TECHNICAL NOTE

Establishing hardwood plantations via direct seeding

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INTRODUCTION

Hardwood establishment by direct seeding has been investigated as an alternate method to planting of nursery-grown stock. Very little has been done to test and record the direct seeding of maple plantations. The direct seeding technique for afforestation of former agricultural fields was pioneered by foresters in Iowa, Minnesota and Wisconsin in the late 1990's. In many sites where hardwoods were not growing previously, direct seeding involves mechanical and chemical site preparation and so we can learn much from ecological restoration of hardwoods and apply it to silviculture to grow high-quality timber. Establishing hardwood trees by sowing seed is a relatively new method that has several advantages over traditional planting of seedlings, and this note highlights those advantages, disadvantages and best practices that are more specific than seedling stock planting recommendations found in the rest of this series of notes: Plantation Planning and Tending and Maintenance.

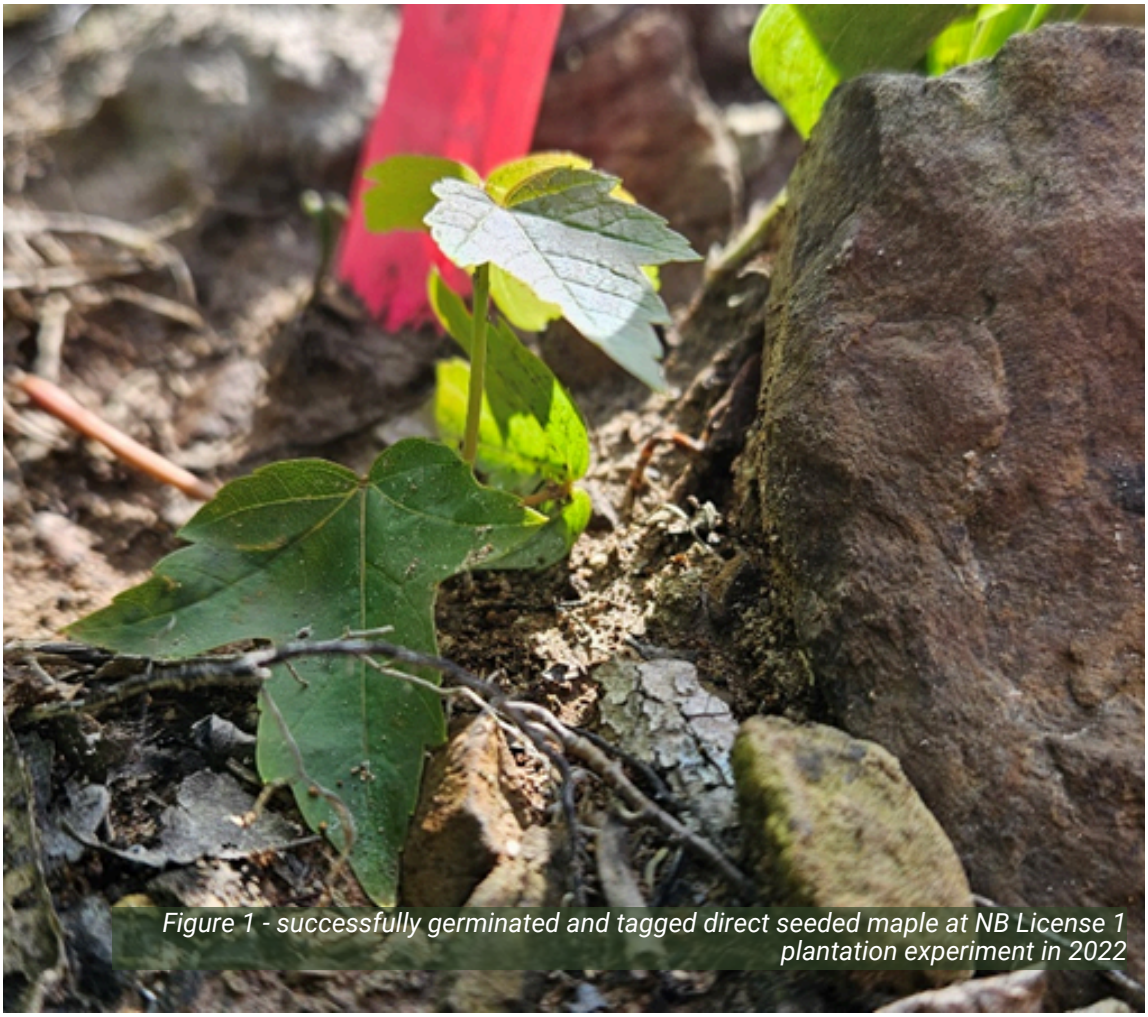


Figure 1 - successfully germinated and tagged direct seeded maple at NB License 1 plantation experiment in 2022

HIGHLIGHTS

Seed size significantly influences success in direct seeding. Large-seeded hardwoods like oaks and walnuts generally perform well, while light-seeded species such as ash, birch, and maple are less reliable and remain experimental due to lower germination and survival rates.

Managing seed collection and storage can be challenging, especially for large-scale operations. For small plantings, seed predation by wildlife poses a significant risk. Fall sowing is often preferred to maintain seed viability and avoid storage issues, though spring sowing may reduce predation.

Broadcast seeding allows for high stand densities and is suitable for light-seeded species but requires intensive site preparation and thinning. Mechanical or spot seeding is more efficient in seed use and density control, though calibration issues and high costs can be obstacles, particularly for larger seeds.

Effective site preparation is essential. In agricultural fields, mowing, tilling, and selective use of chemical site preparation can suppress weeds and reduce erosion. In forest sites, combining mechanical scarification with chemical preparation enhances germination conditions.

Post-establishment care is critical, with 3-4 years of weed control necessary to ensure seedlings compete effectively for sunlight and moisture. This involves mowing, herbicide applications, and regular monitoring to manage invasive species.

Mechanical seeding for hardwoods remains a challenge due to high equipment costs and technical issues, despite newfound drone and robotics technology. Manual planting is often necessary, particularly for species like sugar maple, which do not fare well with seeders. Success depends on consistent maintenance and monitoring.

Figure 2 - Broadcast seeding at a high density makes sense in a controlled nursery bed where there is high intensity site preparation, thinning, and monitoring opportunities. Many seedlings get their start in this way and are later transplanted. Applying this method to an operational scale landbase is much more risky and hard to measure success (Photo by Marcel Faucher).

Figure 3 - Glyphosate being applied during site preparation of a sugar maple plantation (Faucher, M.) The photo is from the 90's in Quebec, and much of the legislation has changed since then. Always consult with local DNR and recommendations when it comes to chemical site preparation.

ADVANTAGES

- Better and quicker establishment: Direct seeding establishes thousands of seedlings per hectare rather than hundreds with traditional planting. Trees reach "crown closure" and begin shading out vegetative competition earlier. Follow-up weed control typically only needs to be done for two years after seeding, instead of eight to 12 years with planting.

- Higher quality timber: Greater density of seedlings forces trees to grow straighter due to side competition from nearby stems. Competition decreases pruning needs and produces higher quality hardwood saw logs.

- Better use of natural selection: Trees best suited to a particular site will dominate because of large numbers of seed and species.

- Better adaptation to variations in site conditions: Small variances in site conditions aren't planned for when planting seedlings. If direct seeding includes diversification of species, then species and specimens best suited will take over in each area.

- More natural appearance: Direct seeding is a much closer approximation of mother nature's hardwood establishment method than seedling planting in rows.

- Better ability to withstand animal predation: Animals such as deer, while still causing damage by browsing, will be less likely to devastate a direct seeding operation than a traditional seedling plantation due to far higher stems per hectare.

Figure 4 - Red and white oak direct seeding plantation in Nebraska (Arens, C. 2019 retrieved from https://www.farmprogress.com/conservation-and-sustainability/5-advantages-to-direct-tree-seed-planting)

Figure 5 - 19-year-old direct seeded Nuttall oak stand. Note the difference in size among blue and orange flagged trees despite their age similarity. Blue flags mark trees that would be removed in a thinning operation when they reach a commercial harvest size. (https://extension.msstate.edu/publications/thinning-hardwood-plantations)

DISADVANTAGES

⊖ Higher initial cost: Establishing seeds may be somewhat costlier than planting seedlings ($1200/ hectare vs. $850/ hectare on average). Keep in mind, however, that part of the higher cost can often be offset by collecting some seed yourself or doing your own site preparation. Follow-up care costs will be compressed into the first two to three years, but should be less than with seedling planting, due to earlier crown closure.

⊖ Inconsistent seed availability: If you commit to direct seeding, the densities required for a higher likelihood of success in your plantation can be very draining on seed supplies. In a species that masts rarely such as sugar maple this is of greatest concern. For information on seed and seed supply issues, please read our first volume in this series, Seed collection and nursery practices.

DIRECT SEEDING METHODS

The size of the seed has been found to affect the success rate and should be considered in your decision to direct seed versus planting seedlings. In many cases, hardwood species with relatively small seeds such as ash and birch were generally found to be unsuitable for direct seeding (Scholz 1964, Bjorkbom 1969), and Von Althen (1964) claimed that only oaks and walnuts had any success. In a more recent study by Edge (2004), walnut had very high success, followed by many species of oak, but they concluded that much more research is needed on light-seeded hardwoods such as ash, maple, and birch.

Direct seeding with light-seeded hardwoods should be considered experimental (Edge, 2004). In yet other research, lighter seed was more successful and easily implemented into new technologies such as robotics and drone technology, and lighter seed is less preferred by rodent predators.

Collecting, transporting, and storing large amounts of seed is not easy, so keep the size of your direct seeding plantation manageable. For large plantings, consider doing part with seed and the rest with seedlings or establish the plantation over several seasons. On the other hand, be cautious with very small plantings. Research with southern oak species found the greatest nut predation by mice, squirrels, and deer were within plantings of less than two acres in size, especially plantings within existing forest cover (Stoeckeler et al. 1950). Spring seeding may be an option to help avoid heavy seed predation in these small, forested plantings, but fall sowing is the best method to avoid potential storage problems and maintain high seed viability.

SITE PREPARATION FOR DIRECT SEEDING

Herbaceous competition is especially hard on newly germinated seed, and it can slow seedling growth for years, or cause “check” in sugar maple. Heavy discing in forest stands or strips, or tillage of agriculture fields is an excellent way to eliminate a sod layer and create soil conditions that are good for seed germination, but keep in mind that operating machinery may be more difficult on freshly tilled soil. A variety of weeds may become established from the seed bank or get blown in from adjacent areas. Cover crops can help this problem, however, in some studies, the germination and survival rates appeared to be no better in the plantations with a cover crop (Edge, 2004). An option for agriculture fields is to seed directly into mowed grass stubble, then kill the grass with glyphosate prior to tree seed germination in the spring. This method leaves a layer of dead grass to limit soil erosion and suppress weed growth. Pre-emergent herbicide must be used with caution during the first growing season to avoid chemically killing or damaging germinating tree seed. It is also important to mention that herbicide use in Canada is under provincial jurisdiction and there is legislation to adhere to. Refer to the section on Chemical Weed Control in the ARM Guide Vol. 2 for more detailed information. Many foresters have preferred to apply only good site preparation and monitor the planting during the first growing season.

In forest sites, it is recommended to conduct intensive site preparation such as with disk trenchers. Prior to mechanical scarification, there are options for chemical site preparation.

SEEDING METHODS

Broadcast seeding

Broadcast seeding is a method by which seeds are scattered over site-prepared soil, where there is no predetermined spacing or arrangement. The advantages of broadcast seeding include the ability to achieve very high stand densities and more options for incorporating light-seeded species. This method may allow the grower to select for what appears to be the superior tree when thinning. Thinning is the process of removing excess seedlings in high-density stands once they have developed their first set of true leaves. This allows the other seedlings room to grow and access to nutrients. Thin the crop to the correct stand density by cutting or pinching out the stem to prevent disturbing the root system of the remaining seedlings.

Contact with the soil is especially important in broadcast seeding, so site preparation is just as important as with planting or mechanical seeding.

Figure 6 – Direct seeding operation on site prepared agricultural field in Minnesota. Their biggest finding was the adaptability of the different microsites to specific species 5 to 10 Soil details Mount Carrol Silt Loam, 2 to 6 % slopes on approximately 6 acres • Mount Carrol Silt Loam, 6 to 12 % slopes on approximately 1.9 acres Stand area: 8 acres. Species target: red oak. Retrieved from https://silvlib.cfans.umn.edu/direct-seeding-hardwoods-former-agricultural-site-observations-soil-compaction-mn-dnr

MECHANICAL SEEDING

Seed supply is often the most limiting factor for direct seeding, so mechanical seeding makes sense, when possible. Mechanical or spot seeding is a much more efficient use of seed than broadcast methods. Mechanical seeding allows better control over the final stand density and keeps planting costs lower over hand seeding. The location within the soil matrix that is most likely to provide optimal soil moisture and temperature is difficult to predict since they vary through the soil, so there are ongoing improvements and suggestions to mechanical seeding methods.The depth at which a seed is sown is important to optimize germination rates when it comes to direct seeding because of the risk of predation, desiccation, and wind but must not be sown too deep, otherwise the seed may struggle to emerge (Masarei et al 2019). There are issues with mechanical seeding as well. If a seeder was used for sowing, it may not have been correctly calibrated to the size of the seed, resulting in skipping and/or the seeds being planted too shallow or too deep. The cost of a larger seed hardwood seeder is usually well beyond the scope of a hardwood plantation, so spot seeding is recommended.

As an example, a study of direct seeding of hardwoods in Wisconsin included a density of hardwoods broad seeded at 7500 – 20000 seeds per hectare on former agricultural fields. Most sites were planted using a hardwood seeder or drill, but sugar maple was hand planted because it couldn't be run through a seeder. AV group NB recently had similar issues where mechanical seeders did not work for hardwoods.

They decided to hand plant/ direct seed maple species because a seeder on a disc trencher had an estimated cost over $100k.

DEVELOPMENTS IN DRONE TECHNOLOGY SEEDING METHODS

Seed pods

One company working to improve the direct seeding world is Tree Track Intelligence. Over 200,000 seed pods were deployed across 120 hectares of forested land, demonstrating the potential for scalable, efficient reforestation methods. Behind this achievement is a year of rigorous testing, during which 500,000 seed pods and 200 + unique formulas were evaluated to combat environmental challenges.

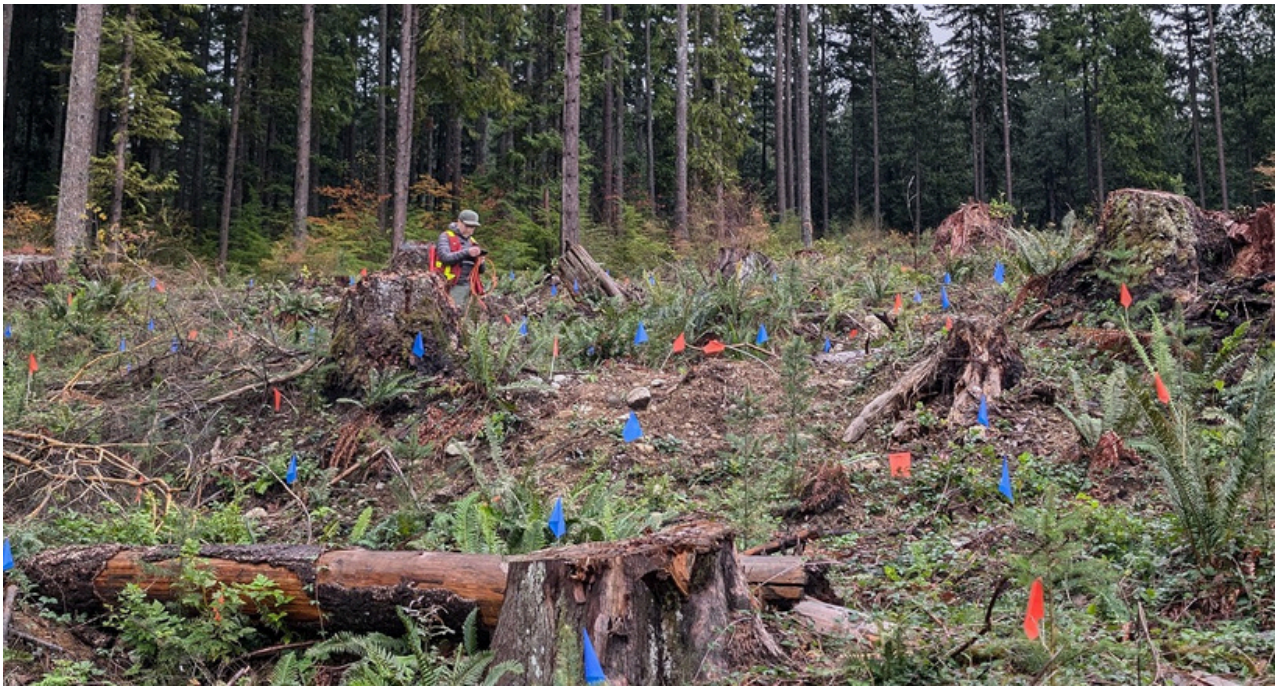
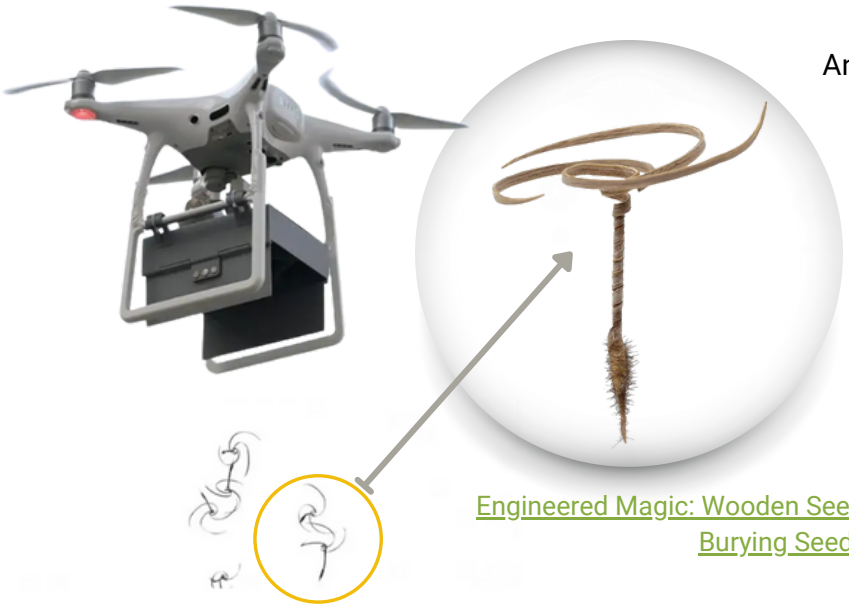


Figure 7 - https://treetrack.ca/a-milestone-in-reforestation-tree-tracks-first-forest-germination-results/



Wooden seed carriers

Another example is a biodegradable seed carrier referred to as E-seed. This seed carrier, fashioned from wood veneer, could enable aerial seeding of difficult-to-access areas, and could be used for a variety of seeds or fertilizers and adapted to many different environments.

Engineered Magic: Wooden Seed Carriers Mimic the Behavior of Self-Burying Seeds - News - Carnegie Mellon University

Photo Credit: Carnegie Mellon University

CALCULATING SEEDING FOR SUGAR MAPLE

The lighter seed (ash, maple) should be broadcast seeded and dragged in lightly. It is recommended to only seed the actual trenches made by the scarifier. Sugar maple requires a minimum of 144 litres/acre or 356 litres/ha. Therefore, when direct seeding after site preparation such as done with a disc trencher and only treating the trenches (about 30% of gross area), the number of seeds required to treat a full hectare is approximately 107 litres.

POST ESTABLISHMENT WEED CONTROL

Controlling grass and weed competition until seedlings reach "crown closure" (which often happens in about 3-4 years) is crucial to the success of any seeding project. If weeds are not controlled, tree seedlings will be outcompeted for moisture and sunlight. Typically, for direct seeding, a pre- or post-emergent herbicide has been used early in the first season and a post-emergent herbicide has been used later in the first year, but local recommendations and legislations must be adhered to, and permits and certifications are required for those applying any herbicide. If broadleaf weeds become a problem in year one, mow the area. The area will need to be scouted often to determine weed control needs. More information on tending and weed control options, especially important considerations before deciding to use chemical weed control are presented in the next technical note in the series, on tending and maintenance of plantations.

Figure 8 - If this much herbaceous competition exists on your site, intensive site preparation and maintenance would be required for direct seeding of hardwoods to be successful.

CONCLUSION

In conclusion, direct seeding offers a promising alternative to traditional hardwood planting methods, with several advantages including quicker establishment, higher stand densities, and better adaptation to site conditions. However, challenges such as seed predation, inconsistent seed availability, and the need for intensive site preparation and post-establishment care must be carefully managed. While mechanical seeding methods are still evolving, broadcast and manual seeding can be effective, especially when paired with good site preparation and weed control practices. Although more research is needed, particularly for light-seeded species like maple, direct seeding has the potential to enhance hardwood plantation success under the right conditions, and it's methods are a great reference for the early phases of tree growth and starting a plantation. The technical note will provide more detailed guidance on tending and predation control methods, encouraging long-term planning for direct seeding and plantation projects.

Figure 9 – This broadcast seeded sugar maple nursery from the 1990's was expanded and site prepared for the transplanting of select trees for the plantation. This encourages natural selection, genetically favouring the best future trees, planted on the right soil, at the right site. The land surrounding it also has a fence to keep out predators (Faucher, M. 2019)

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