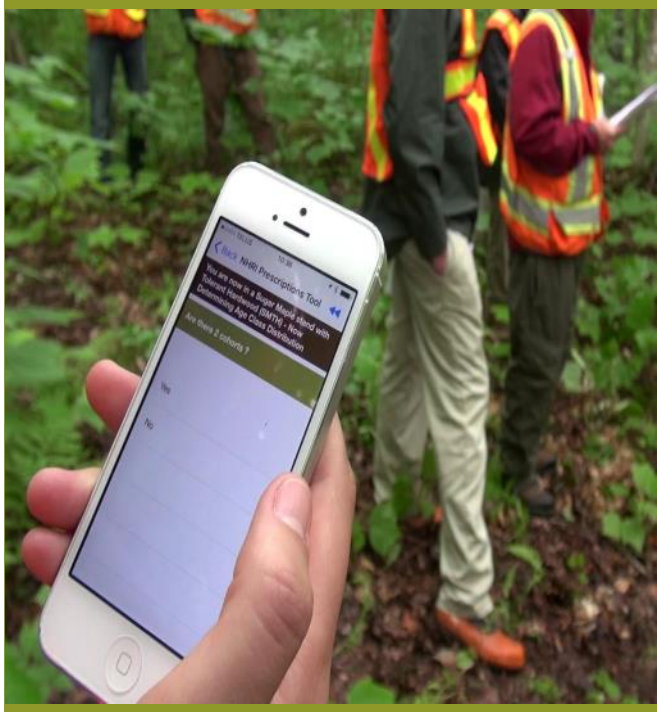
The NHRI Silvicultural Prescription System (SPS) is a five-step method that utilizes the ecological characteristics of the forest (e.g. species composition, stand structure, and regeneration status of desirable species) to recommend silvicultural systems and practices that favour the establishment of desired species. While the NHRI SPS is still relatively new in terms of its application on an industrial scale our preliminary research indicates that it is a very promising tool in our efforts to improve the quality of regeneration in northern hardwood forests.

Over the last few years our team has been busy offering training to foresters, technicians, contractors and students on how best to apply our flagship silvicultural system. We are confident that our new innovative approach to northern hardwoods silviculture will bring excellent results when it comes to improving the quality of regeneration.

Evaluating the field-tested long-term results of our efforts is out of our grasp for the immediate future – considering the time required to produce a quality hardwood log. However, this study evaluates the early regeneration response of the NHRI proposed treatments against the current status quo.

Research Highlights

- Surface disturbance was the main driver of successful Yellow Birch regeneration among the treatments.
- Yellow Birch dominated the regeneration layer across all treatments; however, Sugar Maple seedling density increased significantly in group shelterwood with wider trail spacing.
- Group shelterwood with 16m trail spacing produced the highest seedling density among the treatment combinations.
- Trail pattern has a significant impact on the establishment of regeneration (less for Sugar Maple).



" Over the last few years our team has been busy offering training to foresters, technicians, contractors and students on how best to apply our flagship silvicultural system. We are confident that our new innovative approach to northern hardwoods silviculture will bring excellent results when it comes to improving the quality of regeneration."

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NHRI SPS

Step by Step Application

ONE: Stand type

- *Follow the keys to determine the stand type.*

TWO: Silvicultural system

- *From combinations of FUNA and structure types in step one, review eligible silviculture systems.*

THREE: Treatment

- *Determine the appropriate decision key to use in order to recommend system/treatment. Specific questions in the keys are answered using NHRI concepts as in the following tables.*

FOUR: Prescription

- *Consult the treatment tearsheets for scheduling operations.*

FIVE: Instructions/cutting orders

- *Determine instructions/cutting orders for each treatment.*

MORE INFO
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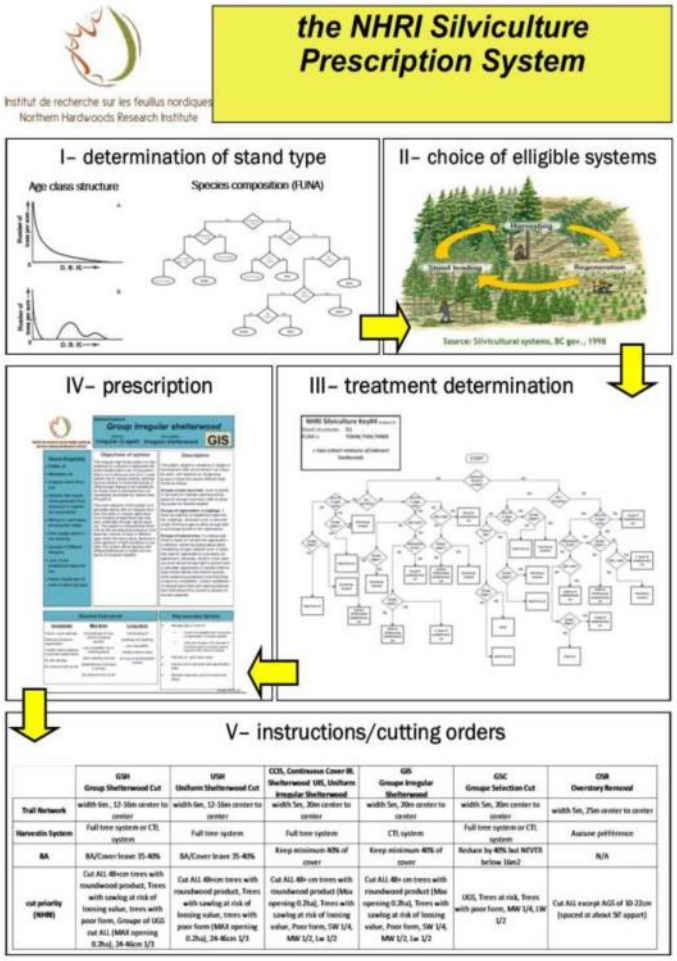
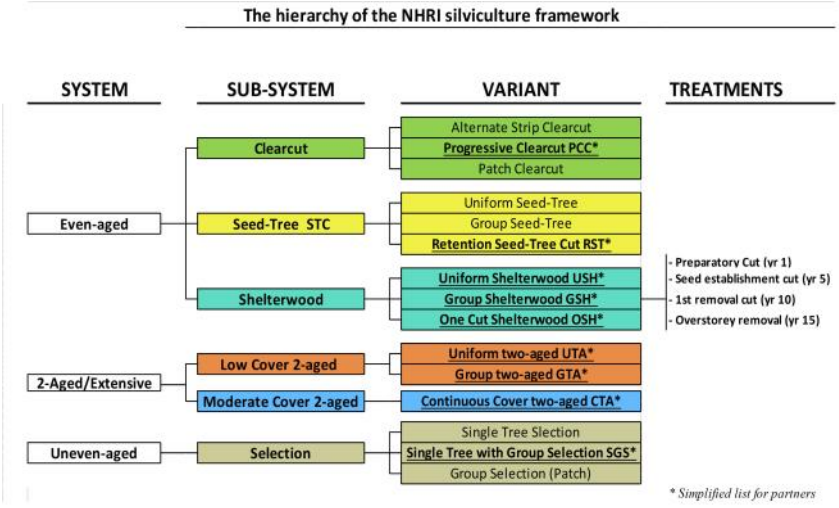
NHRI'S SILVICULTURE PRESCRIPTION SYSTEM

A PROMISING TOOL TO IMPROVE REGENERATION





REGENERATION STARTS AT HARVEST

ARE SEASON AND METHOD OF HARVEST INFLUENCING REGENERATION?

In the northern hardwood forest, light is often recognized as one of the major factor limiting the growth of regeneration. However, the relative importance of light on regeneration growth is dependant on site conditions and species.

Even if we have a good knowledge of the factors limiting the growth of the regeneration following a harvesting treatment, not a lot is known about the interaction between those factors. Several factors, such as light, harvesting treatment, season of harvest, overstory composition and seedbed can impact the growth of the regeneration.

Our research suggests that treatment intensity, season and method of harvest and their interaction term all had an influence on regeneration. Showing that silvicultural treatment is not the only factor affecting regeneration success, but season and method of harvest and their interaction need to be taken into account when a silvicultural plan is done.

Research Highlights

- Treatment intensity, season of harvest, harvesting method and their interaction term all had an influence on regeneration.
- A low treatment intensity and a treatment done in summer yielded higher proportion of commercial saplings.
- The highest density of commercial species was achieved with a manual full-tree harvesting method.

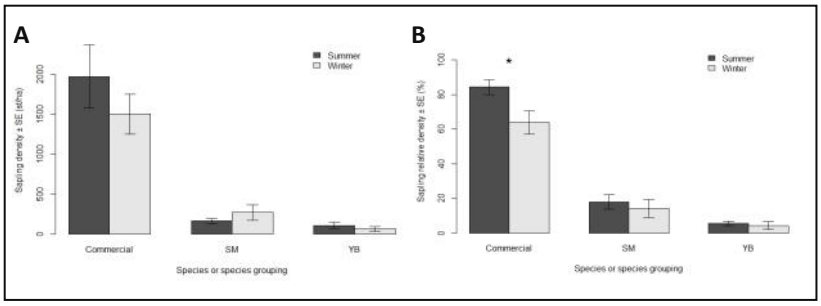


Figure 1: Mean sapling density (A) and proportion (B) ± standard error (SE) of commercial species, Sugar Maple (SM) and Yellow Birch (YB) as a function of season of harvest.

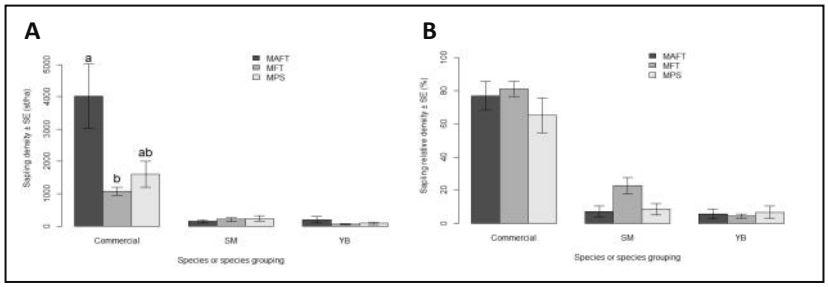


Figure 2: Mean sapling density (A) and proportion (B) ± standard error (SE) of commercial species, Sugar Maple (SM) and Yellow Birch (YB) as a function of method of harvest (MAFT: manual full-tree, MFT: mechanical full-tree and MPS: mechanical process system).

READ MORE

" Treatment intensity, season of harvest, harvesting method and their interaction term all had an influence on regeneration."

STOCKING GUIDE

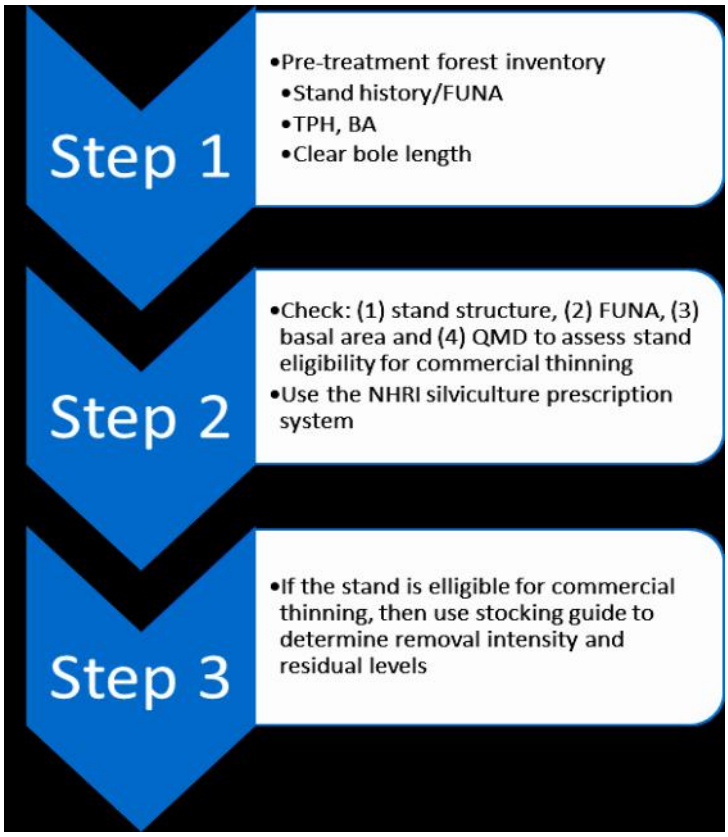
A TOOL FOR MANAGING YOUNG EVEN-AGED STANDS

Stocking guides, initially developed by Gingrich in 1967, are tools that help: (1) to assess current competitive status of a forest stand, and (2) suggest the timing and intensity of thinning required to increase growth and quality of the crop trees in the future. It is also useful for visualizing stand growth dynamics as a stand matures.

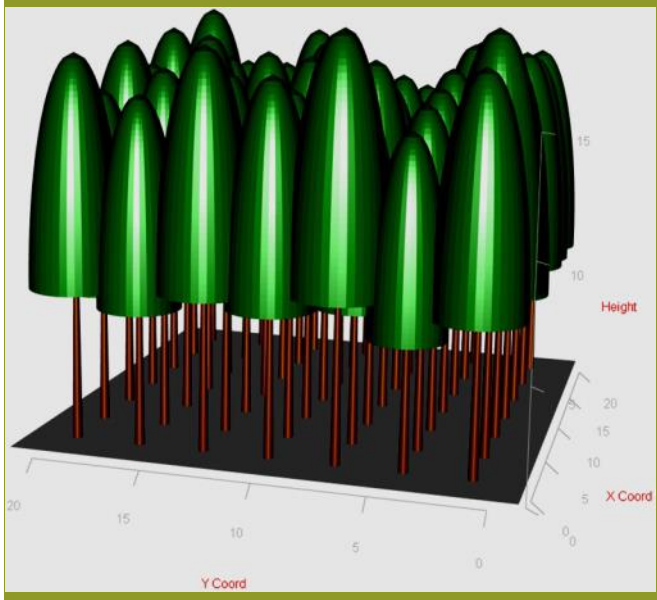
The Gingrich (1967) stocking guide was calibrated for yellow birch dominated stratified mixture, in even-aged stands of northwest New Brunswick, to help foresters with silviculture decision making. Periodically measured data coming from a commercial thinning experiment located in northwest New Brunswick was used to calibrate the stocking guide.

Research Highlights

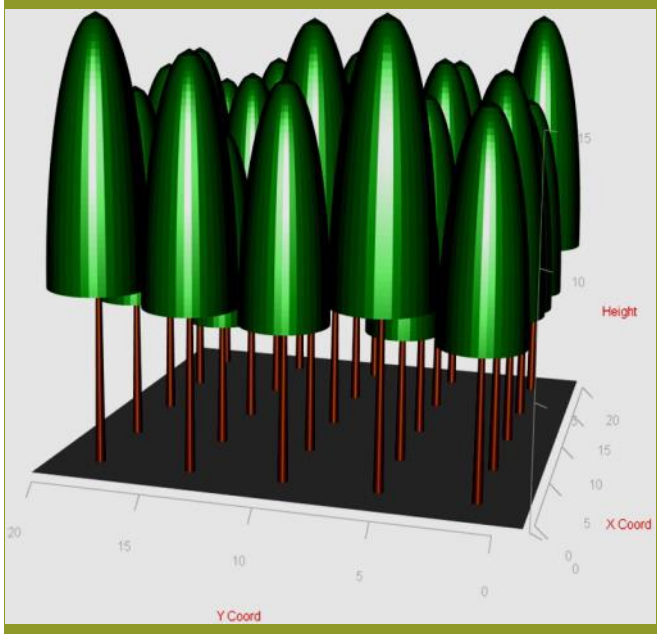
- Gingrich stocking guide was calibrated for yellow birch dominated stands with even-aged stratified mixture in New Brunswick to help forest practitioners with silviculture decision making.
- Elements and applicability of the guides are illustrated with examples in this technical note.



STOCKING GUIDE



" Gingrich stocking guide was calibrated for yellow birch dominated stands with even-aged stratified mixture in New Brunswick to help forest practitioners with silviculture decision making. "



REGENERATING QUALITY STEMS

EFFECTS OF JUVENILE SUPPRESSION, WILDLIFE AND OPERATIONS

Tree vigor can be defined as a trees' ability and potential to grow (OMNR 1990 in OMNR 2004) and is a function of competitive status and health. The Northern Hardwoods Research Institute (NHRI) has developed a classification key that can be used to assess risk of a tree losing vigor. Having the necessary tools to evaluate the vigor of regeneration will help determine future stand composition and health, which is an important aspect to consider when making post-treatment silviculture decisions. Several factors can have a negative impact on tree vigor such as browsing by wildlife, weather, competition, damage caused during a silvicultural treatment, insects and disease.

At the NHRI, we explored the links between juvenile suppression of Sugar Maple and Yellow Birch and the presence of damages on mature tree stems. We found that the longer the juvenile suppression goes on the more likely the mature tree stem will have damage (Figure 1).

Browsing by wildlife can also decrease regeneration vigor even to a point where it can shift stand composition. Northern New Brunswick has one of the highest population densities of moose in North America which can lead to high browsing pressure. Our team looked at the impact of moose browsing on regeneration. We found that 1) 9 harvested blocks out of 10 were not stocked at a level of 60% if we take into account the stems intensively browsed by moose (Figure 2), 2) regeneration strata composed of hardwood were browsed more intensely, and 3) Sugar Maple, Red Maple and Yellow Birch were browsed more than other species.

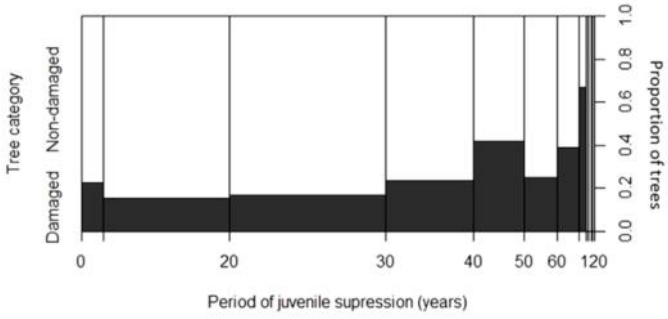


Figure 1: Proportion of sample trees possessing stem damages as period of juvenile suppression increases.

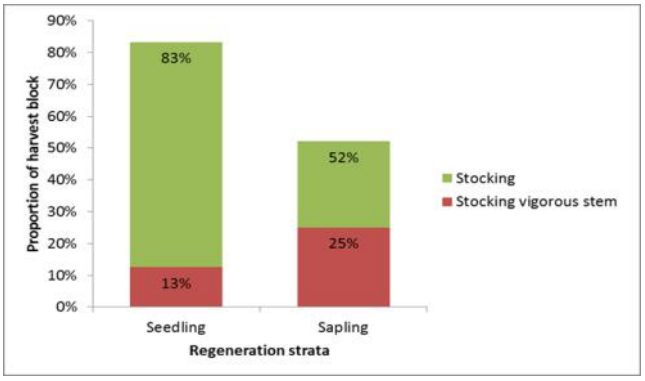


Figure 2: Proportion of harvested block with a stocking ≥ 60%, when moose browsing is not assessed (green) and when moose browsing is assessed (red) for the seedling strata and sapling strata.

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PREDICTING RECRUITMENT

HOW ACCURATE ARE TREE-LIST SIMULATION MODELS?

The processes underlying forest regeneration and the recruitment of new trees into new cohorts are highly variable and largely stochastic (Li et al., 2011, Vanclay 1992). Understanding the dynamics of forest regeneration and recruitment is pivotal to predict the growth and yield of commercial hardwood species and to improve management practices in the Acadian Forest Region of North America (Danyagri et al., 2017). In particular, there is a critical need to predict how commercial species will regenerate and be recruited into new cohorts under various environmental scenarios (Matías et al., 2011). The main objective of this project was to determine how well a tree-list model can predict the recruitment of stems into new cohorts in unharvested stands for different species found in the Acadian Forest Region of North America. The recruitment of stems into new cohorts can be estimated by the ingrowth, which is defined as the number of trees in a sample plot that have grown into a required threshold size (e.g. diameter at breast height [hereafter "DBH"] treshold). We achieved the objective using a tree-list model to predict the ingrowth in unharvested plots, and we then compared the predictions with observed values of ingrowth from field data.

Research Highlights

- A key question for forest stakeholders in NB is how well OSM, a tree-list growth model calibrated for the Acadian Forest Region, can predict the recruitment of new stems with a DBH equal or above 5 cm over a 9-10 year period (hereafter "ingrowth"). We started answering this question in this study.
- We aimed at providing results for hardwood species, but statistical analyses for these species require further work to provide valid information that can be used by forest stakeholders in NB. We here present results for two softwood species, but further analytical work can allow determining how well OSM can predict ingrowth of hardwood species.
- For both Balsam Fir and Black Spruce, more observed ingrowth in permanent sample plots corresponds to more predicted ingrowth by OSM. Yet, OSM underestimates ingrowth, and this is more pronounced for Balsam Fir than for Black Spruce.
- For Balsam Fir, when 100 new stems were recruited only 1 new stem was predicted by OSM.
- For Black Spruce, when 100 new stems were recruited only 50 new stems was predicted by OSM.
- Further analytical work can allow us to determine how well OSM can predict ingrowth for other species, and compare how OSM performs for different species across a range of stand types (FUNA) and basal area classes.

To keep providing the required information to improve OSM, we suggest conducting the statistical comparison of predicted and observed values for the different species, basal area class, and FUNA type. Then, we suggest conducting optimization analyses that would aim at finding parameter values that would minimize the difference between predicted and observed values for these different variables.

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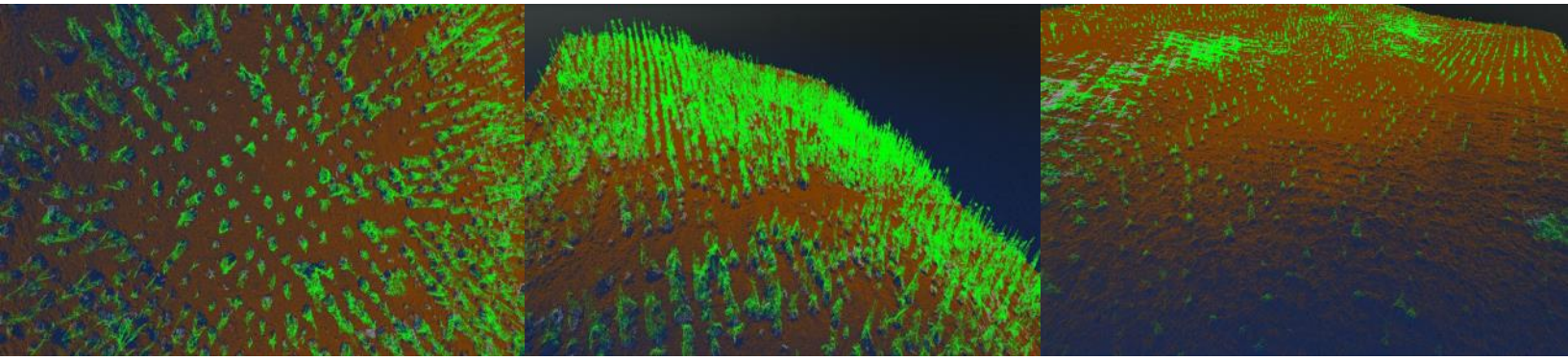
PRELIMINARY STUDY

USING REMOTE SENSING TO EVALUATE STOCKING



In forestry, stocking is a quantitative measure of the area occupied by trees, usually measured in terms of well-spaced trees or basal area per hectare, relative to an optimum or desired level of density. A desirable level of stocking is often considered that which maximizes timber production, or other management objectives.

During the winter of 2018 our Precision Silviculture Team, lead by Pamela Hurley Poitras, completed some preliminary field experiments in order to determine if remote sensing could be used as an accurate and affordable tool for evaluating stocking in softwood plantations. We chose softwood plantation as a simpler alternative to test our methods before taking on the more complicated task of evaluating hardwood stands.

On January 11th, 2018, data was captured by flying our drones over 2 young softwood plantations.

The first one, a young plantation of 5-7 years old proved to be a challenge to capture and evaluate using the automatic method (Global Mapper) since it couldn't detect the crown of the trees properly due to the fact that there was too much snow on the ground – thus covering the foliage and making accurate data analysis more difficult and less accurate. To obtain better results our Precision Forestry Team used the directed classification method with ArcGIS.

The second plantation being older, 10-12 years old proved easier to evaluate with the automated method in Global Mapper, since it was possible to detect more foliage.

A simulation of the classic survey method was also done by applying a grid with 2 points per hectares (since we had a small area) using 1.46m radius plots.

Results Highlights

The optimal time to capture data is after the first snow fall when the round is white, but the snow is not deep enough to cover the foliage.

Early spring when the vegetation is still in dormancy should also be a good time to capture data in softwood plantations since there is a good contrast between the foliage and surrounding vegetation.

Images allow us to see 100% of the plantation. This provides a different perspective than on the field observations thus rendering the task of prescribing silviculture treatments easier and much better informed.

Remote sensing could be used as an accurate and affordable tool for evaluating stocking in softwood plantations – given that further research confirms our findings and Standard Operating Procedures (SOPs) for each step are developed in order to identify efficiencies. For more information please contact: **pamela.h.poitras@hardwoodsnb.ca**

THE IMPORTANCE OF MODELLING REGENERATION

ANNOTATED BIBLIOGRAPHY: REGENERATION MODELS

Forest regeneration over time is one of the main objectives of sustainable forest management. Therefore, it is of great interest to create efficient tools that allow us to predict regeneration from seed production to seedling establishment and beyond. Consequently, regeneration modelling has become progressively more popular. In fact, modelling provides an important tool for synthesis because models can project long-term response to changes in management practices. In addition to, new improvements in modelling, decision making in forestry has largely benefited from the development of optimization techniques.

Considering the importance of modelling as a tool to study regeneration and its growing use in the field of forest management our team decided to put together an annotated bibliography in order to gather the several studies that have focused on the modelling of the different stages of regeneration.

READ MORE

" Modelling provides an important tool for synthesis because models can project long-term response to changes in management practices."

ON-GOING RESEARCH AT NHRI

SAPLING ESTABLISHMENT AND SAPLING GROWTH MODELS

The objective of this project is to predict the quantity and type of saplings present in a stand according to its biotic (species, vertical and horizontal structure of the stand, etc.) and abiotic (topography, type of soil, etc.) characteristics. As a first step, we are using the data from the Forest Development Survey (FDS) performed in 2004-2012 (41476 plots in 5781 stands) to predict the overall density of saplings. As a second step, we plan to combine the New Brunswick data with other data sources from the Acadian forest in Nova Scotia, Québec and possibly Maine. This would create a better resolution and allow us to predict the density and size of saplings per species.

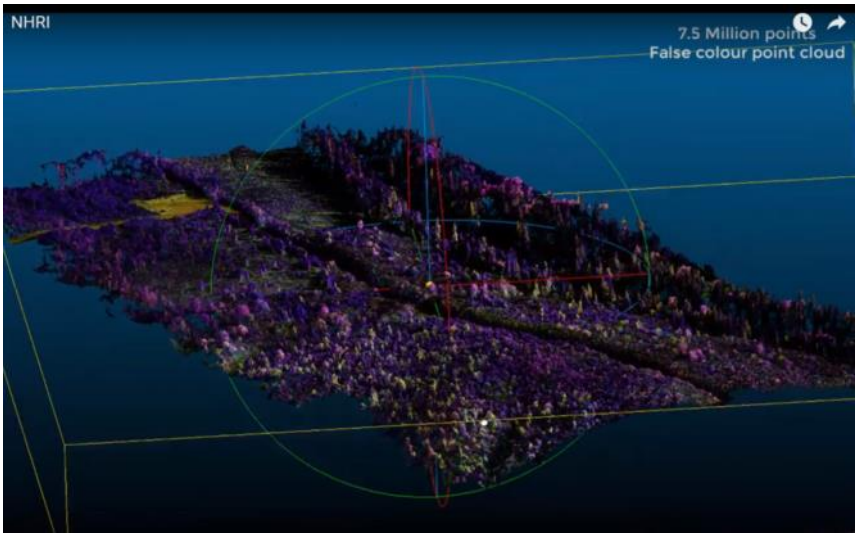
Utility for Forest Sector

The models developed will contribute to a better prediction of regeneration after silvicultural treatments. Ultimately, we aim to predict the frequency of saplings of different sizes for target species (high value or harmful species). Better predicting saplings will improve models predicting recruitment into the mature strata. Finally, the models could also guide foresters in their silvicultural practices to promote the regeneration of target species.

" The models developed will contribute to a better prediction of regeneration after silvicultural treatments. Ultimately, we aim to predict the frequency of saplings of different sizes for target species (high value or harmful species). Better predicting saplings will improve models predicting recruitment into the mature strata."

ON-GOING RESEARCH AT NHRI

CHARACTERIZING REGENERATION THROUGH REMOTE SENSING



Field assessment of regeneration is time consuming and has limited spatial extent. On the other hand, remote sensing technologies such as satellite images and Light Detection and Ranging (LiDAR) can derive certain forest characteristics accurately. At NHRI, we decided to characterize regeneration using remote sensing in an attempt to better understand the limits of those technologies along a gradient of basal area.

To do so, the Continuous Land Inventory (CLI) plots measured by the New Brunswick Energy and Resources Development (NBERD) department will be used to estimate density, proportion and basal area of the sapling cohort (diameter to breast height (DBH) ranging from 1 to 9 cm) of hardwood, softwood and non-commercial species separately.

We also want to identify which one of the technologies (Sentinel-2 images, LiDAR vs both) are the most accurate for characterizing sapling occupancy, and the limits of those along a gradient of basal area. The variables being considered are:

⇒ Data year
⇒ Treatment history
⇒ Satellite images
⇒ LiDAR

This project is on-going, if you would like to have more information please contact Stéphanie Landry, stephanie.landry@hardwoodsnb.ca.

" We decided to characterize regeneration using remote sensing in an attempt to better understand the limits of those technologies ."

ON-GOING RESEARCH AT NHRI

TREE RECRUITMENT MODEL FOR THE ACADIAN FOREST

" The objective of this project is to develop models to predict the annual recruitment of commercial trees (saplings) based on silvicultural treatments, climate, soil characteristics, topography, species composition as well as the vertical and horizontal structure of the stands. "

The objective of this project is to develop models to predict the annual recruitment of commercial trees (saplings) based on silvicultural treatments, climate, soil characteristics, topography, species composition as well as the vertical and horizontal structure of the stands. To achieve this goal, we use data from 22,000 temporary plots established across the province of New Brunswick (Figure 1). The application period of silvicultural treatments extends from 1946 to 2007, and the plots have been established between 1982 and 2010.

Expected / deliverable results

1. Statistical models to predict annual recruitment of commercial trees and codes used in the R environment to establish them.

2. A routine that can be used in popular simulation software such as OSM, FVS etc.

3. A technical note for NHRI and a scientific article for the publication of these models.

Utility for the forest sector

These models will make it possible to adapt silvicultural practices to the characteristics of sites and stands (climate, soil, ownership, etc.) to promote the recruitment of the desired commercial trees.

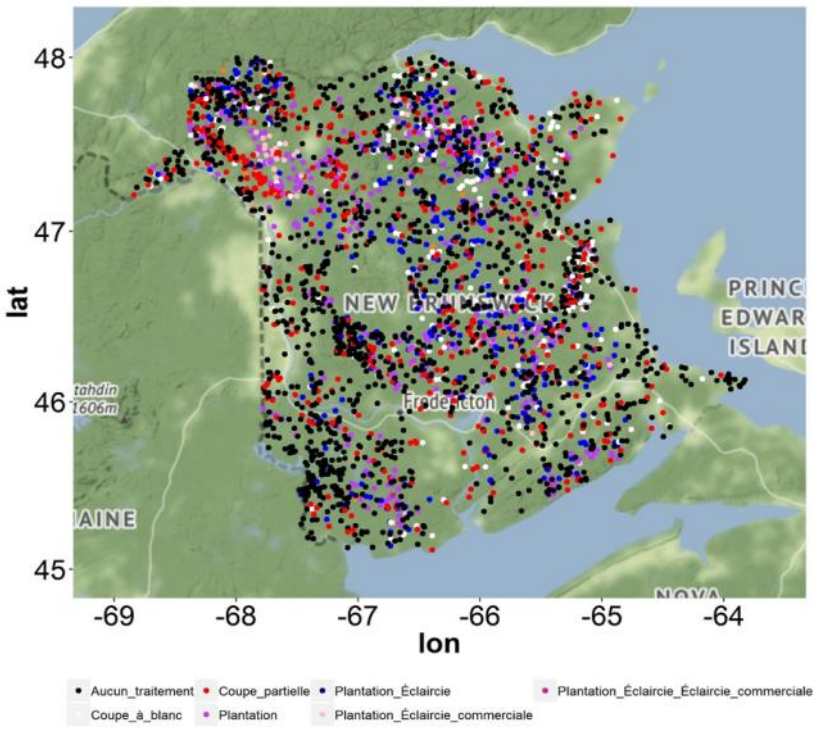


Figure 1. Distribution of plots used in the study

ON-GOING RESEARCH AT NHRI

EFFECTS OF CUT TO LENGHT AND FULL TREE HARVESTING ON REGENERATION

Cut-to-length and full-tree are common harvesting methods in the hardwood stands of New Brunswick. These harvesting methods have varying effects on the forest floor, which may affect the success of natural regeneration. However, studies quantifying the impacts of these harvesting methods on seedbed quality and regeneration establishment are generally limited.

Cut-to-length harvesting is thought to be the more economical option for harvesting since delimbing, crosscutting, sorting, piling and scaling are all done at the stump. This achieves a higher recovery of fibre, reduces logging residues management at the landings, and produces a higher quality log. However, cut-to-length harvesting generates significantly more slash in cut blocks than full-tree harvesting which has led to concerns about the impact of the slash on forest regeneration. The complete removal of slash in full-tree harvesting also has the potential to damage advance regeneration and increase exposure-related stress and mortality of advanced regeneration.

The influence of these harvesting methods on conifer regeneration are widely studied, but less so in hardwood stands. Natural regeneration of Yellow Birch could prove particularly problematic due to the post-harvest effects of these methods on potential seedbeds. Therefore, it is worth investigating the most commonly used harvesting methods in hardwood stands.

Proposed Methodology

Thirty-six blocks (60 m x 90 m each) within NB license 1 and 9 will be selected for this study. The blocks will be at least 300 m apart to minimize local site effect. Each harvest method (HM) will have years since the last harvest (TSLH) ranging from 2 to 10 years, and 2 replications for each year. Within each block, six circular plots (1.46 m radius) will be randomly established to measure Yellow Birch regeneration ≥30 cm and ≤ 130 cm in height. Within the circular plot, all regeneration will be tallied in four height classes: 30- <55cm, 55 -<80 cm, 80 - <105 cm, and 105 - < 130 cm. The pre- and post-harvest block conditions will be used to estimate the harvest intensity (basal cut). Harvest intensity estimation will be limited to only merchantable trees (trees ≥ 10 cm dbh). Additionally, topographic (elevation, slope) and edaphic (soil type, bed rock) parameters will be obtained for each circular plot. Yellow Birch regeneration density between the two harvesting methods will be analyzed using one-way ANOVA with repeated measure at a significant level of 0.05.

Project goals & objectives

- Compare the effects of cut-to-length and full-tree on post-harvest Yellow Birch regeneration recruitment.
- Assess the effects of cut-to-length and full-tree on seedbed quality.
- Assess the influence of cut-to-length and full-tree on regeneration establishment.
- Determine the regeneration dynamics following CTL and FT harvest operations.

MORE INFO
info@hardwoodsnb.ca

PEOPLE IN THE SPOTLIGHT

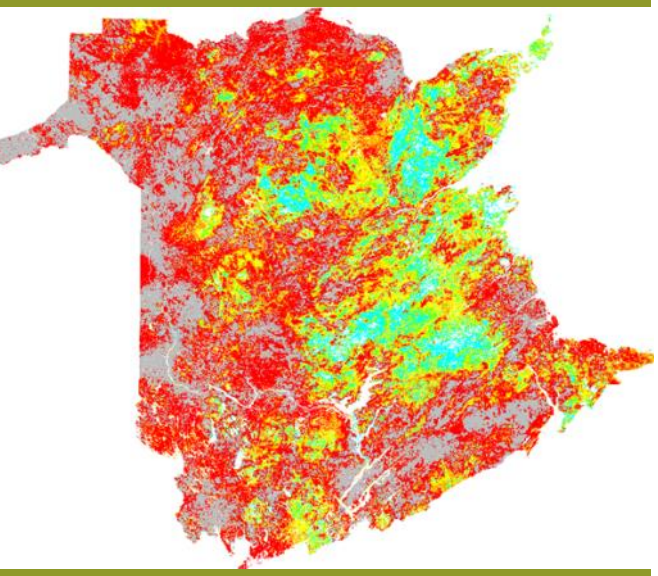
STÉPHANIE LANDRY… DEVELOPPING SOLUTIONS USING REMOTE SENSING!

Stéphanie Landry holds a bachelor's degree in biology from Université de Moncton, and a master's in environmental science from Sherbrooke University. She is currently a PhD candidate in biology at UQAR. Stéphanie has considerable experience in the field of environmental management. She is very passionate about forests and wildlife management. Stéphanie dedicates time and energy to the regional branch of Quality Deer Management Association at the same time acquiring in-depth insights into the effects of wildlife on the regeneration of the northern hardwood forest.

Originally from the Edmundston area, Stéphanie has been working as part of the NHRI team since 2014. She is the NHRI regeneration specialist and her research centers around the use of remote sensing tools, such as satellite and LiDAR, to determine forest characteristics.

For the last decade, remote sensing research has focused mainly on overstory characteristics. Due to the limits of remote sensing in terms of getting through the canopy, very little research has been done on the use of these tools to estimate regeneration. Stéphanie's main research project is attempting to fill that void by estimating regeneration occupancy in the Acadian forest of New Brunswick using a combination of satellite images and LiDAR. This project will also help better understand, and establish, the limits of remote sensing in terms of its ability to penetrate through the forest canopy and thus be a useful tool to estimate regeneration characteristics. Stéphanie's work is pivotal to our team's future research agenda and more importantly to the future of precision forestry as an effective tool to help establish quality regeneration in the northern hardwood forest.

" Stéphanie's work is pivotal to our team's future research agenda and more importantly to the future of precision forestry as an effective tool to help establish quality regeneration in northern hardwood forests."



PROMISING PARTNERSHIP

FORUS RESEARCH AND NHRI: LEVERAGING THE PAST TO MAP FUTURE REGENERATION

FORUS Research

One of the most promising partnerships at NHRI in terms of regeneration research is the one developed with Chris Hennigar, the owner of FORUS Research.

The objective of the collaboration between NHRI and FORUS Research is to develop topographical-dependent and locally informed predictions of tree species occurrence probability across all of NB forests for 15 commercially important species, based on immature to old stand species compositions observations in NB over the past 100 years.

In order to achieve this, approximately 30,000 ground surveys of species composition from across New Brunswick and three separate provincial photo-interpreted stand inventories (1908s forest, 1990s forest, current forest) were used as observations of historical species occurrence. Species occurrence was correlated locally (within 2km) to digital elevation, slope, and drainage and mapped on a 20x20m grid across the entire province.

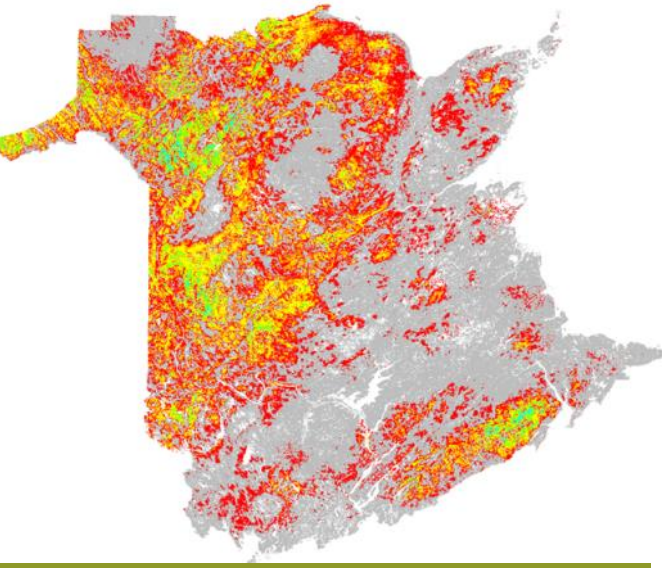
It's also important to note that other collaborators participated in the project by supplying some of the required data. All input data layers were provided by the New Brunswick Department of Energy and Resource Development and the depth to water table predictions were produced by the University of New Brunswick. Furthermore, this project is the outcome of a wider climate change research agenda at the University of New Brunswick that both FORUS Research and NHRI are collaborators on.

The end-result of the project will be the production of maps of species site occurrence probability based on recent historic species distributions. These maps should prove useful to the various stakeholders responsible for managing New Brunswick's forests. Once completed the maps will provide decision makers with some key information needed to make enlightened forest management choices, now and in the future:

- Species regeneration prediction and regeneration management planning;
- As an indicator of site productivity (e.g., well drained and nutrient demanding species occurrence probability);
- Maps of current species range and likely abundance in the province for use in projecting future forest species migration, range expansion or retraction under climate change;
- Useful for developing or correcting local errors in computer-based species predictions from satellites.

This collaboration between FORUS Research and NHRI is another good example of how we strive to build solid partnerships in order to produce applied research that is useful to those making the though decisions about the future of our forests.

" The end-result of the project will be the production of maps of species site occurrence probability based on recent historic species distributions."



VISIT

FORUSRESEARCH.COM

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FUTURE RESEARCH

UPCOMING REGENERATION RESEARCH AT NHRI

While our team is very proud of the research accomplished to date when it comes to studying regeneration, we are continually looking to narrow the knowledge gap when it comes to managing northern hardwood and mixed-wood forests. Applied research in the field of forest regeneration is a long-term endeavor and our research has only begun to scratch the surface. As this special edition of The Leaflet should demonstrate, quality regeneration is fundamental to the future of our forests and the communities that depend on them for their livelihoods. That is why we intend to keep pushing forward with more, and better, applied research in the field of northern hardwoods regeneration. Below is a list of forest regeneration themes we intend to develop in the coming months and years:

- Predicting regeneration success with remote sensing tools (including UAV's);
- Investigating the impact of slash created by cut-to-length harvesting systems on regeneration establishment;
- Building a simulation model for the response of regeneration to treatments by stand type and site;
- Understanding the dynamics of regeneration (germination, survival, growth of seedlings into saplings and commercial-size trees)

The knowledge gained through these projects will make sure that we can effectively create new cohorts of desired species to sustain our mixed and hardwood stands today and, in the future, particularly in the context of a changing climate.

If these research themes resonate with you and you are interested in working with us, as an industry or academic collaborator, research partner or student researcher please do not hesitate to contact us: (info@hardwoodsnb.ca).

"The knowledge gained through these projects will make sure that we can effectively create new cohorts of desired species to sustain our mixed and hardwood stands today and, in the future, particularly in the context of a changing climate."

CALL FOR COLLABORATIONS

PROJECTS FOR COLLABORATORS, RESEARCH PARTNERS AND STUDENTS

" At NHRI we are constantly looking to develop new partnerships with collaborators that share our passion for northern hardwoods and mixed-woods forest management with the objectives of improving resource growth, value and long-term sustainability."

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At NHRI we are constantly looking to develop new partnerships with collaborators that share our passion for northern hardwoods and mixed-woods forest management with the objectives of improving resource growth, value and long-term sustainability. Our key objectives are the following:

I. Improve knowledge of the northern hardwoods and mixed-woods resource by:

- Creating a methodology for qualitative and quantitative inventory;
- Modeling growth and yield under various management scenarios.

II. Develop silvicultural methods that promote the sustainable yield of desired species by:

- Reviewing the literature on what is already know elsewhere;
- Experimenting with new approaches.

III. Develop management and harvesting techniques that improve volume and value for the existing and future hardwoods and mixed-woods resource.

IV. Ensure transfer of knowledge and results to industry with:

- On-the-ground collaborative research projects on industry lands;
- Repeated and regular production and dissemination of technical information and technical reports making preliminary results of ongoing research accessible;
- Organization of information sessions and conferences for forestry stakeholders;
- Research dissemination in scientific forums (conferences, journals, etc.).

V. Influence forest policy based on the results of NHRI research.

In order to reach those objectives our research is focused on the following themes:

⇒ **Resource characterization**
⇒ **Importance of site and climate**
⇒ **Implementation and impacts of silviculture**
⇒ **Efficient forest operations**
⇒ **Wood supply, planning, logistics and analytics**

If these objectives and research themes resonate with you and you are interested in working with us, as an industry or academic collaborator, research partner or student researcher, please do not hesitate to contact us at: (info@hardwoodsnb.ca).

STUDENT JOB

JOIN THE NHRI TEAM AND WORK ON INTERESTING PROJECTS

We are currently seeking student candidates for a position as Knowledge Mobilization Project Assistant at NHRI. We are looking for dynamic young people with good written and oral communication skills and a general grasp of modern communication tools – video, social media, modular online learning, publishing software and apps, etc. Candidates should also be creative, collaborative, and passionate about knowledge mobilization. We have several interesting projects we are looking to either initiate or complete. Knowledge of forestry is considered an asset, but not a must. While we would prefer someone directly on-site, we are willing to try various off-site arrangements if a qualified candidate does not reside in the Edmundston region.

If you are interested in this position or you would like obtain further information please contact us and/or send a short cover letter and a copy of your CV to Joey Volpe our Manager of Knowledge Mobilization (joey.volpe@hardwoodsnb.ca).

UPCOMING EVENTS

MORE INFO

UPCOMING EVENTS

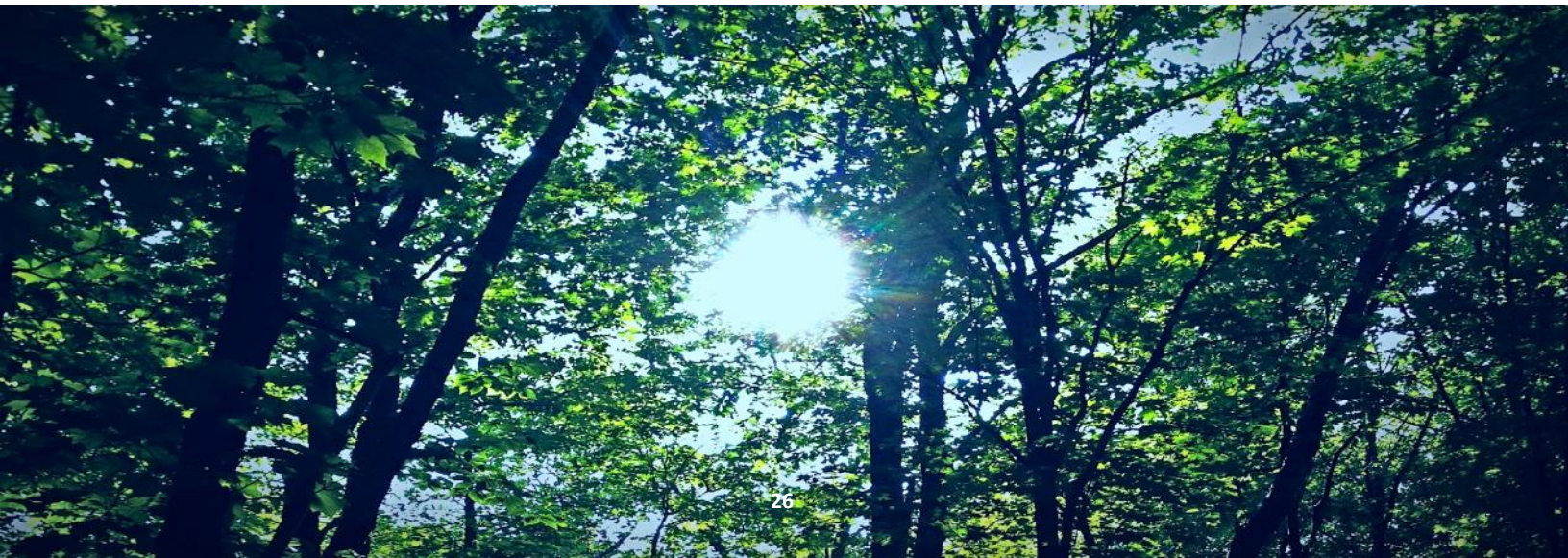
111TH CIF-IFC ANNUAL GENERAL MEETING & CONFERENCE

Hosted by the CIF-IFC Algonquin Section, the 2019 National Conference & AGM will take place from October 6th-9th in Pembroke, Ontario at the Best Western Pembroke Inn & Conference Centre.

In 2019, for the first time, Latin America will host a World Congress of the IUFRO (International Union of Forest Research Organizations). This event will take place in Curitiba, Paraná, Brazil (at Expo Unimed), from September 29 to October 5, and will be organized and coordinated by the Brazilian Forest Service (SFB) and EMBRAPA. Approximately three thousand participants are expected at the event, which will discuss various aspects related to forest research.

The Food and Agriculture Organization of the UN (FAO) will convene in Missoula, MT, US on 9-12 September 2019 for the 30th session of the North American Forestry Commission. This meeting will bring together forestry experts and decision makers from the region.

One of six region-specific meetings held every two years in support of the FAO Regional Forestry Commissions, the event serves as a policy and technical forum for countries to discuss and address forest issues on a regional basis.



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HARVEST KNOWLEDGE, **PROMOTE** GROWTH