SPRING 2024 VOLUME 6 • ISSUE 2

THE LEAFLET

NORTHERN HARDWOODS RESEARCH INSTITUTE'S QUARTERLY NEWSLETTER

HARVEST KNOWLEDGE | **PROMOTE** GROWTH

SILVICULTURE SPOTLIGHT

Demystifying the Irregular Shelterwood System

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FOREWORD

Welcome to the spring edition of The Leaflet

Dear Readers,

Springtime marks a period of awakening as the forest emerges from its winter slumber. Nutrient-filled sap flows, fueling new growth and signaling a resurgence in forest productivity. Just as the cold months and subsequent warmer temperatures are essential for budburst and seed germination, these months have also been crucial for cultivating NHRI's winter efforts. Now, with the onset of spring, our projects, products, and partnerships are preparing to blossom with this season's renewal.

In this issue of The Leaflet, we delve into the strategies, opportunities, and challenges surrounding irregular shelterwood. My current work with NHRI heavily focuses on tree phenology. Spring phenology – the onset of budburst and the resumption of tree growth – are critical periods from both a forest management and climate change perspective. Spring poses a vulnerable time for northern hardwoods, which, after ending their winter dormancy, face increased susceptibility to environmental stressors like late frosts. Predicting the timing of spring phenology can significantly benefit the industry, guiding management decisions to protect forests from such stressors before implementing irregular shelterwood treatments, such as thinning or planting. Moreover, accurate forecasting of spring phenology enables us to predict merchantable timber availability, gauge ecological resilience, and adjust silvicultural practices for the long-term realities of climate change.

The spring season is beautiful yet delicate. As trees sprout new leaves and seeds begin to grow, they, like many of us, rely on the promise of longer, warmer days ahead to emerge from hibernation. I hope you enjoy this issue of The Leaflet as much as the forthcoming warmth. I encourage readers to stay up to date on NHRI's activities and our continuous efforts to provide innovative tools and products to the industry.

Jeneya Smith
Research Forester - NHRI

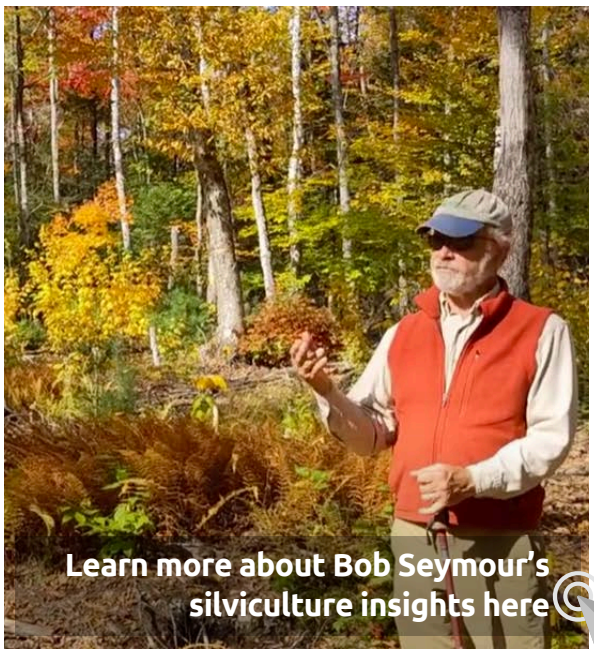
INTRODUCTION

Demystifying the irregular shelterwood silviculture system

By Gaetan Pelletier, Executive Director, NHRI

We are often asked by our stakeholders and forestry professionals at large to explain and clarify the silviculture regimes that are part of the irregular system. We must admit, the nomenclature itself can lead to some confusion as sometimes, the adjective 'irregular' as in irregular shelterwood can be erroneously interpreted as the starting point and/or the result in terms of spatial distribution of structure within a stand.

In the late 1990s to early 2000s, I was introduced to the concept of 'the Acadian Femelschlag' by Bob Wagner and Bob Seymour, both affiliated with the University of Maine at the time. They educated me on this variant of the irregular shelterwood system, which they had developed after studying similar practices in Germany and Eastern Europe. At the time, I found it nebulous and difficult to comprehend as an industrial forester and, to create expanding gaps in succession to eventually treat the whole stand, did not look practical to me. Bob Seymour explains the concept and application in this video: The Acadian Femelschlag - Irregular Group Shelterwood with Reserves in Northern Hardwoods.



I was reminded again and re-introduced to the system in 2012, by Si Balch, a consulting forester with much experience in the forests of the Northeast brought the topic up again while we were touring the Bartlet Experimental Forest in the White Mountains of New Hampshire with Bill Leak. He explained that the concept had deep roots from Western Europe and Si had with him, an English copy of the booklet from the 'Association de la Futaie Irrégulière' entitled: Management of Irregular Forests.

We had just started the operations of the Northern Hardwoods Research Institute that year and coming from industry, I was still perplexed on how to improve our 'less-than-ideal' tolerant hardwood stands using the classic single-tree selection silviculture system at large scales. I vividly remember a day when we hosted a visit to our operations with Ralph Nyland. He pulled me aside and politely explained that our relentless desire to apply that regime in our forests would not be effective; our stands simply did not have the desired quality and structure, and they were 'irregular'.

Of course, I only realized this a few years later, and fortunately, we hadn't caused any irreparable damage to our tolerant hardwood forest while attempting to do the noble thing.

After the trip to Bartlett Forest, I came across a 2009 paper written by Patricia Raymond, Steve Bédard and others (link here) and only then did I start to understand the concepts of harvest-based silviculture of irregular tolerant and mixed hardwood stands properly. We went to work shortly after and started to produce our Silviculture Prescription System (SPS) and immediately saw the benefits of promoting irregular shelterwoods as one of the key tools to restore our forests. The first version of our SPS used that exact terminology but we found practitioners struggled with the terms. The second version of our system now refers to that family of regimes as two-aged irregular but in hindsight, we are not certain that it was the right thing to do either.

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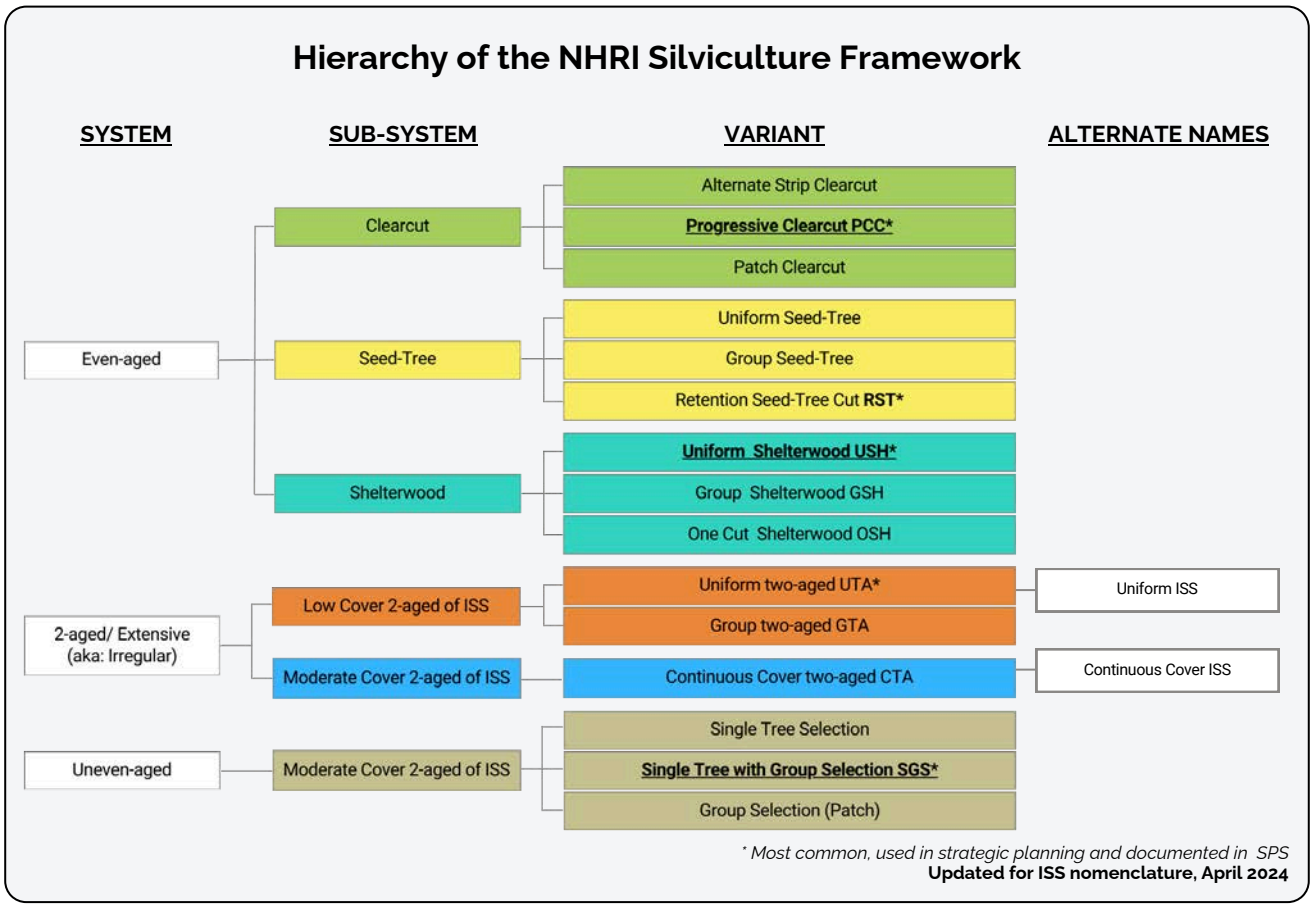
Demystifying the irregular shelterwood silviculture system



It is important to view silviculture actions (treatments) within a comprehensive framework that depicts whole regimes rather than just the current prescriptions. For the NHRI Silviculture Prescription System (SPS) a hierarchy of the main silviculture systems is used. It has been slightly modified to reflect the mainstream nomenclature used in particular with regards to irregular systems. While the focus is on the variant or method, one can understand to which system and sub-system it is related to. Finally, it is at the treatment level that the required actions are planned and described. Here, using the continuous cover two-aged variant, we can see that there are 4 separate treatments in sequence necessary to achieve the desired outcomes.

TIMELINE AND DESCRIPTION OF TREATMENTS:

Year 1: Restoration cut; remove trees of undesired species, of poor health and poor form, release vigorous crop trees. Leave 16-18m^2/ha of merchantable basal area, regenerate new cohort of trees

Year 30: Improvement cut #1: release quality crop trees, maintain 18m^2/ha basal area, promote saplings into poll-sized trees, establish a new cohort of trees

Year 50: Improvement cut; same as at year 30 and promote multi-age structure

Year 70 and beyond: Promote multi-age structure with 20yr re-entries

Click on each box to view a detailed image

INTRODUCTION

Demystifying the irregular shelterwood silviculture system

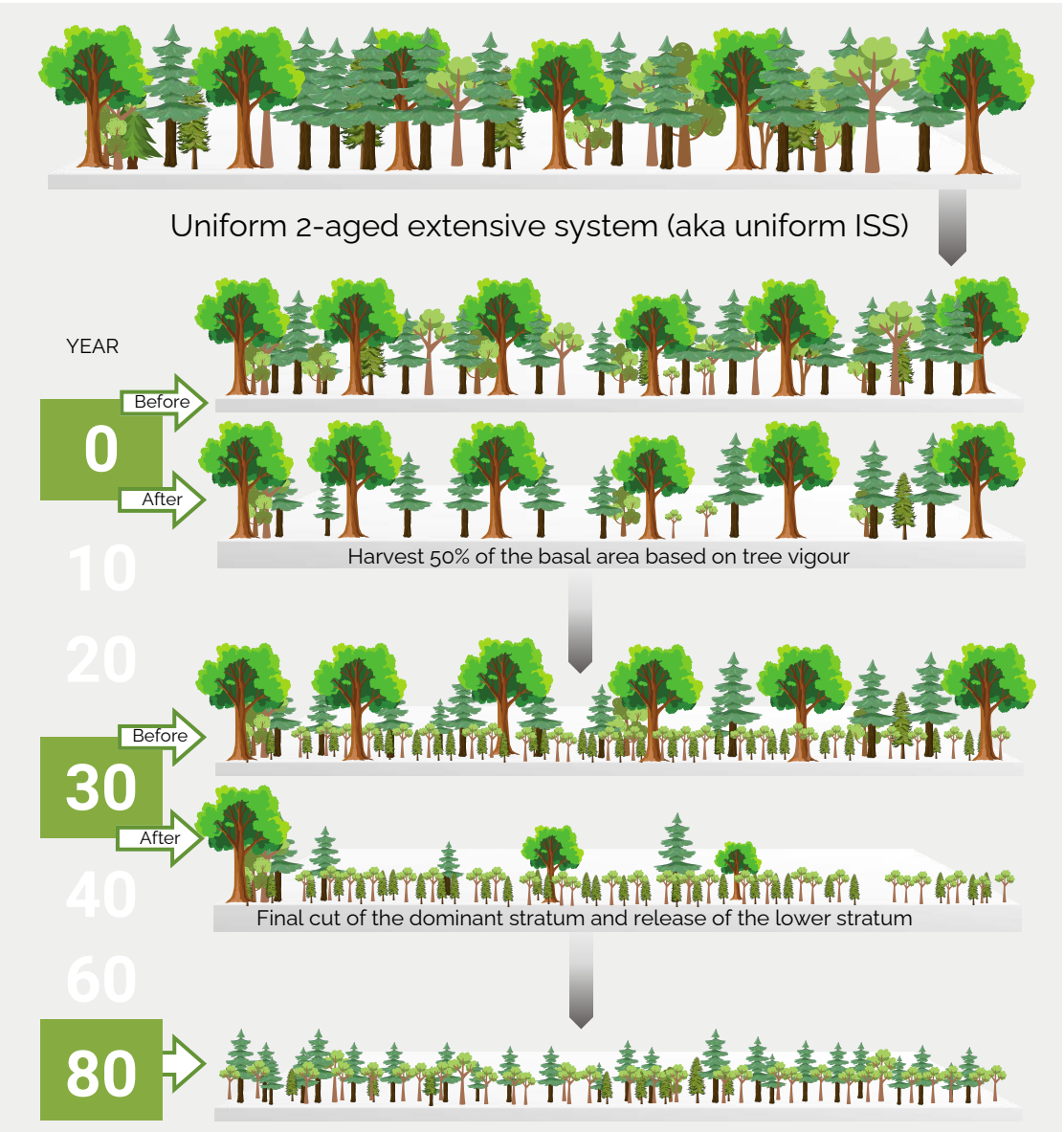
At our Institute, we value our relationship with practitioners of the forest sector. We have performed stand diagnostic timber cruises in thousands of hectares in New Brunswick and Nova Scotia during the last five years. Tree quality, species composition and forest structure are key components of our diagnostics and as a result, in over two thirds of the area surveyed, the recommended treatments and regimes were variants of the irregular shelterwood systems because of the condition of our forest stands. Today, many of our forest sector partners are implementing those treatments at large scales and we are already working on improvements to our SPS system and hope to release version 3.0 sometime in 2025.

It is safe to say that in our mixed and hardwood forests of the Northeast, the irregular forest systems and their variants must be part of the toolbox of forest managers and silviculturists. Their application is certainly instrumental at restoring our forest stands today as well as offering many advantages for inclusion in our strategy to consider and adapt in light of a changing climate.

While preparing to write this introduction article dedicated to the irregular shelterwood system, I came across a well-written 'plain language' magazine article authored by Christel Kern of the United States Forest Service (USFS). Our collaboration with her dates back to the early days of NHRI, and she has significantly contributed to demystifying the irregular shelterwood system, particularly in its application to mixed and hardwood forests. You can find her article here and I strongly encourage you to read it as an introduction to the concept.

Uniform Two-Aged Extensive system
(aka uniform ISS)

UTA

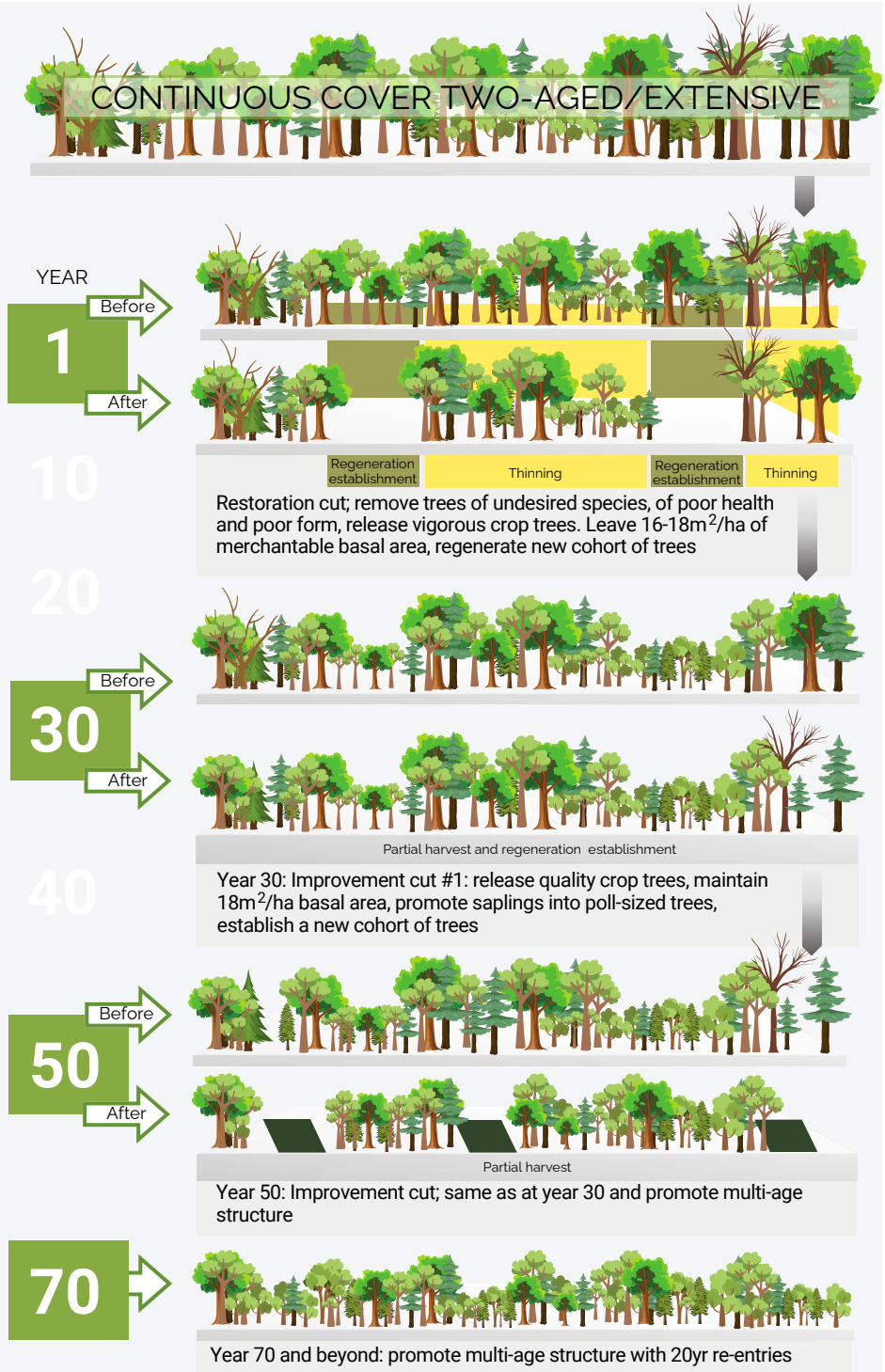


The uniform two-aged extensive system (aka uniform ISS) is widely used when the current stand lacks the species composition, structure and quality that is desired but still contains quality pole-sized trees. Initially, the maintenance of between 8-12m^2 of merchantable basal area (mostly pole size trees) helps provide shade and shelter while creating conditions for the installment of a new cohort of trees. Subsequent entries differ as compared to multi-cohort regimes.

Full details here:
UTA

Continuous Cover Two-Aged Extensive Treatment
(aka continuous cover ISS)

CTA



Continuous cover two-aged extensive treatment (aka continuous cover ISS) is also a popular choice in the forests of New Brunswick and beyond. This system is well suited for stands having a more defined structure, adequate species composition and tree quality but require some restoration. These stands typically lack the structure that would make them eligible to true multi-aged regimes right away. The first treatment will reduce merchantable basal area to around 16-18 m^2 /ha by removing subjects of poor quality or of undesirable species. The goal is through future treatments, bring the forest stand to a structure more typical of multi-aged types.

Full details here:
CTA

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Below are examples of irregular shelterwood treatment:

Stand that received a uniform irregular shelterwood treatment about 30 years ago that is ready for the next treatment to remove most of the overstory to release the newly established cohort that is now in sapling stage.

A small tail-swing tracked harvester conducting an irregular shelterwood treatment in a highly variable stand. In the section visible in the photo, the harvester operator releases pole-sized trees and saplings that are of acceptable growing stock (AGS) by respecting residual basal area targets. Simple standard instructions are provided for the whole harvest block which will be irregular by nature because of the diverse structure at the outset.

We hope you will enjoy reading the following insightful contributions by seasoned practitioners who design and implement irregular shelterwoods operationally around Eastern North America. They all gratefully accepted the challenge of producing content for our newsletter under tight deadlines and while trying to meet their own at the end of their financial year. This is a new approach for us as we actively seek contributions from established experts in the field rather than create much of the content in-house. We are very grateful and value this collaboration tremendously.

Our role at NHRI is to make the silviculture of mixed and hardwood stands practical by developing tools and processes for proper implementation. The irregular shelterwood silviculture system is a key part of that.

IRREGULAR SHELTERWOOD:
Enhancing Forest Resilience with Irregular Shelterwood

By Patricia Raymond, ing.f., Ph. D. and Steve Bédard, ing.f., M. Sc.
Direction de la recherche forestière, Ministère des Ressources naturelles et des Forêts du Québec



Irregular shelterwood: a flexible tool to promote rehabilitation, complexity, and resilience in temperate mixedwood and deciduous stands

Little known until recently in North America, the practice of irregular shelterwood system (ISS) is gaining popularity, because it meets the management needs of natural stands with an irregular structure, i.e., stands that are neither even-aged nor balanced uneven-aged[i] . In Québec for example, research by the Direction de la recherche forestière (DRF) of the Ministère des Ressources naturelles et des Forêts has led to application guidelines for the main forest types published in 2013 in the provincial silvicultural guide[ii] . Since then, some 20,000 ha of public forests have been treated in this way every year, particularly to meet ecosystem management objectives. Given its ability to promote stand structural and compositional complexity, this silvicultural system could prove to be an asset in promoting resilience in the face of global change.

What is irregular shelterwood?

The irregular shelterwood system, or Femelschlag, was developed in Central Europe and was first described by Gayer in 1880. It involves harvesting the stand with a series of successive partial cuts with the aim of establishing a new regeneration cohort under the protective canopy of seed trees after each cut. In addition to creating favourable environmental conditions for the establishment of regeneration and the release of advance regeneration, ISS aims to harvest mature trees and improve stand quality by eliminating weak and defective trees.

ISS generates stands with an irregular age structure, since they include at least two age classes. Therefore, the structure is not even-aged (with a single age class). It also differs from the balanced uneven-aged structure in that it does not include all the age classes necessary to produce a constant volume of wood at regular intervals, as would be obtained through selection cutting. The distribution of cuts in space and time, as well as their effect on stand structure, will change depending on the variant selected.

THE MAIN ISS VARIANTS

Initial stand structure, the number and spatial arrangement of cohorts, as well as management objectives will guide the choice of the most appropriate ISS variant. Those used in North America can be grouped into three main categories:

- The **expanding-gap ISS (EGIS)** aims to regenerate new cohorts within harvest gaps that are gradually enlarged, without the passage of machinery on regenerating areas, until the entire stand is harvested. The final cut is optional, however. This variant is suitable for even-aged stands composed of conifers mixed with deciduous species with low shade tolerance [iii].
- With **continuous cover ISS (CCIS)**, the sequence of establishment cuts is applied more freely in space and time, enabling a continuous cover and a structure comprising several cohorts of different ages to be maintained. The main difference with other variants is the absence of a final cut. This variant resembles the single-tree and group selection cutting systems, without necessarily aiming for a balanced uneven-aged structure. It applies to stands with an irregular structure composed mainly of shade-tolerant species (Figure 1). The trees to be harvested are selected according to stand conditions, with priority given to weak trees and those of short-lived species. Small gaps are created both to remove groups of mature, non-vigorous trees or insect- or disease-ridden trees, and to promote the regeneration of mid-tolerant species.
- The **extended ISS (EIS)** aims to regenerate the entire stand, maintaining a more regular structure, but with a prolonged canopy retention to allow a cohort of high regeneration to grow protected from adverse conditions. Compared with the regular shelterwood system (RSS), the regeneration period is longer, extending over the equivalent of more than 20% of the rotation. Furthermore, the EIS does not necessarily include a final cut, unlike the RSS. In Québec, the EIS is proposed as an alternative to RSS when the goal is to maintain or promote an irregular structure in a stand composed of at least two age classes (Figure 2).

IRREGULAR SHELTERWOOD:
Enhancing Forest Resilience with Irregular Shelterwood

Figure 1. Examples of applications for continuous cover irregular shelterwood.

YELLOW BIRCH–BALSAM FIR STAND

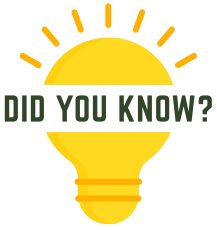
A **continuous cover ISS** establishment cut was applied in a yellow birch–balsam fir stand to produce high-quality yellow birch and conifers while maintaining an irregular structure. Priority was given to harvesting weak trees and short-lived species such as balsam fir and trembling aspen, to promote the regeneration and growth of long-lived, shade-tolerant species such as yellow birch, eastern white cedar and red spruce.


Photo: Patricia Raymond (MRNF)


Photo: François Guillemette (MRNF)

SUGAR MAPLE–YELLOW BIRCH STAND

A **continuous cover ISS** establishment cut was carried out in a sugar maple–yellow birch stand to reduce the dominance of beech regeneration and produce high-quality yellow birch and sugar maple, while maintaining an irregular structure. Priority was given to harvesting trees of low vigour and American beech, which is vulnerable to beech bark disease. Mechanical clearing of beech saplings in the gaps was carried out to facilitate the regeneration of long-lived species such as yellow birch and sugar maple.



Irregular shelterwood systems can be adapted to different forest types, management goals, and ecological conditions, making them a versatile and flexible approach to forest management that can be tailored to specific circumstances and objectives.

Figure 2. Examples of applications for extended irregular shelterwood.


Photo: Patricia Raymond (MRNF)


Photo: François Guillemette (MRNF)

Left photo: Extended ISS can be applied in balsam fir–yellow birch stands with either a two-aged or an irregular structure to promote the regeneration of long-lived species such as yellow birch and red spruce.

Right photo: In sugar maple–yellow birch stands, extended ISS can help rehabilitate stands impoverished by past logging. The succession of seed cutting, scarification (skidder with a blade rake), and understory beech control (mechanical brushing) aims to promote the regeneration of long-lived species such as yellow birch and sugar maple. A two-aged structure should be produced by maintaining part of the main canopy and regenerating a new cohort of desired species.

Benefits and challenges

In Québec, irregular shelterwood systems are used in public forests, namely to maintain an irregular structure and old forest attributes, and to promote the regeneration or rare species. With CCIS, it is possible to reconcile wood production with other forest uses. In the context of rehabilitation, CCIS can help restore irregular structure and improve stand species composition and quality.

The DRF's research program on irregular shelterwood shows that it can be applied to six major forest types in the hardwood, mixed and boreal forests of Québec. In temperate mixedwoods, it is inspired by the natural disturbance cycle caused by spruce budworm. CCIS has proven particularly effective to regenerate a diverse cohort of desired species and to maintain irregular stand structures and old forests attributes[iv,v]. In northern hardwoods, it is mostly inspired by moderate severity disturbances and aims to rehabilitate impoverished stands. CCIS and EIS combined with beech control and ground scarification help maintain an irregular structure, while improving stand quality and promoting yellow birch regeneration when cervid browsing is controlled (Figure 3).[vi,vii]

In the presence of high-density white-tailed deer populations, however, yellow birch regeneration is compromised due to the dominance of beech sprouts and suckers that grow back vigorously after mechanical control[viii].

Figure 3. The impact of white-tailed deer browsing is visible to the naked eye. Inside the deer exclosure (right of photo), an abundant natural regeneration of desired and companion species has developed six years after irregular shelterwood cut, while outside the exclosure, repeated browsing continues to restrict yellow birch height growth. Photo: Steve Bédard (MRNF)

Applying an irregular shelterwood system involves several challenges. For example, one must be able to define silvicultural scenarios that will ensure the maintenance of an irregular forest cover and sufficient wood production that is sustained enough to be operationally feasible. In addition, it is also necessary to minimize the impact of logging operations on the residual stand, especially tree injuries and windthrow. Managing understory, competing vegetation, and deer browsing also poses significant challenges to achieving regeneration objectives, particularly for hardwood species such as yellow birch and sugar maple, as well as for palatable conifers like white cedar.

Future research results, as well as those from the provincial monitoring in operational conditions, will make it possible to quantify longer-term effects of this treatment on regeneration, wood production, carbon sequestration and resilience in a context of global change. We already plan to test certain adaptation measures, such as the enrichment planting of commercial species that are potentially better adapted to changing conditions.

[i] Raymond, P., Bédard, S., Roy, V., Larouche, C., Tremblay, S. 2009. The irregular shelterwood system: Review, classification, and potential application to forests affected by partial disturbances. J. For. 107:405-413. https://doi.org/10.1093/jof/107.8.405.

[ii] Raymond, P., Larouche, C., Bédard, S., Tremblay, S. 2013. « Chapitre 20 — La coupe progressive irrégulière. Dans : Le guide sylvicole du Québec, Tome 2 — Les concepts et l'application de la sylviculture. Larouche, C., Guillemette, F., Raymond, P., Saucier, J.-P. (éditeurs). Gouvernement du Québec, ministère des Ressources naturelles. Publications du Québec, Québec (QC). p. 456-515.

[iii] Seymour, R.S. 2005. Integrating natural disturbance parameters into conventional silvicultural systems: experience from the Acadian Forest of northeastern North America. USDA Forest Service, PNW-GTR-635. p. 41-48.

[iv] Raymond, P., Bédard, S. 2017. The irregular shelterwood system as an alternative to clearcutting to achieve compositional and structural objectives in temperate mixedwood stands. For. Ecol. Manage. 398:91-100. http://doi.org/10.1016/j.foreco.2017.04.042

[v] Martin, M., Raymond, P. 2019. Assessing tree-related microhabitat retention according to a harvest gradient using tree-defect surveys as proxies in Eastern Canadian mixedwood forests. For. Chron. 95(3): 157-170, https://doi.org/10.5558/tfc2019-025

[vi] Bédard, S., F. Guillemette, P. Raymond, S. Tremblay, C. Larouche et J. DeBlois. 2014. Rehabilitation of northern hardwood stands using multi-cohort silvicultural scenarios in Québec. J. For. 112 (3): 276-286. https://doi.org/10.5849/jof.13-035

[vii] Bédard, S., Raymond, P., DeBlois, J. 2022. Northern hardwood regeneration dynamics 10 years after irregular shelterwood and mechanical control of understory American beech. For. Ecol. Manage. https://doi.org/10.1016/j.foreco.2022.120142

[viii] Dumont, S., Bédard, S., Achim, A. 2023. Growth response and survival of American beech, yellow birch, and sugar maple regeneration to partial harvest. For. Ecol. Manage. https://doi.org/10.1016/j.foreco.2023.121476

IRREGULAR SHELTERWOOD:
A forest management perspective

By Thomas McCay, Chief Forester for Haliburton Forest & Wild Life Reserve



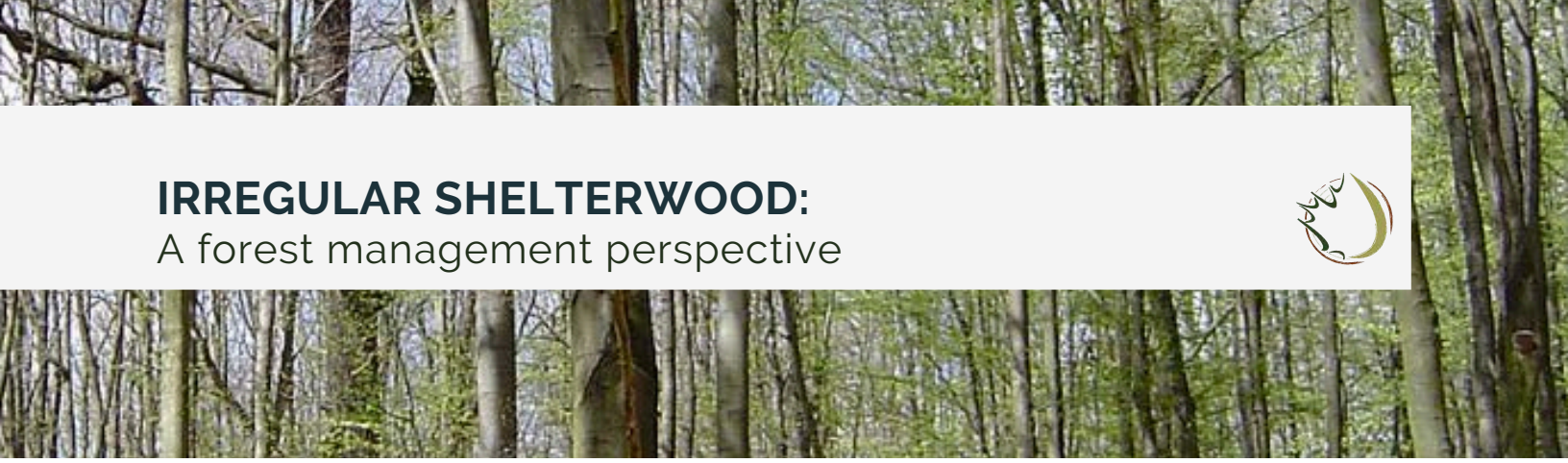
Photo credit: Haliburton Forest & Wildlife Reserve

DEMYSTIFYING IRREGULAR SHELTERWOOD

I once gave a presentation at a Canadian Institute of Forestry (CIF) run workshop that brought together half a dozen researchers and practitioners to speak on the topic of Irregular Shelterwood. At the end of a whole morning of presentations, the first comment from the audience was: "I still don't understand what irregular shelterwood is!". Throughout Ontario, where I practice, there is accelerating adoption of irregular shelterwood as a treatment and as a silvicultural system, but also an increasing amount of confusion, consternation, and resistance.

I believe there are two reasons for confusion. First, foresters have come to irregular shelterwood from different starting positions – from different jurisdictions and from different silvicultural systems. And second, practitioners are looking for irregular shelterwood to solve different problems. We have fallen into the trap that Tony D'Amato warned of: that we need to prevent making irregular shelterwood a 'catch-all' classification. Irregular shelterwood is not one thing, and foresters need to be much more specific in how they describe and prescribe what they are doing.

For the team at Haliburton Forest & Wild Life Reserve, we arrived at the concept of irregular shelterwood out of the challenges of Single Tree Selection and Uniform Shelterwood. These two systems, implemented through tree marking, have been the standard in Ontario tolerant hardwoods for decades. However, stands have been increasingly unlikely to meet the minimum eligibility criteria for selection management – even when they had been managed with selection in the past – because of beech bark disease and possibly because of misapplication of single tree selection on the wrong sites or in the wrong age structures. These stands now need to be managed with a different silvicultural system.



IRREGULAR SHELTERWOOD:
A forest management perspective

Because these stands with long histories of partial cutting come with a lot of spatial and structural heterogeneity, the use of the Uniform Shelterwood with exceptions and workarounds feels constricting. The appeal of irregular shelterwood among foresters has been to make the irregularity the focus of the prescription. The goal is to have extensive treatments that cover a whole stand or set of stands, responding flexibly to various micro-site conditions such as patches and clumps of thinning, shelterwood seed cutting, overstory removal, and bypass as they are encountered.

Let's start first with the principles in play at Haliburton Forest with irregular shelterwood.

- This is a SHELTERWOOD system. The word 'irregular' is an important modifier, not an entirely new system.
- It is a multi-treatment within a single stand. Marking and cutting respond to spatial variation, and regeneration will be spatially variable and may be spread over multiple entries.
- Trees are a crop. The goal is to grow and harvest better trees by thinning immature growing stock, harvest growing stock when it is mature and no longer needed for shelter or seed.

Following on the idea that this is a modification of conventional shelterwood, our implementation of irregular shelterwood follows the general pathway for shelterwood development: there is a regeneration cut, followed by 1 or 2 removal cuts, followed by a long delay while the newly regenerated cohort becomes commercially operable. For those of you who read Patricia Raymond's review paper, this description trends towards the definition of "Extended Irregular Shelterwood". In formal settings, we can call our implementation "Extended Irregular Shelterwood with Groups and Reserves". The "Extended" tag indicates that the regeneration period of this system is expected to take longer than the Ontario silviculture guide standard of 7-20 years for sugar maple. The "Groups" tag indicates that a sub-stand multi-treatment approach will result in abundant groups and patches that deviate from the dominant matrix.

IRREGULAR SHELTERWOOD:
A forest management perspective

The “Reserves” tag indicates that crop trees and immature AGS growing stock will be retained in important quantities, even in a final removal. Permanent ecological legacies will be retained as well, but they are also retained in all silvicultural systems in Ontario. Following the basic outline of a conventional shelterwood helps to implement this system practically. Identifying the dominant stage of development within a stand directs the intervention even if that condition is only 40% of the stand area. Using the dominant condition can anchor the marking and thinning. Not sure what to do in a tricky patch? Do a removal cut! The 'anchor' condition generally sets the return interval for the next cut. For example, if the dominant treatment will be a removal cut, we will return in 60 years. We collect our inventory data, with a particular focus on the plot-to-plot variation in regeneration and overstory condition. This approach helps us anticipate the amount and degree of spatial variation present within a single stand. By understanding these nuances, we can create a more effective forest management plan.

Some readers may question how different this system is from a conventional shelterwood or from their own experience of uniform shelterwood, which they do not bother to apply the prefix ‘irregular’ to. Is the irregular label necessary? They may be right to be a bit grumpy. In an editorial, Ralph Nyland criticized the push for irregular shelterwood as “…proposals for seemingly new methods”. For all the press and attention that irregular shelterwood gets, for the purposes of Haliburton Forest, I advocate an approach that varies the least from conventional methods.

There are practical and cultural reasons to use the terminology. The tag of ‘irregular’ helps describe these stands in our inventory. They may be substantially different to manage than their uniform cousins, with probably >1/3 of the stand area in cohorts that are at least 20 years different than the dominant stand condition, and with ample BA (basal area) in good quality veterans of the prior cohort. The spatial variance and abundance of growing stock retention also make them unusual and flexible to schedule for the next harvest, compared to a textbook situation. I believe that the use of the word irregular is part of a positive culture shift towards management which is responsive to the patch and the tree, and towards a management system that identifies and manages regeneration more specifically. At another CIF workshop, I asked for a show of hands of who had implemented a conventional shelterwood or a Group Selection prescription. Extremely few had used these old methods that Ralph was referring to. But with clear guidance and support there may be interest in the flexible and responsive approach that can help achieve some common goals that foresters share.

IRREGULAR SHELTERWOOD
Summary

The NHRI Silviculture Prescription System is well aligned for managing irregular high-forest systems.

We express our gratitude to the contributors for offering diverse perspectives on irregular shelterwood. For those seeking deeper insights, we encourage exploration through the provided links to videos, podcasts, and papers throughout this edition of the Leaflet. Regarding NHRI's SPS, you might be curious about how it tackles the confusion surrounding irregular shelterwood. While various terms have been used to describe its variants, our SPS offers extensive and valuable guidance.

How does NHRI implement irregular management?

The irregular high-forest system aims to regenerate the entire treated stand gradually over an extended period, utilizing partial cuts of varying extents. This approach maintains multiple vertical or horizontal age classes, resulting in a permanent forest cover that may not be dominated solely by mature trees. The primary goal is to foster stands with irregular structures, preferably through natural seeding, comprising at least three age classes or a two-story configuration. This system facilitates the coexistence of tree cohorts of different ages within the same stand, creating a diverse range of light conditions suitable for species with varying tolerances to shade and longevity. Re-entry after the initial treatment is prolonged, typically occurring after 30-35 years. NHRI has described this type of silviculture with 2 main variants in our Silviculture Prescription System (SPS 2.0). Continuous cover two-aged (CTA) and Uniform two-aged (UTA). The decision for or between the two systems is dependent on the amount of acceptable growing stock and desired regeneration in your stand.

What forest types are eligible?

☑ Recommended in forests with longer-lived species such as northern hardwood and mixedwood stands >30% tolerant hardwood species composition.

IRREGULAR SHELTERWOOD
Summary

Why should I consider CTA or UTA?

Irregular management with CTA and UTA from NHRI's SPS 2.0 is the ideal silviculture in stands where:

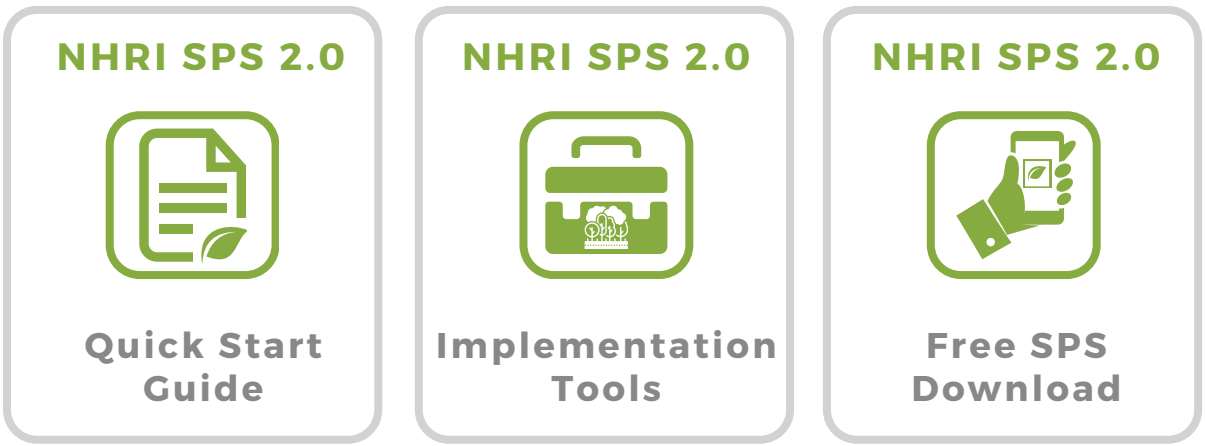
- you don't have a lot of acceptable growing stock (AGS)
- you are thinking of using single tree selection, but there's just not enough high quality
- you have an even age stand you would like to convert to an uneven age stand
- you want to push more toward yellow birch because it's not a good maple site due to American beech
- you are moving toward transitioning forests due to predicted shifts in climate and suitability
- you want to build more resistance to climate change

If you are interested in growing timber for economic value, here are a few ways you can prioritize resilience and quality in degraded stands:

- open the canopy more
- monitor over time
- re-enter the stand for multiple removals
- reevaluate along the way using adaptive management

What does this mean for those who use NHRI's SPS?

Step 1: Follow the master key of the SPS to determine if your stand type is eligible for our system



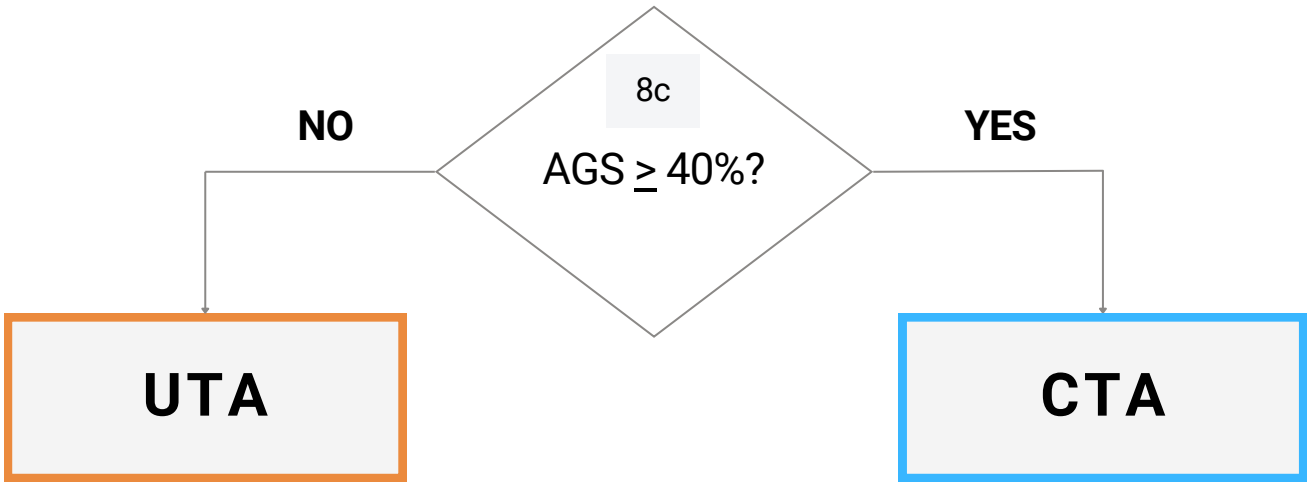
IRREGULAR SHELTERWOOD:
Summary

Step 2: Determine the treatment from determination keys; the SPS 2.0 already incorporates issues such as presence of beech or unacceptable growing stock (UGS) that may result in a CTA/UTA prescription. The most common method to designate quality of standing trees is the AGS/UGS system. Acceptable growing stock (AGS) consists of vigorous trees of desired species and of good quality that can continue to grow (or not stagnate) and will not lose value and health in the near future or at least until the next entry. Unacceptable growing stock (UGS) possess one or several of the opposite characteristics. High proportion of AGS will help maximize the growth of residual trees and improve the quality of the residual and future stands.

The determination of AGS/UGS is done using species, form and risk with tables and determination keys from the Tree Classification System for New Brunswick (Pelletier et al. 2016). As mentioned, these classifications are of utmost importance when deciding whether to manage your stand with CTA or UTA over other types of shelterwood or selection.

Below is an example of a question from our SPS 2.0 Decision Key designed to help decide between a Continuous Two-Aged (CTA) or a Uniform Two-Aged (UTA) treatment. Complete Decision Keys are available here.

NHRI Silviculture Key #1B
Stand structures: **M1, M2**
FUNA's: **SMTH, YBTH, TOHW, OKHW, FPHW, BETH, THHW**
multi-cohort, uneven-aged mixtures of tolerant hardwoods



IRREGULAR SHELTERWOOD:
Summary

Step 3: Review prescriptions: If you came to a UTA or CTA result, your stand is likely best managed through irregular shelterwood. CTA stands for continuous cover two-aged and results in trails 4-5m wide 20m center to center, and a target basal area of 14-16m^2/ha between trails. UTA stands for uniform two-age and results in trails 5m wide and 15m center to center or, 6m wide and 16m center to center and an 8 – 12m² target basal area between trails. Implementation instructions are in the table below.

VARIANT	CTA CONTINUOUS COVER TWO-AGED	
GOALS	Promote a two-age class stand but maintain significant crown cover at all time. The entries are extended longer than in other regimes (25-35 years). This sub-system differs from other two-aged systems because it maintains a minimum 40% cover.	
HARVESTING SYSTEM	MFT (preferred), CTL (adapted to increase scarification)	
SEASON	Fall, winter, early summer when beech present	
TRAIL	5 wide and 20m center to center or 4m wide and 18m center to center	
RESIDUAL DENSITY	14-16m^2/ ha	
CUT PRIORITY	Cut most trees >48cm, trees with high grade products at risk and those from the UGS group	
CUTTING INSTRUCTIONS	saplings <10 cm	protect AGS
	small 10-22 cm	1/4
	medium 22-38 cm	1/2
	large 38-48 cm	1/2
	very large >48 cm	all
	openings	<0.2 ha

IRREGULAR SHELTERWOOD:
Summary

VARIANT	UTA UNIFORM TWO-AGED	
GOALS	Promote a two-age class stand by putting emphasis on establishing regeneration. The entries are extended longer than in other regimes (25-35 years) and the resulting stand is homogenous.	
HARVESTING SYSTEM	MFT (preferred), CTL (adapted to increase scarification)	
SEASON	Fall, early summer when beech present	
TRAIL	5-6m wide, 15-16m center to center	
RESIDUAL DENSITY	8-12m^2/ ha	
CUT PRIORITY	Cut most trees >48cm, trees with high grade products at risk and those from the UGS group	
CUTTING INSTRUCTIONS	saplings <10 cm	protect AGS
	small 10-22 cm	1/4
	medium 22-38 cm	1/2
	large 38-48 cm	2/3
	very large >48 cm	all
	openings	<0.2 ha

We genuinely believe that clarifying the concept of irregular shelterwood will positively influence our approach to silviculture in mixed and hardwood stands. The crucial step in advancing silviculture, safeguarding our valuable hardwood resource, and adapting to climate change lies in practicing effective silviculture. Please feel free to contact us anytime for further information or to discuss enhancing our hardwood management practices. We are always here to help.

CFRU
Navigating Irregular Forest Types

By Regina Smith, Program Manager, CFRU

Updated Stand Density Management Charts Useful for Irregular Spruce-fir Forest Types

A recent paper by researchers from the University of Maine and the U.S. Forest Service describes the science behind stocking guides and density management diagrams using new charts developed for eastern spruce-fir forests.

Stand density management is crucial in achieving diverse silvicultural objectives, and the updated stand density management chart recently released by researchers (figure 1) gives forest practitioners a revised decision-support tool that can be used for eastern spruce-fir silvicultural prescriptions, including what we call the irregular shelterwood. These charts are based on more comprehensive datasets and more robust maximum size-density relationships than were previously available. Because of these incorporations, they can be used in a wider range of spruce-fir stand types, including irregular and multi-aged stands.

Most of the authors are collaborating on an updated Northern Conifer Silviculture Guide, to be released by the U.S. Forest Service with financial support from the Cooperative Forestry Research Unit. In addition to the new stand density management chart for spruce-fir, the publication by the U.S. Forest Service will include eco-type specific versions of the charts. In the meantime, the versions included in Ray et. al 2023 are based on a range-wide average maximum density value and are a good resource for practitioners looking to manage irregular spruce-fir shelterwoods.

A link to the paper, plain language summary, and clean image of the charts are available here.

From left to right: Carolyn Ziegra, Research Forester, Appalachian Mountain Club. Nicole Rogers, Assistant Professor of Silviculture, University of Maine. Laura Kenefic, Research Forester and Team Leader, U.S. Forest Service, Northern Research Station

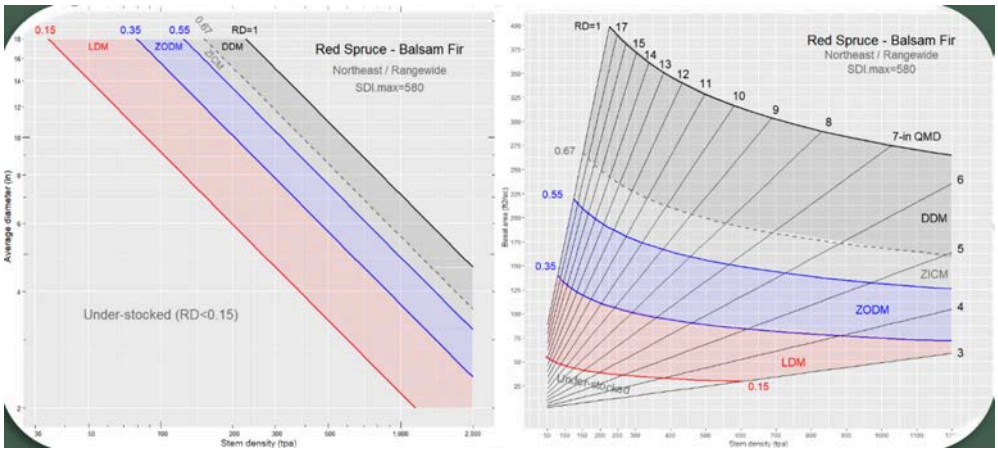


Figure 1. Updated quantitative silviculture tools for the spruce – fir forest type in the Northeast includes a stocking guide based on stand density index (SDI). This guide shows basal area (ft ^{2}/acre) on the y-axis and average stand diameter (QMD) isolines (3-17 inches). It uses relative density (RD), a function of maximum and observed SDI, to define upper and lower bounds of five management zones: zone of high density-dependent mortality (DDM) (RD 1.0 - 0.67), zone of imminent competition mortality corresponding to the average self-thinning trajectory (ZICM) (RD 0.67 - 0.55); zone of optimal density management where net stand level production is expected to be highest (ZODM) (RD 0.55 - 0.35), and zone of low density management where growth rates of individual trees are optimized (LDM) (RD 0.35 - 0.15). RD < 0.15 is considered understocked relative to wood production objectives. This figure compares the updated guide (black lines) to previous spruce – fir stocking guides published by the U.S. Forest Service (Solomon et al. 1987 in orange, and Frank and Bjorkbom 1973 in green). The data points shown are from the U.S. Forest Service, FIA (colored dots) and the CFRU Commercial Thinning Research Network (black solid dots = unthinned, black hollow dots = thinned). Many of the data points fall outside the bounds of previously published stocking guides; the new guide more accurately reflects spruce – fir forest dynamics. The choice of SDI.max=580 corresponds to average values for red spruce and balsam fir used to predict density-dependent mortality in the Northeast Variant of the Forest Vegetation Simulator; other values can be used. Credit: David Ray. Graph is available with additional explanation in the Supplementary Materials of Ray et al. 2023.

IN THE SPOTLIGHT
Stéphanie Lebel-Landry

Stéphanie Lebel-Landry has successfully defended her PhD at Université du Québec à Rimouski !!!

What inspired you to choose this particular research topic for your thesis?

I had the privilege of being a part of the NHRI team from 2014 to 2019 as a regeneration specialist, which significantly influenced the choice of my Ph.D. topic. This decision was driven by the forest industry's needs regarding forest regeneration. In 2014, as the application of remote sensing in forest characterization was becoming increasingly prominent, the need for detailed characterization of regeneration emerged as a crucial research area. Thus, NHRI and I decided to explore this avenue for my doctoral research.

Additionally, the high moose density in northern New Brunswick and the consequent browsing damage on regeneration highlighted a gap in our understanding of the extent of damage and management strategies. This issue also became the focus of my research.

How did you approach the initial stages of your research?

My initial step was to thoroughly understand the forest industry's needs and expectations to formulate relevant research questions. After defining my research questions, I developed an inventory plan and protocol. I was fortunate to have the guidance of a highly experienced team of researchers and field technicians from NHRI, which expedited this process.

Were there any pivotal moments during your thesis journey that significantly influenced your work?

Beginning my Ph.D. journey without prior experience in scientific publishing, my first publication significantly boosted my confidence and motivation, accelerating the progress of my doctoral work.

What were the major obstacles or roadblocks you encountered during your research?

A significant hurdle I encountered was towards the end of the statistical analysis for my last chapter, where we discovered that our model for mapping moose wintering areas did not accurately represent the reality. This necessitated the development of a new model using New Brunswick data, delaying the process by a month, and causing considerable discouragement.

IN THE SPOTLIGHT
Stéphanie Lebel-Landry

How did you overcome these challenges?
Upon realizing the inefficacy of our initial model, I took a short break to regroup before resuming the statistical analysis with renewed determination.

Were there times when you felt stuck or discouraged? How did you stay motivated?
During periods of discouragement, I would take brief breaks from my Ph.D. to engage in activities with my children. These moments served as a crucial reset, helping me to stay motivated.

What technical skills or research methodologies did you acquire during your thesis work?
Throughout my Ph.D. journey, I honed significant skills, notably coding in R for statistical analysis and utilizing satellite imagery. These skills have broadened my capabilities beyond my primary field of study.

I would add that, on a personal level, I learned to take breaks when needed. Before, I did not allow myself to take breaks because I was feeling like I was wasting some time. However, during my Ph.D. journey, I understood that taking breaks was just making me more productive afterward.

Reflecting on the process, what would you do differently if you were to start over?
Although I could contemplate adjustments such as increasing my sample size or revising my inventory plan, I believe this journey has shaped me both personally and professionally. I have learned so much about myself and scientifically, I feel that if I had changed something, I would have missed the chance of learning something important.

What advice would you give to future students embarking on a similar thesis journey?
I advise prospective Ph.D. candidates not to overthink and to embrace the challenge. While the journey is demanding and may at times seem overwhelming, the rewards and personal growth are well worth the effort.

I would also emphasize that my greatest achievement is not merely obtaining the title of doctor but doing so without compromising my personal life, my role as a mother, partner, and friend. This accomplishment, I hope, will inspire other women to pursue their professional goals without forsaking their personal roles.

IN THE SPOTLIGHT
Team news & updates

Growing up on Lake Superior's north shore surrounded by boreal forest, NHRI Research Forester, Sophie Cation developed an interest in the relationship between forests and aquatic ecosystems. Her research is focused on understanding nutrient cycles within forested landscapes and the potential nutrient depletion in managed forested watersheds due to rapid growth and nutrient uptake by secondary successional forests. Sophie's work, exemplified through the Upsalquitch River Watershed, aims to provide a foundational framework for developing better predictive models for forested watershed nutrient budgets. Full summary here.

Learn more about NHRI's Research Forester, Jeneya Smith's thesis journey, exploring the intricate role of spring frost in shaping temperate hardwood distribution. His research in Mount Carleton Provincial Park reveals the dominance of cold spring temperatures over winter ones. Jeneya has gained expertise in ecological methods, data interpretation, and the importance of perseverance in navigating research challenges, offering invaluable advice for future scholars. Full summary here.

Discover more about Elizabeth White's compelling journey from passion to purpose, shaped by unexpected surprises and pivotal moments. Learn how Elizabeth has overcome obstacles, from burnout to imposter syndrome, and learn how she navigated through challenges with resilience and perseverance. Gain insights into the technical skills and methodologies she mastered along the way, and uncover valuable lessons learned for your own academic endeavors. More detail here.

Discover more about Bastien Vandendaele's recently published article: *Evaluation of mobile laser scanning acquisition scenarios for automated wood volume estimation in a temperate hardwood forest using Quantitative Structural Models*.
This study investigates the use of data from a handheld mobile laser scanning (MLS) system and quantitative structural models (QSM) to estimate tree structural attributes. The 20 m × 20 m grid acquisition scenario demonstrated the highest accuracy, with a root mean square error (RMSE) of 0.41 m (2.07%) for tree height, 3.98 cm (14.93%) for diameter at breast height, 0.21 m^3 (19.28%) for merchantable wood volume, and 0.07 m^3 (10.11%) for merchantable stem volume. While MLS shows promise for non-destructive estimation, refining noise removal and assessing suitable acquisition scenarios remain essential for accurate results in various forest types. Read the full article here.

RESOURCES

Discover what's happening in our forestry community

The Leaflet Events Calendar and Recommended Reading sections have moved to our website!

We are excited to announce that we have made some changes to our newsletter to improve your reading experience. From now on, you can find the Events Calendar and the Recommended Reading sections on our website, by visiting the NHRI News & Events page. Now, you can easily access the latest information on our upcoming workshops, community events, and conferences, as well as browse through our curated list of guidebooks, articles, and reports on topics related to northern hardwoods research. We hope you enjoy this new feature, and we look forward to hearing your feedback.

EVENTS CALENDAR ➤

Keep informed on upcoming events, conferences, and key dates from our Forestry Community with NHRI's new Events Calendar!

NEWS & RECOMMENDED READING ➤

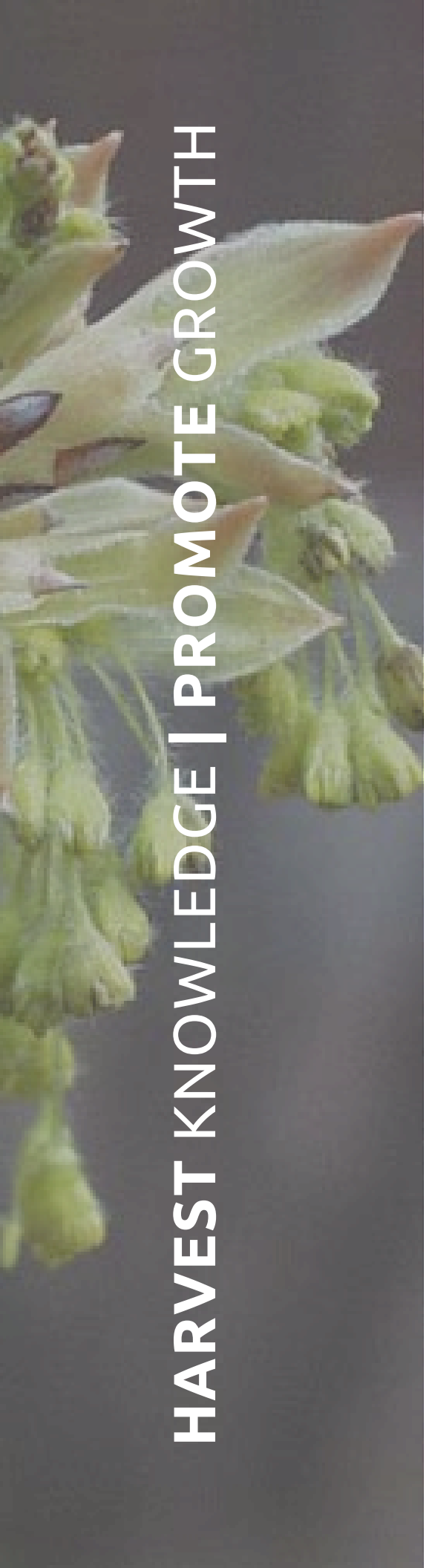
Discover the stories that interest you the most: Stay informed of the latest news, important announcements, engaging articles, key papers, and exciting innovations.

VIDEO ARCHIVE ➤

Stay current on forest industry advancements with our NEW video archive. Explore past newsletter videos for the research, technology, and insights that matter most.

THE LEAFLET ARCHIVE ➤

Explore NHRI's quarterly newsletter for updates on forest industry research, technology, and best practices. Dive into our newsletter collection and enjoy the best moments.



MORE THAN A THEORETICAL CONCEPT...

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