

Photo credit: Linda Williams, Wisconsin DNR

ANNUAL REPORT 2023

Wisconsin Reforestation Program

Wisconsin Department of Natural Resources
State Reforestation Program
Forest Genetics Program

University of Wisconsin-Madison
Department of Forest and Wildlife Ecology

WISCONSIN DNR REFORESTATION PROGRAM

Carmen Hardin	Applied Forestry Bureau Director	1
Joe Vande Hey	Reforestation Team Leader	2
Jeremiah Auer	Regeneration Specialist	3
Roger Bohringer	Wilson Nursery Assistant Manager	2
Richard Nessler	Tree Improvement Specialist	4
Scott O'Donnell	Forest Geneticist/Ecologist	5
Mark Caldwell	Wilson Nursery Operations Coordinator	2
Pat Hromadka	Wilson Nursery Operations Coordinator	2
Jackie Knoble	Wilson Nursery Operations Coordinator	2
Carey Skerven	Reforestation Office Operations Associate	3
Ray Aguilera	Hayward Nursery Foreman	4
Walker Jaroch	Communications Specialist	5

WISCONSIN TREE IMPROVEMENT PROGRAM

Stuart Seaborne Tree Improvement Research Specialist

- 1 **Wisconsin Department of Natural Resources** 107 Sutcliff Avenue, Rhinelander, WI 54501
- 2 **Wilson State Nursery** 5350 Hwy 133 E, Boscobel, WI 53805
- 3 **Griffith State Nursery** 473 Griffith Avenue, Wisconsin Rapids, WI 54494
- 4 **Hayward State Nursery** 16133 W Nursery Road, Hayward, WI 54843
- 5 **Wisconsin Department of Natural Resources** 101 S Webster Street, Madison, WI 53707



TABLE OF CONTENTS

REFORESTATION PROGRAM.....	4	FUMIGATION AND FALL SOWING	17
REFORESTATION MONITORING	4	FALL LIFTING AND GRADING.....	18
INTRODUCTION.....	4	TREE IMPROVEMENT PROGRAM.....	19
PERSONNEL	4	2023 HIGHLIGHTS	19
WEATHER CONDITIONS.....	4	WELCOME TO SCOTT O'DONNELL AND RICHARD	
SITE SELECTION AND PLOT INSTALLATION.....	5	NESSLAR.....	20
PLOT INSTALLATION 2021	5	JACK PINE CONE COLLECTION FOR FOURTH	
DATA ANALYSIS.....	5	GENERATION SEED	21
OVERALL CONCLUSIONS	8	WISCONSIN PROGENY TESTS OF THE WHITE OAK	
REGENERATION TRIALS.....	9	GENETICS AND TREE IMPROVEMENT PROGRAM	21
INTRODUCTION.....	9	CORRECTIONAL CENTER CREW PROJECTS.....	23
FALL LIFTED SEEDLINGS	9	HAYWARD RED PINE CONES.....	24
NURSERY PROGRAM	11	ORCHARD MAINTENANCE: MOWING, PRUNING	
DISTRIBUTION	11	AND SPRAYING	24
SPRING SEEDING	12	WHITE SPRUCE GRAFTING	25
GERMINATION	12	DATA COLLECTION AND FILE UPDATES.....	26
NURSERY TRIALS.....	13	SEED COLLECTION	27
WHITE OAK MULCH TRIAL.....	13	SEED PRODUCTION AND COLLECTION	27
WHITE OAK SEEDING RATE TRIAL	15	SEED SALES.....	30
BIOCHAR TRIALS.....	15	PERSONNEL CHANGES AND FACILITY	
OTHER TRIALS	15	IMPROVEMENT	30
SEEDLING HEALTH AND MONTHLY NURSERY			
WALKS	16		

REFORESTATION PROGRAM

Reforestation Monitoring

Introduction

Since 2007, the Division of Forestry's Reforestation Program staff has examined a sample of Wisconsin's forest plantations during their initial year of establishment to assess the successes and failures of tree planting throughout Wisconsin. Many of these sites are then revisited after the third and seventh year of establishment to examine the health and vitality of the seedlings and plantations. This monitoring also allows for interactions and discussions with landowners and land managers.

Personnel

The regeneration specialist, Jeremiah Auer, directed a team of limited term employees (LTEs) in 2023. Michael Ard participated in his ninth and final field season, and Ian Walton in his first. This crew was effective, and while Auer accompanied on occasion, the duo was responsible for most of the data collection statewide.

Weather Conditions

Planting and growing conditions in late spring were cool and wet, conducive to seedling establishment. However, by the end of May, over $\frac{2}{3}$ of the state was abnormally dry. Only a narrow strip from west central Wisconsin to the extreme northeast had adequate precipitation. By the end of June, the entire state was experiencing dry conditions with over $\frac{3}{4}$ of the state experiencing moderate drought. The conditions continued through July and August, with areas of the far northwest and south central experiencing severe drought.

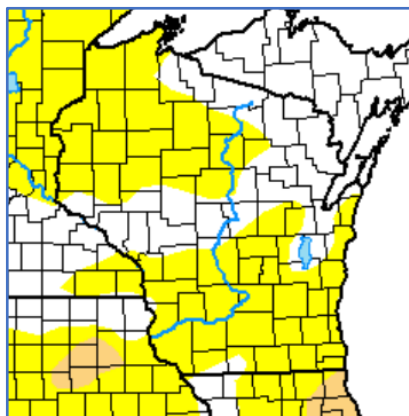


Figure 1: WI Drought Monitor May 30, 2023.

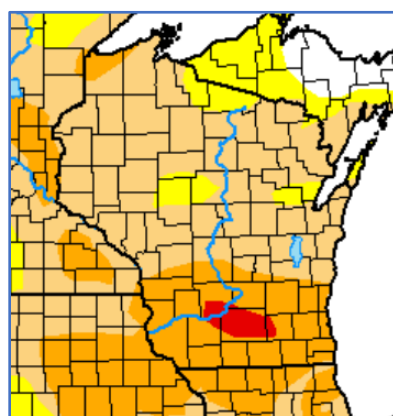


Figure 2: WI Drought Monitor July 4, 2023.

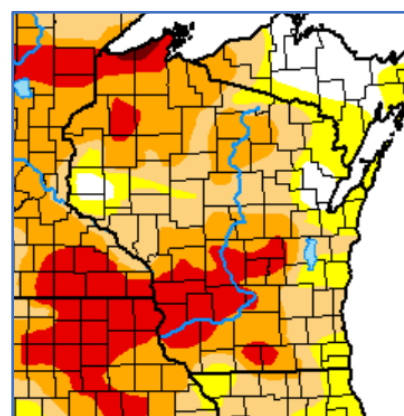


Figure 3: WI Drought Monitor Aug. 19, 2023

Source: National Drought Mitigation Center, University of Nebraska-Lincoln.

Site Selection And Plot Installation

Sites are selected from among landowners who order a minimum of 3,000 seedlings from Wisconsin Department of Natural Resources (DNR) nurseries, a volume that can cover approximately three acres of land. The landowner's main objective must be to establish a forested environment. Other goals, including wildlife habitat and erosion mitigation can be considered, but the management techniques must focus on developing a forest.

After the sites are randomly selected, plots are installed within the planted area. Areas greater than 10 acres receive six plots, and sites with less acres receive three plots. Each plot center is marked with a wooden stake and orange flagging. The corners are established at 20.87 feet at bearings of SW, NW, NE and SE. Each seedling within the plot is marked with an identification whisker, the first is blue, with red whiskers designating the other seedlings, and is mapped to ease data collection in the third and seventh years.

Plot Installation 2023

The 2023 field season was fruitful. Staff established plots on 33 sites, representing 30 ownerships. Of these sites, 16 are located on public lands and 17 on private property. The counties involved include Barron (1), Brown (1), Buffalo (1), Crawford (2), Dodge (1), Door (1), Douglas (2), Dunn (1), Forest (1), Jackson (3), Lincoln (1), Oconto (1), Ozaukee (1), Pierce (1), Polk (1), Portage (2), Rock (2), Sauk (1), St. Croix (1), Walworth (1), Washburn (1), Washington (2), Waushara (2), Waupaca (1) and Winnebago (1).

This widespread approach allows us to monitor seedling growth and development in a wide variety of soils and conditions. After the third growing season, staff also remeasured monitoring sites on plantations from 2021. Staff revisited all 27 sites, representing 12 public and 15 private properties. Again, these sites were scattered across Wisconsin, in the counties of Ashland (1), Brown (1), Columbia (1), Dane (1), Dodge (2), Door (1), Douglas (1), Juneau (1), Kewaunee (1), Langlade (1), Lincoln (1), Manitowoc (1), Marinette (2), Monroe (1), Outagamie (2), Pepin (2), Richland (1), Rock (1), Sauk (1), Vilas (1), Washington (1), Waukesha (1) and Winnebago (1).

Finally, staff visited 29 of the original 32 sites after their seventh growing season. They were originally established in 2017 and remeasured in 2019. There are 18 public and 11 privately owned sites. These are found in Adams (1), Bayfield (1), Calumet (1), Dodge (1), Door (1), Grant (2), Jackson (1), Jefferson (1), Juneau (1), Kewaunee (2), Lincoln (1), Manitowoc (1), Marinette (2), Milwaukee (1), Outagamie (1), Ozaukee (1), Sheboygan (1), St. Croix (1), Trempealeau (1), Vilas (2), Walworth (2), Waushara (1) and Wood (2) counties. Staff was unable to visit three of the original sites. One landowner sold the property and staff could not contact the new owners and the other two are owned by a landowner who did not respond to numerous attempts to contact him.

Data Analysis

Year Zero

Data was collected on 2,409 newly planted seedlings at 33 sites. All seedlings originated at a DNR nursery. Overall, seedlings had a survival of 75.3%. A further breakdown shows

62.5% are considered healthy and 12.8% are lightly damaged – indicating a seedling, while impacted by some type of minor damage such as mechanical impacts, incorrect planting technique, insect or disease, can overcome this damage and survive. Mortality is 24.7%. A further breakdown of this shows that 9.5% suffered some form of heavy damage – indicating the seedling is damaged to the point that it would not be able to recover and likely die prior to being surveyed again after the third growing season – and 15.2% were dead. Compared to previous years, 2023 seedling survival is below the nine-year average of 85.4%.

Public lands: Public land sites are typically planted with more conifers than hardwoods, and plantings tend to be larger in size. This was not true in 2023. Of the 1,265 seedlings sampled on public lands, 47% were conifers and 53% hardwoods. Overall, seedling health was below the overall average of 75.3%. However, the public land planted conifers performed better than the hardwoods, with 80% reported as healthy or lightly damaged. Public land planted hardwoods had only 60% of seedlings reported as healthy or lightly damaged.

It is not easy to estimate the impact of browse or girdling during the early summer when the data was collected, as conifers generally suffer from these impacts during mid-to-late winter when there is much less sustenance available to wildlife. Thus, unsurprisingly, no conifer seedlings exhibited signs of browse. Hardwoods tend to be more susceptible to browse in summer, especially oaks and maples. Approximately 14% of hardwood suffered some sort of browse with enough impact to damage the seedlings. This is down significantly from 2022 when almost 27% of hardwoods showed significant signs of browse.

A common problem with conifers on public lands has been planting too deep. This year, this wasn't as much of an issue, with only 7% of seedlings planted deeper than suggested. While deep planting doesn't typically impact survival or health in the early growing season, it can be detrimental in later years. Hopefully, this trend continues. The increase in hardwood plantings, the incidence of shallow planting has increased to over 16%. Hopefully, this trend does not continue.

Private lands: The increase in hardwood seedlings planted, comes with an increased incidence in shallow planting; over 16% in 2023. These seedlings tend to have larger roots systems, complicating the planting process.

The seedlings did well overall; the rate of healthy and slightly damaged trees was 81.9%. As most seedlings were conifers, browse was minimal. When it did occur, the aspen, maples and oaks seemed to be subject to the most pressure. Other hardwoods have only been minimally impacted by browse to this point.

	Public Lands		Private Lands	
	No. Seedlings	%	No. Seedlings	%
Healthy	698	55.1	808	70.6
Light Damage	179	14.2	129	11.3
Heavy Damage	152	12.0	76	6.6
Dead	236	18.7	131	11.5
Total	1265	100.0	1144	100.0

Table 1: 2023 Seedling Health Year Zero.

Year Three

These 28 sites were planted in 2021. This was the year after the cancellations related to COVID-19, and orders were plentiful. Staff visited 27 sites, representing 27 ownerships. Of these sites, 12 were located on public lands and 15 on private property. The sites were in several counties: Ashland (1), Brown (1), Columbia (1), Dane (1), Dodge (2), Door (1), Douglas (1), Juneau (1), Kewaunee (1), Langlade (1), Lincoln (1), Manitowoc (1), Marinette (2), Monroe (1), Outagamie (2), Pepin (1), Richland (1), Rock (1), Sauk (1), Shawano (1), Vilas (1), Washington (1), Waukesha (1), and Winnebago (1). The one site not visited was lost to blackberry and invasives.

In year Zero, data was collected on 2,049 seedlings – all originating from a DNR nursery. Overall, seedlings had a survival of 80.4%. A further breakdown shows 63.0% were considered healthy, 17.4% were lightly damaged but growing and expected to survive, 11.1% suffered from heavily damage, 8.2% were dead and 0.4% were missing data. In year Three, a total of 1,872 seedlings were measured on the 27 sites. Of the seedlings remeasured, 56.3% were healthy, 6.5% were slightly damaged, 3.9% were heavily damaged, 24.7% were dead and 8.6% were not able to be located and measured. In addition to the one lost site, nine plots were lost. Most were not able to be located, but one was plowed under to make way for row crops.

The number of surviving and thriving seedlings dropped from 1,646 to 1,286 from year Zero to Year Three.

2021	2021 Year 0		2023 Year 3	
	No. Seedlings	%	No. Seedlings	%
Healthy	1290	63.0	1153	56.3
Light Damage	356	17.4	134	6.5
Heavy Damage	227	11.1	79	3.9
Dead	167	8.2	506	24.7
Unknown	9	0.4	177	8.6
Total	2049	100.0	2049	100.0

Table 2: 2021 Comparison of Seedling Health from year Zero to year Three.

Year Seven

These sites were established in 2017 and remeasured in 2019. These are the final measurements to determine if the sites developed to a point where they could be considered successful. For the purposes of this monitoring, a successful planting is one with greater than 450 seedlings per acre and above the impacts of deer browse and competing vegetation. Originally, 32 sites were visited and measured. Then, in 2019, we revisited 30 of the sites to ascertain seedling survival and growth. In the final year, staff revisited 29 of the original sites. The sites not visited were either sold or we were unable to contact the landowner. Overall, of the 29 sites, 16 are public and 13 are privately owned. There are seven successful public land plantings and nine unsuccessful. There are six successful private land sites and seven unsuccessful. This represents a success rate of 44% on public lands and 46% on private lands – an overall rate of 45%.

For success in relation to having a forester provided planting plan, all public properties are required to have a planting plan. As previously mentioned, the public lands success rate was

44%. The reasons that nine sites failed are typical: heavy competition from both native and invasive species (5), heavy deer browse (2) and suspected insect activity (1). The final site is an underplanting whose canopy did not allow enough light to penetrate to the forest floor.

Only three private lands sites did not have a written plan; two of them were successful. Of the nine others with written plans, five were successful and four were not. One landowner did not comment on having a plan. The six unsuccessful privately owned sites had heavy deer browse (2), heavy weed competition (1), drought conditions during planting (1), a low initial stocking that dropped the stocking below the minimum (1) and one that is a bit of a mystery.

The trend has been that sites with planting plans tend to perform better over the 7-year study than those without. In 2023, this trend continued.

2017	2017 Year 0		2019 Year 3		2023 Year 7	
	# Seedlings	%	# Seedlings	%	# Seedlings	%
Healthy	1914	78.3	1199	49.0	1012	41.4
Light Damage	275	11.2	191	7.8	88	3.6
Heavy Damage	65	2.7	116	4.7	82	3.4
Dead	188	7.7	609	24.9	742	30.3
Unknown	0	0.2	331	13.5	522	21.3
Total	2442	100.0	2442		2442	

Table 3: 2017 Comparison of Seedling Health from years Zero, Three and Seven.

Overall Conclusions

This is the ninth year with the current regeneration monitoring protocol. We completed two full measurement cycles (first, third and seventh years of growth) and have noticed trends.

1. Plantations with professionally created planting plans tend to do better than those without (see table below). The correlation isn't as strong as expected but shows private landowners with planting plans tend to have success.

	Planting Plans	2012		2013		2014		2015		2016		2017		Overall Success	
		+	-	+	-	+	-	+	-	+	-	+	-	+	-
Public Lands	Yes	6	4	13	2	8	2	11	9	10	8	7	9	62%	38%
	No	0	0	0	0	0	0	0	0	0	0	0	0	0%	0%
Private Lands	Yes	2	3	4	0	8	0	4	2	6	3	5	4	70%	30%
	No	4	5	0	1	0	0	2	1	1	1	2	1	50%	50%

Table 4: (+) Successful plantings (-) Unsuccessful plantings

2. Seedlings planted on public lands by private contractors are more likely to be planted deeper than what is suggested. Contract crews are planting over 90% of the public land sites, mostly by hand. Since 2015, an average of 37.0% of seedlings planted on public lands were planted deeper than suggested by the nursery, >2 inches below the root collar. Planting depth problems have improved in recent years, especially in 2023, but staff needs to be diligent. Hopefully, this downward trend of deep planting continues. Deeply planted seedlings can be susceptible to fungal infection in the lower stem. By comparison, private lands had a similar incidence of deep planting, 8.6% of seedlings. Another opportunity for forestry staff to work with private lands customers and discuss tree planting.

Public Lands Planting 2015-2023			
Year	Planting Depth		
	Acceptable	Deep (soil level >2" above root collar)	Shallow (soil level >2" below root collar)
2015	88.2 %	11.2%	0.6%
2016	42.6%	55.6%	1.8%
2017	45.1%	52.0%	2.8%
2018	32.5%	58.0%	9.6%
2019	33.7%	56.3%	10.0%
2020	63.8%	36.2%	0.0%
2021	71.7%	24.3%	4.0%
2022	60.8%	32.6%	6.6%
2023	76.7%	7.1%	16.2%
Average	57.2%	37.0%	5.7%

Table 5: Public lands planting 2015-2023.

The Reforestation Monitoring effort has proven useful and allows the Reforestation Program to gather information about seedling performance and plantation establishment statewide and stay abreast of any short- and long-term challenges or trends. In addition to providing valuable data on plantation performance, customers and staff interact and provide an opportunity for idea exchange and advice. The 2023 field season was a success in that our staff was able to visit a variety of diverse plantings. Continued data collection and analysis will continue to provide the information needed to assist landowners and property managers in maintaining and growing their forests.

REGENERATION TRIALS

Introduction

In addition to supplying landowners and managers with quality nursery stock, the Reforestation Program also endeavors to act as a reservoir of information and experience in all aspects of reforestation. To that end, we undertake trials to test the efficacy of herbicides used in site preparation, chemicals that claim to mitigate deer browse, seedling lifting and storage techniques, etc.

Fall Lifted Seedlings

Nurseries have long used fall harvest and overwintering to lessen the stress of early spring. In the case of DNR nurseries, some hardwoods and most conifers in the fields tend to stay frozen well into the spring, making it difficult to keep trucking schedules and distribution goals. With seedlings already in storage, this early season crunch can be alleviated. However, the concern is that seedlings will not be as healthy and thus, not perform as well when out planted. Nursery staff plant a small subset of seedlings harvested in the fall to monitor seedling performance throughout the following summer. In 2023, staff planted red pine 2-0 and 3-0, white pine 2-0 and 3-0, white spruce 2-0 and 3-0, swamp white oak 2-0 and red oak 2-0 in the fields of Griffith Nursery. A control group was not planted in 2023, but as we continue in this effort, we will establish a control group to compare seedling performance.

The seedlings were planted on a cool, sunny day using a DNR tree planter. Results are found in the table below.

Of those out planted, the red pine, white pine 2-0 and swamp white oak did the best. Surprisingly, red oak did the worse. Others fell in-between. Staff did hear of some challenges with seedlings during the summer, but most problems were attributed to the lack of precipitation across the state. However, if evidence suggests that seedlings were compromised prior to planting, staff will reach out to customers in the future.

STATUS	SPECIES								
	PR2	PR3	PW2	PW3	SW2	SW3	OR2	OS2	
Healthy	20	23	19	12	15	13	7	22	
Light Damage	0	1	0	4	1	0	3	2	
Heavy Damage	1	0	0	1	2	0	1	0	
Dead	4	1	6	8	5	12	14	1	
Total	25	25	25	25	23	25	25	25	
Survival	80%	96%	76%	64%	70%	52%	40%	96%	

Table 6: Overwintered seedling survival 2023.



Sites with planting plans tend to perform better than those without.

Photo credit: Andrew Teece Creative

NURSERY PROGRAM

DISTRIBUTION

Once again, the nursery's spring distribution season began the previous November. Starting on Nov. 7 and working through Nov. 23, a contract labor crew from Champion Forestry worked to lift and grade approximately 700,000 seedlings, which were held in cold storage until spring. Fall lifting allows us to get a hard count of many of our species, especially shrubs, so that we can sell from a verified inventory instead of from field estimates that are not always accurate. This greatly reduces the number of orders needing to be modified or cancelled due to inventory shortfalls.

On the flip side, fall lifting allows inventory over-runs to be discovered early enough that the surplus can be sold to meet customer demand, rather than surplus stock possibly being destroyed at the end of the distribution season. Starting the spring lifting season with 700,000 seedlings already in the cooler is also a tremendous logistical help, allowing the nursery to start packing and shipping orders as soon as the spring thaw arrives, instead of having to lift and grade for a week or more to build up inventory prior to packing any orders.

The contract for spring lifting and grading was, again, awarded to Superior Forestry Service, who sent two experienced crews that were familiar with our operation. One crew graded trees full time, while the other crew worked in the field pulling trees. When not pulling seedlings, they bulk packed seedlings or graded trees on our auxiliary grade line. The contract crews were supported by Reforestation Program staff. Support staff operated the machinery and did whatever jobs were needed to keep the contract crew and overall operation working smoothly. Both crews began work on March 27, 2023.

By April 14, the grade shed crew was done. The field crew stayed on two more days to finish lifting a few odds and ends, and wrap up the last of the grading. The final combined tally for both crews over the 17 day period was 2,678,000 conifers and 712,000 hardwoods lifted. Grading totals over the same period were 1,748,000 conifers and 660,000 hardwoods. An additional 640,000 conifers and 72,000 hardwoods were bulk packed. The lifting crew averaged about 300,000 seedlings per day. The dedicated grading crew averaged 105,000 seedlings per day. Overall, grade average was 141,000 seedlings per day.

Although lifting and grading operations were completed by April 18, order packing and distribution was still ongoing. Some will call orders picked up in late March, but distribution got off to its true start on April 4, when the first semi left the dock bound for southeast Wisconsin. From that date on, there were three to four full semi loads per week, until the last truck shipped out on May 4, bound for NE Wisconsin. Sixteen semi loads in total were shipped. A total of 3,800,227 seedlings were distributed in 2,879 orders. Of that, 37,131

seedlings in 503 orders were packed for the Fourth Grade Arbor Day program. See the 2023 Distribution Report for more details.

SPRING SEEDING

The completion of seedling lifting and grading triggers the start of spring sowing operations, even as other staff finish packing and shipping. Since the nursery began using contract labor for lifting and grading, those operations wrap up much sooner than they historically did, leaving more time and nursery manpower to devote to spring seeding. Some species, like silver maple, aspen and elm, are spring seed dispersers. Silver maple does not store well, so it can't be sown until fresh seed ripens around the end of May. However, other species, such as tamarack, spruce and hackberry, can be sown from stored seed as soon as the danger of frost has passed, provided the seed has been properly hydrated and stratified to bring it out of dormancy.

In 2023, sowing began on May 2, with the sowing of stored hackberry, as well as two rows of aspen root cuttings, gleaned from the root pruning operation when the aspen seedlings were graded. Spring seeding wrapped up on June 9, with the sowing of the last of the silver maple. Most nursery seed is still sown in the fall, but we have gone to spring seeding for a few species that have performed poorly or erratically when fall sown. Small-seeded conifers like spruce and tamarack frequently suffer from seedbed erosion and desiccation when fall sown. Spring sown seed is yielding better germination and improved bed densities for most species tried. The trade-off is that fall sown beds have from 2-5 weeks more growing time over the course of their first summer. That may not sound like much, but spring sown beds often require an additional year of growing time to reach desirable size.

	Fall Sown White Spruce	Spring Sown White Spruce	Target Germination Trees/Bed
2022 Germination trees/ 48 ft ² bed	1,548	2,940	1,800
2023 Germination trees/48ft ² bed	1,499	2,013	1,800

Hackberry generally germinates well if fall sown, but comes up too early and has nearly zero frost tolerance. Fall sown hackberry beds often suffer heavy losses due to late spring freezes. By spring sowing, we can delay germination until the danger of frost is much lower. For instance, in 2023, it was 87°F on April 12, kicking germination into high gear. Five days later, on April 17, the nursery got nearly 5 inches of snow, and seven days later, the overnight temperature dropped to 24°F, killing most of the newly germinated hackberry, as well as impacting several other species. Spring sown hackberry beds germinated after the freeze at excellent bed densities, but it was a struggle to get them to saleable size in one shortened growing season.

GERMINATION

Despite some problems caused by early April's warm weather and the May frosts, 2023 germination was good for most species. It was a very dry spring, with the months of April, May and June having a combined rain deficit of more than 8 inches relative to the 30-year

average. The low humidity and lack of rain led to more frequent waterings for newly germinating beds, but a combination of germination fabric used on some seedbeds and the nursery's irrigation system made up for the lack of precipitation.

Overall, conifer germination was excellent, with most seedlots germinating at well above target rates. The most notable exceptions were the hemlock and tamarack, both of which germinated fair, but well below target bed density. It was likely a combination of poor seed quality, combined with the fact that they were both spring seeded, and germinating in the peak of June's hot, dry weather. The delicate seedlings have no real root system at that phase of their development, and one delayed watering could easily lead to seedling mortality. Interestingly, the spring seeded white and black spruce both produced excellent stands under the same conditions.

Hardwood and shrub germination was mixed, but most species germinated quite well. White birch and winterberry were the only complete failures. Highbush cranberry and the fall-sown hackberry both suffered heavy losses due to freezing post-germination. Black cherry, bitternut hickory, yellow birch and ninebark all germinated at about $\frac{1}{2}$ the target rate, but still produced salvageable stands. Everything else germinated near or above target bed densities. Unfortunately, the small-seeded spring sown hardwoods sycamore, American elm and river birch all germinated at 3-4 times the target density. These species are all very vigorous growers, so we were still able to produce quality 1-0 seedlings despite the overly thick beds. The high bed density just leads to a higher cull rate and a lot of seedlings being discarded on the grade line. Sowing rates for these species will be adjusted down in the future. With the use of germination fabric, there is much less mortality due to seedling desiccation than we typically experienced germinating small-seeded hardwoods and shrubs in our sandy soils, so less seed is needed to reach the desired bed density.

NURSERY TRIALS

White Oak Mulch Trial

In 2022, the nursery did an informal test of various mulches on its white oak seedbeds. That trial concluded that a 3- to 4-inch layer of loose straw tacked down with a layer of commercial hydromulch was the most effective in protecting seed viability. The commercial polypropylene frost blanket or germination fabric was only slightly less effective, but was cheaper than straw and much less labor intensive. A living mulch of winter wheat was also tested but performed more poorly than the other options.

Based on the 2022 results, the nursery used the DeWitt $\frac{1}{2}$ oz germination fabric as its primary white oak mulch in 2023. For the sake of repeating 2022's experiment, we also covered some rows with straw, as well as sowing a couple rows with a living winter wheat cover. As a further test, we experimented with some of the heavier DeWitt 1.5 oz polypropylene frost blanket fabric.

Regardless of mulch type, 2023 white oak germination was phenomenal. The strawed rows germinated just slightly below target (-0.8% of target). All other rows germinated well above target. The results were basically the inverse of 2022's results. The winter wheat living mulch produced more than twice the target bed density (65.7% above target). The 1.5oz frost blanket germinated 13.4% above target, and the $\frac{1}{2}$ oz germination fabric was 6.4% above

target. The winter wheat data is a bit unreliable, since it is based on only two rows, and one of those had unexplainably high seedling density at our June germination inventory.

The primary conclusion to be drawn from this experiment is that the winter of 2022-2023 produced very little negative effect on seedling germination. There was little in the way of extreme temperatures, and when it was cold, the seedbeds were cozy under a heavy blanket of snow. Although “no mulch” wasn’t an option in this experiment, it is likely that white oak sown with no mulch of any kind would have also experienced very good germination. There was only one small area of the nursery that showed any sign of white oak seed loss. That area was a low spot that ponded during the spring snow melt and then froze into a solid sheet of ice. Even though it was covered with fabric, that area germinated poorly and the seedlings that did germinate had poor vigor. It likely suffered from a lack of air in the saturated, frozen soil. In years of poor acorn germination, it seems that the areas hit hardest are the low areas where soils stay saturated or the opposite, extreme areas of slightly higher elevation vulnerable to wind erosion and desiccation in a snow-free winter.

Treatment	June Germination Inventory Seedlings/Ft ²	September Saleable Inventory Seedlings/Ft ²
Straw/hydromulch	11.9	6.4
1.5 oz frost blanket	13	7.3
0.5 oz germination fabric	12.7	6.4
Winter wheat living mulch	21.9	7.3



Hardwood and shrub germination was mixed, but most species germinated quite well. White birch and winterberry were the only complete failures in 2023.

Photo credit: Grace Hershberg, Wisconsin DNR

White Oak Seeding Rate Trial

2023 was a huge white oak mast year, and the nursery found itself with surplus seed, making it a good year to experiment with target seeding rates. Historically, white oak acorns were sown at a rate of 5 quarts per 12 foot “bed” (48ft²), but for a variety of reasons we seldom hit our 400 seedlings/bed (8.3seedlings/ft²) target. In 2023, the target sowing rate was adjusted up to 6 qts/bed, in hopes of using up surplus seed and hitting our target bed density.

Germination ended up well above target, but even the densest rows failed to consistently reach 400 saleable seedlings/bed, indicating that our 400/bed (8.3/ft²) target is probably not a realistic goal for 1-0 white oak. Regardless of how dense the beds were at germination, very few yielded more than 350 saleable trees/bed (7.3/ft²). The rest were lost as culls as the more vigorous seedlings outcompeted them. In conclusion, the jump to 6 qts/bed yielded better bed densities than 5 qts/bed and should become the new standard, but for planning purposes, the white oak bed density target should be adjusted down to 350 saleable trees/bed (7.3 ft²).

Biochar Trials

During fall 2022 sowing, several test plots of biochar were applied pre-plant to a variety of species. This char was made on-site from nursery brush piles by Brian Zweifel, of the DNR Forest Products Team. For more info on the process visit:

<https://forestrynews.blogs.govdelivery.com/2023/05/11/wisconsin-dnr-begins-state-nursery-biochar-trial/>.

These plots are also being monitored by Joanne Tirocke of the US Forest Service, Rocky Mountain Research Station, who flew in from Idaho to install monitoring instruments. Her study has been hampered by the nursery’s local fox population, which seems to think her instruments are their own personal chew toys. However, some equipment has survived the curious canines and her data collection is ongoing, with plans to analyze and publish a formal paper sometime in the future.

Other Trials

Two other university studies are currently underway in the nursery. Both studies are in the early stages but should eventually be the subject of published research papers. The first study involves the relationship between soil pH and nursery pathogens, particularly *Fusarium* spp. It is under the direction Dr. Nick Balster of the UW Madison Soils Department.

The second study is taking place in several different midwestern nurseries, including Wilson State Nursery. It studies the microbial associations that tree seedlings develop in nurseries and how well these microbes serve the trees after out-planting. It also plans to subject the nursery seedbed to various environmental stressors to see how the microbial population responds. That study is being led by Dr. Richard Lankau and Dr. Cassandra Allsup of the UW Madison Plant Pathology Department.

Both studies should yield valuable insights on how we can improve our growing operations at the nursery, leading to better seedlings for our customers. Results will be shared as they become available.

Seedling Health And Monthly Nursery Walks

Nursery staff once again teamed up with DNR Forest Health staff for monthly nursery walks. This practice began in 2021 and has become a regular monthly occurrence during the nursery growing season. These walks help to familiarize Forest Health staff with the day-to-day operations of the nursery, allowing them to make more informed decisions when inevitable seedling health issues arise. The nursery gains the observations and insights of professional pathologists, who may notice seedling health issues that nursery staff have overlooked. Scheduling a 3-4 hour block of time once per month for a thorough walking tour of the nursery beds is a far more reliable way of finding and fixing problems than simply waiting until someone notices something amiss.

Seedling health was excellent in 2023. The dry conditions were hard on out-planted seedlings, but the lack of rain is much less of a problem in the nursery where everything is under irrigation. The lack of rain and humidity greatly reduces the transmission of fungal leaf and shoot blights, which are a constant worry for seedlings in crowded nursery beds. The dry weather, combined with a stringent prophylactic fungicide regime meant that there were no significant blight issues in 2023.

Historically, one of the greatest problems is infection by conifer tip blight, *Diplodia pinea*. This serious red pine disease is common throughout Wisconsin, but can be especially troublesome under nursery conditions. Seedlings infected in the nursery can appear healthy, but they are at increased risk of dying when exposed to drought stress after being out-planted. Red pine nursery stock is monitored annually under a strict sampling protocol to ensure that stock being distributed to customers is not infected or asymptomatic.

The disease spreads primarily through water droplets during the driving rain of summer storm events, when spores from infected trees can be picked up and carried much further than a simple raindrop splash. The near absence of summer storms in 2023, along with a strict fungicide schedule, led to very low incidences of diplodia. The state forest health lab began testing annually for asymptomatic infection in 2009 to ensure seedlings shipped to customers are healthy and viable.

2023 Asymptomatic *Diplodia* sampling results:

Age Class	Positive Samples	% Positive
1-0 red pine	1 of 269	.4%
2-0 red pine	2 of 252	.8%
3-0 red pine	3 of 272	1.1%

Another disease that the Forest Health Team tests for annually is eastern pine gall rust *Cronartium quercuum*. A diverse, random sample of 1000 seedlings each of 1-0 and 2-0 jack pine are given a thorough visual inspection for the presence of stem galls or any suspicious swollen areas. Suspicious trees are then grown out in pots to see if galls develop. This disease typically has a very low incidence in Wilson Nursery, but stock is on a preventative fungicide schedule nonetheless and tested annually to assure that stock we are shipping is disease free. 2023 testing revealed no gall rust in the 1-0 jack pine, and only 3 of 1000 2-0

jack pine were found to have galls, for an infection rate of 0.3%. Most 2-0 jack pine is sold as graded stock, and graders are instructed to watch for stem galls and cull all suspicious seedlings. A few may slip through, but the infection rate of graded stock leaving the nursery is probably far lower than the 0.3% found in the sample inspected.

One of the main motivations for starting the monthly nursery health walks was the long-standing issue of white pine pocket mortality. Nursery white pine beds typically look very healthy in spring and early summer, but around August, as fall approaches, we would frequently see pockets of yellowing and dying white pine in the 2-0 and 3-0 beds. For many years, we suspected it was a root rot but were never able to pin down a causal organism or abiotic factor. Trees just declined and died. Those that survived often had only 2-3 healthy roots, making them poor quality for out-planting. Monthly Forest Health visits eventually led to the discovery of small stem cankers where some of the needles attached to the stem. This indicated that the problem might be a needle/stomata path of infection, rather than a root rot.

After collecting many dozens of samples, and months of lab work and sleuthing, DNR forest pathologist Kyoko Scanlon came up with the likely cause of our white pine woes. She suggested *Pestalotiopsis* funereal as the causal agent. It is a fungus that is common and relatively benign until seedlings are under stress of some kind, typically too much water. Then, the fungus becomes pathogenic, travelling quickly through the dense seedling bed canopy. Root pruning operations in early August, and the heavy watering required post-pruning provide the perfect opportunity for *Pestalotiopsis* to spread. Fortunately, Scanlon's research indicated that the spread of the fungus should be able to be controlled with foliar fungicide applications. We have since put white pine on a spray schedule very similar to the regime we use for *diplodia* control in the red pine, and the 2023 white pine crop shows no needle yellowing or any other signs of *Pestalotiopsis* blight.

Pestalotiopsis has been identified as a common problem in southern nurseries, especially for white pine seedling beds, but has never really been published as a concern in the north. An interesting discovery was made after the recent diagnosis of *Pestalotiopsis* in Wilson Nursery. While searching for something unrelated in the nursery's files, a November 1987 memo was discovered from Scanlon's predecessor Jane Cummings Carlson. This memo identified *Pestalotiopsis* as the likely cause of 2-0 white pine mortality in Wilson Nursery that summer, more than 30 years ago. Apparently, that information never spread farther than an internal memo tucked away in a file cabinet, leaving future managers and forest pathologists to struggle for years to discover this "new" nursery disease that supposedly only exists in the southern U.S.

Fumigation And Fall Sowing

Planting acreage was slightly down in 2023, with 13.5 acres prepped for sowing and fumigated in late August. The weather conditions were extremely hot and uncomfortable, but the fumigation operation proceeded smoothly. Pre-fumigation prep work included the addition of 400 lbs/ac of Sulfur 90 to help with the nursery's rising pH rates. It also included the addition of 20-75 yards/acre of sedge peat, based on soil testing data, in an attempt to further lower pH and reach a minimum 2% soil organic matter. Maintaining organic matter in the nursery's light sandy soil is always a challenge. The fields were then subsoiled down to 24 inches which was very effective at breaking the soil hard pan with the very dry conditions. After plowing in the sulfur and peat, the fields were levelled and irrigated as needed. Much

like foliar herbicides, soil fumigants are less effective if the target organisms are in drought-induced dormancy. Most pine ground (2.5 acres) was treated with straight chloropicrin (Tri-Pic 100) at 175 lbs/acre. The other 11 acres of prepped ground were treated with a 67% methyl bromide/33% chloropicrin mixture (MBC-33) at a rate of 300 lbs/ac. All beds were left tarped for two weeks after fumigation, and then the plastic was removed.

Fall sowing began on Sept. 27, with black cherry being the first seed sown. Planting season was wrapped up on Oct. 30, with the sowing of the last bushels of acorns in the cooler. Nearly 3 acres of fumigated ground remain available for spring sowing. 10.25 acres of fumigated ground were fall sown, along with 1.2 acres of unfumigated ground, which was sown to red oak and swamp white oak. The original seeding plan called for an unrealistically high target of swamp white oak beds. Because of the high cost of fumigation, the acreage to be fumigated was reduced by a couple acres to reflect a more realistic acorn harvest. 2023 was a phenomenal mast year for red, white and swamp white oak, and our network of seed pickers rose to the challenge. In the end, our acorn targets were met, and we had more seed than we had prepped ground for, leading to the overflow going into unfumigated ground. Past experience shows that red oak and swamp white oak will likely require a bit more monitoring and maintenance on unfumigated ground versus fumigated beds, but they should perform well.

Fall Lifting And Grading

Seeding operations wrapped up on Monday, Oct. 30. By Thursday afternoon, the entire crew was busy digging trees. Thursday and Friday were spent digging odd beds and difficult species such as hawthorn, which are very inefficient to lift with a contract crew. On the following Monday, Nov. 6, our contract crew from Champion Forestry arrived to begin digging the one million trees we hoped to fall lift and grade. Lifting and grading went well, although some minor modifications to the plan were made due to some species refusing to drop their leaves. Grading operations wrapped up Dec. 1, 2023. The final tally was 938,000 seedlings lifted. On the grade belt, the final yield was 892,000, indicating that some species graded out considerably short of their field inventory estimate.

This fall lifted stock will go a long way towards getting our 2024 distribution season off to a smooth start. There will still be 4 million trees to dig and grade in the spring, but the fall lifting deals with many of the smaller, 'odd' species, leaving the spring crew free to lift and grade the big-ticket items far more efficiently without the distraction of having to deal with all the minor species. It also allows us to start packing and shipping orders right away in the spring, instead of spending 7-10 days lifting and grading inefficient little runs of 40 different species to build up an inventory of graded stock before packing can begin.

TREE IMPROVEMENT PROGRAM

2023 Highlights

The Wisconsin Tree Improvement Program successfully accomplished most goals outlined in the *2023 Work Plan*. It also increased the number of sites and species managed by Improvement Program for research, genetics conservation and seed collection by adding two white oak (*Quercus alba*) progeny test plantings.

Highlights for the year include:

- Hiring Scott O'Donnell as DNR Forest Geneticist/Ecologist and Richard Nessler as tree improvement specialist; each assume key functions managing Wisconsin tree improvement activities as members of the DNR Reforestation Team.
- Harvesting jack pine cones at Black River Falls, Hayward Nursery and Hauer Springs, nearly completing the seed collection required for establishing new fourth generation progeny tests.
- Coordinating, preparing, planting, recording data and establishing two new white oak progeny tests as part of the White Oak Genetics and Tree Improvement Program led by Laura DeWald from the University of Kentucky.
- Contracting correctional center crews to prune the dead lower branches from the white pine orchard at Black River Falls, and the branches on the downed spruce trees within the Sawyer Creek white spruce orchard to improve access and enable mowing.
- Collecting red pine cones in the red pine orchard at Hayward Nursery.
- Mowing and pruning the Bell Center orchard complex to control understory growth and maintain access for the DR mower, as well as other maintenance mowing using a tractor brush-hog.
- Spraying herbicides at the white oak sites and an insecticide to control an exotic green weevil on the newly planted white oak progeny test at Clark County.
- Grafting white spruce scion from select trees at Sawyer Creek onto rootstock to continue establishment of grafted orchard planted for eventual cone production at Hayward Nursery.
- Creating new or updated data collection sheets and field maps for possible data analysis and the ability to locate and identify individual trees in the field.

These highlights are described more thoroughly in the following report. The *2024 Improvement Program Work Plan* further details specific 2023 accomplishments and 2024 goals for each of the tree improvement orchards.



An ice storm glistens off the white spruce at Sawyer Creek on February 27, 2023.

Photo Credit: Stuart Seaborne, UW-Madison

Welcome To Scott O'Donnell and Richard Nessler

The Wisconsin Reforestation Program is pleased to announce the recent hirings of Scott O'Donnell as DNR Forest Geneticist/Ecologist and Richard Nessler as tree improvement specialist. O'Donnell will be guiding the direction of and providing the genetics expertise for the Wisconsin Tree Improvement Program. Nessler will be managing tree improvement and seed processing activities for the Reforestation Team.

O'Donnell received his Ph.D. in biology from UCLA in 2023. He was a member of Dr. Victoria Sork's lab, specializing in the study of the landscape genomics of hybridization and adaptive gene flow across species boundaries in Californian white oaks. His areas of specialization include population genetics, landscape genomics, conservation genomics and natural hybridization of hardwood tree species. He brings experience in designing and implementing large-scale field studies, including range-wide tissue, seed collections, greenhouse propagation and maintenance of hardwood tree seedlings.

Nessler joined the Reforestation Team in August of 2023 as a tree improvement specialist working at Hayward State Nursery. Nessler studied Forestry at Southern Illinois University, earning a B.S. in forestry in 2014. He continued work at Southern Illinois University and later went on to receive an M.S. in forestry with a concentration in forest ecology. His graduate and undergraduate research focused on the development of restoration techniques to improve and expand native canebrake habitat in the Cache River watershed of Southern Illinois. After graduate school, Nessler spent three years as a forester in northern Missouri working for the Missouri Department of Conservation. Nessler then moved to Northwest Wisconsin, holding the position of forester ranger for nearly four years.

Nessler's work as a tree improvement specialist focuses on procuring, processing and distributing seed for Wisconsin, and implementing the state's tree improvement programs.

Stuart Seaborne will continue in his role as tree improvement research specialist for the 2024-2025 budget year before retiring. This timeline will allow ample opportunity for

transferring information and sharing knowledge about each of the tree improvement orchards and the goals for each of the species currently in the program.

Jack Pine Cone Collection For Fourth Generation Seed

The Wisconsin Improvement Program is preparing for the establishment of new fourth generation progeny tests using genetics from three existing orchards. Planning began in 2020 to advance jack pine genetics in our program another generation.

Seed from open-pollinated cones will be used to establish future progeny tests at various regional sites. The jack pine plantings at **Black River Falls**, 80 families, third generation “index” population; **Hayward Nursery**, 20 families, third generation breeding population; and **Hauer Springs**, 20 families, second generation breeding population, were chosen to become the principal seed sources for this next generation of 120 families.

Cones were harvested in 2023 from all three sites. At Black River Falls, cones were collected on Aug. 23, 24, 29, 31 and September 5 by Seaborne, O'Donnell and Nessler. Daily temperatures were high, but nearly all the trees identified for collection had ample cones for the seed needed to establish new progeny tests, alleviating our discomfort. The top tree in each of the 80 families, plus the second tallest tree from the top-ranked half of the families, had cones collected and placed into labelled bags for later seed extraction. It was a productive year, providing ample numbers of cones from almost every selected tree.

Cone harvest needs here for 2024 should be minimal, as we have collected sufficient seed from each of the selected trees for progeny testing – roughly 1000 seeds/tree.

Hauer Springs required an aerial lift for the cone harvest conducted on Aug. 28-30, 2023, by Nessler and Stan Klais. Twenty families are represented at Hauer Springs, and open-pollinated cones for progeny testing were collected from the top remaining trees in 18 of the families. The top trees in the other two families still had siblings adjacent to them until 2023, so the cones of those trees were not used to reduce the potential for sib crossing.

Hayward Nursery is the third site where jack pine cones were harvested for progeny testing. Open-pollinated cones from the top performing trees in each of the 20 families represented were collected by Ray Aguilera, Klais and Nessler on Sept. 13-14, 2023.

The extracted seed from the three orchards will be put into cold storage until the program is ready to start propagating seedlings for planned progeny tests.

Wisconsin Progeny Tests Of The White Oak Genetics And Tree Improvement Program

The White Oak Initiative is a group industry, nonprofits and government partners interested in working together to ensure the long-term sustainability of white oak. The White Oak Genetics and Tree Improvement Program is one of the partners, led by Dr. Laura DeWald, tree improvement specialist in the Dept. of Forestry and Natural Resources at the University of Kentucky. She is leading an effort to establish white oak progeny tests across the natural

range of white oak. This includes organizing the collection efforts and propagation of acorns into seedlings and establishing progeny tests.

The DNR is collaborating with the White Oak Genetics and Tree Improvement Program in these efforts. Two 5-acre progeny test sites were planted in 2023 with bareroot seedlings propagated in Kentucky. In late February 2023, Pat Hromadka and Mark Caldwell traveled to Kentucky to assist with the lifting and packing of the white oak seedlings. They returned to Wisconsin with the seedlings where they were labeled and sorted into replications for each planting site. The southern Wisconsin site is on DNR land in northwest Grant County. Prior, it was an unsuccessful prairie planting. The northern Wisconsin site is on the Clark County Forest near Neillsville. This site was a 12-year-old northern hardwood regen that came in after a red pine plantation was harvested.

The Grant and Clark County planting areas were measured, mapped and flagged with colored flags to identify separate reps in the field. Perimeter flags were marked with their row and column location to help corroborate location coordinates for the planting crews and data recorders.

A contract crew planted both sites on consecutive days, Grant County on April 27 and Clark County on April 28, 2023. Labels on the bareroot white oak seedlings identified the state and county of origin for each bareroot sapling from the 75 families represented in 20 reps. DNR staff distributed the seedlings and assisted in the planting process, while Seaborne and O'Donnell recorded the identity and location of each tree. The initial height measurements for all the white oak seedlings were collected in May and sent to Laura DeWald along with labeled field maps for both plantings.



Scott O'Donnell records family and location of white planting oak being planted April 27, 2023, Grant County. Photo credit: Stuart Seaborne.



Jeremiah Auer, Joe Vande Hey, and the crew planting white oak on April 28, 2023, at Clark County. Photo credit: Stuart Seaborne.

Seedling establishment and control of understory growth presented challenges unique to each location. At the Grant County site, a severely dry beginning to the summer necessitated assistance from Wildfire Control members to apply two different applications of water from tanker trucks to the area immediately around the trees. This almost certainly saved many oak seedlings from succumbing to drought.

Mowing also presented difficulties all year as the seedlings were small compared to the lush weed growth, often obscuring them from sight. A small number of the young trees were hit by the mower over the course of the season, but many of those appear to be growing back from their roots. Hand weeding and hoeing were also used around some seedlings to control the competition from overwhelming the planting. Twenty days of DR mowing and eight person-days of hand work were dedicated in 2023 to this effort, as well as a day with the tractor brush-hog.

Herbicides were used twice as band sprays around the oak seedlings to control weeds around the trees. Pendulum AquaCap, a pre-emergent grass and broadleaf herbicide, was applied May 3, 2023, at a rate of 2 quarts/acre by Joe Vande Hey shortly after planting as a pre-emergent herbicide for grass and broadleaf control. Oust was applied at a rate of 1.9 ounces/acre on Nov. 15, 2023, by Roger Bohringer to provide pre-emergent and some post emergent control targeting perennial and annual grasses plus broadleaf plants.

A formal inventory of survivors and second measurements will be done in early spring of 2024, but the Grant County white oak appeared to have a high survival rate after the 2023 growing season.

The white oak planting in Clark County also had challenges establishing. The drought was not as severe at this site as at Grant County, but a late freeze followed by a severe infestation of exotic green weevils attacked the young early leaves. Additionally, there were many leftover stumps from the clearing process, which made it more difficult to plant the seedlings and to manage it going forward. A stump grinder was used in September to grind the stumps in the aisles between the young trees.

Herbicides were applied twice to control weed competition. Pendulum Aquacap was applied on May 15 at 2 quarts/acre and Oust XP was applied on Nov. 15 at 1 oz/acre. Both were applied by Jeremiah Auer using a backpack sprayer. The results of the applications were excellent. In early June, an infestation of pale green weevils, a quirky invasive beetle that has an appetite for young oak leaves, necessitated an application of permethrin. The 23 oz of chemical spread over each living seedling quickly neutralized the incessant feeding, but the seedlings looked quite ratty until the next flush of growth occurred.

As young plantings, both these white oak progeny tests will receive a lot of attention again in 2024. Height measurements and a mortality inventory are planned at each site before bud break in the early spring. Controlling understory growth with mowing and herbicides will also require significant use of resources while the young trees continue to establish themselves.

Correctional Center Crew Projects

The Correctional Center Crews have been used by the Tree Improvement Program in past years for tasks needing many hands, such as separating spruce cones from branches to be processed for seed. There were two Tree Improvement Program orchards in 2023 that required the services of a crew to complete needed pruning of dead branches: the Black River Falls white pine orchard and the Sawyer Creek white spruce orchard.

The Black River Falls white pine was rogued in 2021, but the dead lower branches on the remaining trees made access for a tractor or other equipment impossible in many spots. A

crew with handsaws came on April 3-4 to remove all the dead branches up to 7 feet from the ground. They did an excellent job in an amazingly short period of time for a 10-acre planting. A tractor or an aerial lift can now travel throughout the orchard.

At Sawyer Creek, there are many trunks lying on the ground within the orchard after the roguing by 2021's feller training class. The dead branches from the downed trees made even walking throughout the orchard difficult. So, a chainsaw crew from Gordon Correctional Center came on July 10-11 to saw them off. The pruning of the branches improved access, but the trunks of the trees still need to be removed.



A correction center worker removes dead branches from white pine at Black River Falls April 3, 2023. Photo credit: Stuart Seaborne



The aisles are open to access for equipment after the removal of the dead lower branches. Photo credit: Stuart Seaborne

Hayward Red Pine Cones

A red pine seed orchard was established on 11 acres at Hayward Nursery in 2014. Nine-hundred-and-thirty seedlings representing the best families from the three red pine orchards at Lake Tomahawk, Ten Mile Creek and Avoca were planted using a final orchard spacing of 15 feet x 30 feet to promote early cone production. This practice proved effective as some of the red pine trees at Hayward Nursery started producing cones in 2022, only eight years after planting.

Another cone harvest was done here in 2023. Klais collected 10 bushels of cones over nine days between Oct. 2 and Oct. 12, 2023. The 10 bushels processed down into 3.3 pounds of improved red pine seed for this year, over 150,000 seeds.

Orchard Maintenance: Mowing, Pruning And Spraying

Understory control is essential to reduce competition from volunteer vegetation and to allow access by people and machines to the trees in Tree Improvement Program research plots and seed orchards. Priority for work being done is established by planned activities such as cone or nut collection, and how often mowing is necessary to maintain control in a particular

orchard. Younger orchards do not shade out competition as well as older ones, so more frequent mowing or the use of herbicides are necessary.

The Bell Center Hardwood Orchard complex is a 12-acre fenced site that contains grafted red oak and black walnut as well as a 5-acre butternut canker trial planted in 2019. Vigorous prairie grasses and other herbaceous weeds necessitate a complete mowing twice each year, once in late-spring and the other in late-summer. A DR mower is being used to mow all the areas within the trees and around the perimeter fence. Paul Berang, retired USFS forest geneticist, has been mowing the butternut trial for two days twice a year since planting and did so again in 2023. Seaborne mowed the rest of the orchard area and additionally pruned the side-branches of the butternut in 2023 to shape the trees and allow for better mower access.



The trees in the butternut canker trial at Bell Center arch over mowed aisles on Sept. 25, 2023.

Photo credit: Stuart Seaborne, UW-Madison

The Mead white spruce, Black River Falls jack and white pine and Greenwood jack pine orchards all had their aisles and perimeters mowed in 2023. Thomas Hoover used a tractor brush-hog to complete this work.

Pine root collar weevil (*Hyllobius radices* Buchanan) has been recognized by the Reforestation Team for a couple of years as a problem in the Hayward Nursery jack and red pine plantings, as well as in the Black River Falls jack pine orchard. Applying herbicide around the base of each tree followed by the application of Permethrin is how control of the weevil is accomplished.

Two treatments of Permethrin were applied to the jack pine at Hayward State Nursery for control of the pine root collar weevil. The first application was on May 16 and the second on July 28, 2023. Permethrin was applied to the red pine orchard at Hayward State Nursery on Aug. 24-25, 2023, also for control of pine root collar weevil.

At Black River Falls, the jack pine trees were sprayed with glyphosate on Aug. 3, 2023, and the Permethrin was applied on Aug. 10, 2023.

White Spruce Grafting

The Wisconsin Tree Improvement Program is continuing to work on developing grafting techniques and operational resources to graft white spruce scion wood from select trees at

the Sawyer Creek orchard and create a new white spruce seed orchard at Hayward Nursery. While there has been modest success in making successful grafts over the past two years, there have been challenges to producing the number of trees that are necessary to meet our goals.

Currently there are around 30 grafted white spruce that were planted at Hayward Nursery in 2015. Another 40 successfully grafted saplings are potted and maintained at Nevin greenhouse. They will be planted in spring of 2024, along with the transplanting of the existing grafted spruce, into a reconfigured seed orchard at Hayward Nursery. The Reforestation Team is continuing to work towards increasing the number of young white spruce originating from known sources to populate a seed orchard that will replace our existing orchards at Mead and Sawyer Creek. Grafting allows for propagating genetic duplicates or cloning of source trees and remains the preferred approach to creating a seed orchard.

The Sawyer Creek white spruce orchard contains trees from Wisconsin, Minnesota, the Upper Peninsula of Michigan and the Ottawa Valley in Ontario, Canada, and is where the genetics of the source trees used in Tree Improvement Program grafting originate. O'Donnell, Nessler and Seaborne toured Sawyer Creek on Oct. 31, 2023, to identify and mark trees providing the branch tips used as scion wood in grafting. Seaborne also identified replacements for source trees that were dead or dying, as well as other candidate trees for consideration.

Grafting in 2024 will be limited to the 55 potted white spruce rootstock available for use. Seaborne, O'Donnell and Nessler will be grafting together this spring to give O'Donnell and Nessler an opportunity to practice their skills with sharp knives, as well as adding more grafted saplings to the seed orchard at Hayward Nursery.

Data Collection And File Updates

Files for the Tree Improvement Program are updated on a regular basis to reflect changes to an orchard, such as the roguing of trees and to record new data that is collected, like height measurements. Data also needs to be entered in a way that allows it to be sorted for answering different questions, such as what are the tallest trees in each family, what the average height of each family is, and how many trees are still alive in each family?

The addition of the two new white oak progeny tests at Grant and Clark counties required new files to be created. The identity and location of each tree was accurately mapped and entered in a data collection sheet. Initial height measurements were collected and recorded for both plantings and sent to Laura DeWald as part of the White Oak Genetics and Tree Improvement Program. First year growth measurements and survival will be collected and recorded in 2024. Files for other orchards were also updated. The three jack pine orchards where cones are being collected for future progeny test plantings needed data sheets organized and field maps updated to identify the trees in each family to be collected from. Also, the data collection sheets and field maps for the Sawyer Creek white spruce were updated to reflect the roguing in 2022 and better identify the trees used for scion wood to graft with.

Seed Collection

Seed Production and Collection

The Reforestation Team had a projected budget of \$299,151.50 for seed purchasing in the 2023 collection season. Of this, \$162,885.72 (54.45%) was spent on seed purchases. Seed was acquired from a total of 201 individuals or organizations. One species of primary focus for collection was red pine. Based on Nursery Stock Projections and available seed in storage, the Reforestation Team had less than a year supply of red pine seed going into fall 2023. The year saw a solid red pine cone crop throughout its range in northern and central Wisconsin. This, coupled with an increased purchase price to \$125.00/BU from \$75.00/BU last year and an increased emphasis on outreach, resulted in a good red pine collection year. Statewide, 452 bushels of red pine cones were purchased, and an additional 10 bushels were collected from the Red Pine Improvement Orchard located at the Hayward State Nursery.

To date, 360 pounds of clean red pine seed has been processed from cones at the Hayward Nursery, with more still to complete this spring. The amount of red pine cones collected exceeded expectations. Seed buying plans are developed each year and account for seed inventories on hand and expected yield of cleaned seed. This year, the Reforestation Team's goal of collecting 840 BU of red pine cleaned seed was based on an expected yield of 0.5 pounds of seed for every bushel of cones collected, and the desire to collect and store eight years of red pine seed. Actual yields were much higher, exceeding 0.8 pounds of seed per bushel of cones.

One potential cause for increased seed yields was a reduction in cone pest populations, which was the cause of many consecutive years of poor cone production before. High seed yields helped improve red pine seed inventories greatly, putting the Reforestation Team at around a six year supply. More work still needs to be done, as our goal is to store an eight year supply of processed seed. With inconsistent seed crops and a lack of consistent pickers over the landscape, the Reforestation Team will keep red pine seed collection a priority.

Lessons learned from the 2023 seed collection season include the importance of both outreach and offering competitive prices for seed. Looking at red pine, there were 118 different seed collectors spread over 34 counties in 2023. Compare this to just eight collectors from seven counties in 2022. Offering competitive pricing along with solid outreach campaigns allowed the Reforestation Team to obtain a more manageable supply of red pine seed for years to come. In the future, a priority should be made to identify good seed crops for desired species and adjust pricing and outreach strategies to capitalize on such events.

Other priority species for collection included jack pine and white pine. To date, 617 bushels of jack pine cones (80%) of the goal have been collected statewide. For white pine, 124 bushels (20%) of the overall goal statewide was collected. As for hardwood species, it was an oak mast year throughout Wisconsin, causing oak species to produce heavy acorn crops. Collection for red oak, white oak and bur oak all met or exceeded collection goals. Swamp white oak, a species that is normally in high demand, had 172 bushels collected (91%) of the overall goal. For a complete breakdown of seed purchasing statewide, refer to **Table 1** below.

Conifer And Hardwood Seed Collection 2023

Species	Nursery Goals (bu/lbs.)	Direct Seeding Needs (bu/lbs.)	Total Needs (bu/lbs.)	Purchases	Surplus /Deficit
Hemlock, Eastern	12.0	0.0	12.0	0.68 bu	-11.3
Pine, Jack	768.0	0.0	768.0	617.7 bu	-150.3
Pine, Red	840.0	0.0	840.0	452.2 bu	-387.8
Pine, White	614.0	0.0	614.0	124.2 bu	-489.8
Spruce, Black	15.0	0.0	15.0	0.6 bu	-14.4
Tamarack	21.0	0.0	21.0	0.0 bu	-21.0
Aspen, Quaking	1.0	0.0	1.0	0.00 lbs	-1.0
Aspen, Big Tooth	1.0	0.0	1.0	0.00 lbs	-1.0
Birch, River	10.0	0.0	10.0	0.00 bu	-10.0
Birch, White	1.0	0.3	1.3	0.00 bu	-1.3
Birch, Yellow	0.0	0.0	0.0	2.50 bu	+2.5
Butternut	20.0	0.0	20.0	21.20 bu	+1.2
Cherry, Black	305.0	25.0	330.0	357.58 lbs	+27.6
Elm, American	5.0	0.0	5.0	0.00 lbs	-5.0
Hickory, Bitternut	8.0	0.0	8.0	19.51 bu	+11.5
Hickory, Shagbark	0.0	4.0	4.0	0.00 bu	-4.0
Locust, Honey	25.0	0.0	25.0	0.00 bu	-25.0
Maple, Hard	500.0	4.0	504.0	7.50 bu	-496.5
Maple, Red	20.0	0.0	20.0	0.00 lbs	-20.0
Maple, Silver	12.0	0.0	12.0	0.00 bu	-12.0

Oak, Bur	87.0	35.0	122.0	117.93 bu	-4.1
Oak, N Pin	0.0	1.0	1.0	1.00 bu	0.0
Oak, S Pin	6.5	0.0	6.5	5.39 bu	-1.1
Oak, N Red	133.0	50.0	183.0	180.90 bu	-2.1
Oak, Swamp White	189.0	0.0	189.0	172.40 bu	-16.6
Oak, White	165.0	9.0	174.0	177.04 bu	+3.0
Poplar, Balsam	1.0	0.0	1.0	0.00 lbs	-1.0
Sycamore	0.0	0.0	0.0	0.70 bu	+0.7
Walnut, Black	0.0	66.0	66.0	99.75 bu	+33.8
Willow, Black	1.0	0.0	1.0	0.00 lbs	-1.0
Cherry, Choke	114.0	0.0	114.0	25.42 lbs	-88.6
Cherry, Fire	35.0	0.0	35.0	0.00 lbs	-35.0
Dogwood, Grey	23.0	0.0	23.0	1.88 lbs	-21.1
Dogwood, Red	86.0	0.0	86.0	0.00 lbs	-86.0
Osier					
Dogwood, Silky	38.0	0.0	38.0	3.96 lbs	-34.0
Elderberry	50.0	0.0	50.0	26.00 lbs	-24.0
Hazelnut	100.0	0.0	100.0	98.90 bu	-1.1
Cranberry, Highbush	75.0	0.0	75.0	329.96 lbs	+255.0
Hawthorne	12.0	0.0	12.0	7.38 bu	-4.6
Juneberry	50.0	0.0	50.0	30.30 lbs	-19.7
Ninebark	9.0	0.0	9.0	0.00 bu	-9.0
Plum, American	27.0	0.0	27.0	30.60 bu	+3.6

Table 1. Showing nursery purchasing goals, direct seed needs, seed purchases, and surplus/deficit by each species in 2023.

Outside of seed collection efforts, the Reforestation Program also began a pilot project at the Hayward Nursery looking into red pine cone and seed ripening. The objective was to determine the earliest date at which cones can be collected, while still being able to open using traditional processing methods and producing a viable seed with acceptable germination rates. Work is ongoing and preliminary results will be available this spring. More samples will be taken in the coming years to determine if it is a question worth pursuing. Similar information has been gathered for other species such as Loblolly Pine. Results will be valuable in guiding seed picking efforts regionally by providing a better time frame for when collection efforts can begin.

Seed Sales

The Reforestation Team has received \$45,860.00 in direct seed orders to date. Species making up the largest proportion of orders were red oak (51 bushels), bur oak (35 bushels) and jack pine (184 lbs. of cleaned seed). Notable trends include an increase in direct seed sale requests from seed brokers and private nurseries. Requests for seed purchase were made by five private nurseries/seed brokers. Of this, four were filled. Seed sold to these entities includes 6 pounds of Tamarack and 1 pound of white spruce. One hardwood order could not be filled due to a lack of seed availability. Seed availability to the public is based on target goals set for storage to insure a consistent supply of seed for growing seedlings at the Wilson State Nursery. If storage goals are not met for a given species, direct seed sales are not made available to the public.

A reduction in private hardwood seed orders occurred this fall, likely driven by a good oak acorn crop, reducing the reliance on direct seed purchases from the Reforestation Team. Hardwood seed purchases often fluctuate in amount, normally based on naturally available seed found throughout Wisconsin. In years with good seed crops, landowners can often find their own seed for planting. In years when seed is difficult to find, the Reforestation Team gets its highest volumes of hardwood direct seed orders.

The Reforestation Team also provided seed to three different research projects. The first, was for an assisted migration study being carried out on the Chequamegon-Nicolet National Forest by the USFS. Species sent included hackberry and tamarack. Trees will be grown at the J.W. Toumey Nursery in Upper Michigan and out-planted onto sites in the Chequamegon-Nicolet National Forest. Another study being carried out by researchers at UW-Madison seeks to determine the microbial associations that tree seedlings develop within nurseries, and how well these microbes serve trees after being out-planted. Lastly, a study being conducted by the University of Tennessee-Knoxville is trying to understand the interactions among different mycorrhizal fungi communities and genetically distinct populations of their host species. The goal is to determine how this effects the extent to which plant populations can establish outside of their native range and how this may impact assisted migration.

Personnel Changes And Facility Improvement

The Hayward State Nursery, the primary location for seed collection and cleaning efforts, experienced a multitude of changes in 2023. First, Richard Nessler began work as the tree improvement specialist Aug. 1. This position was newly created as part of the Division of Forestry's 2023 Strategic Direction. Nessler is staffed out of Hayward. Duties of the position include, but are not limited to, oversight of seed cleaning/collection operations, orchard establishment/maintenance, and implementation of tree genetic trials, with guidance from the also newly hired DNR Forest Geneticist, housed in the Forest Economics and Ecology Section. This position will allow the DNR to meet public demands for seed and seedlings that are best adapted to current and future forest conditions.

The year also saw the Reforestation Team saying goodbye to one of the staples of the Hayward Nursery. Domingo (Ray) Aguilera announced his retirement in the fall of 2023. His last full work week occurred in December 2023. Aguilera had been employed at the Hayward Nursery since 1989. During his 34 years, Aguilera was able to contribute in multiple capacities. He started his career as an LTE Laborer, helping with seedling lifting and other

nursery tasks. In 1999, Aguilera was hired into a full-time position as a technician. Five years later, he became the Nursery Foreman, primarily working on seedling production. In 2011, after the Hayward Nursery ceased seedling production, Aguilera's duties shifted to align with the Hayward Nursery's new role within the state. Instead of a focus on seedling production, he led seed collection/processing efforts, orchard establishment/maintenance and facilities maintenance.

Aguilera stated that, the only reason he stayed working for the nursery so long was because he really enjoyed it. This was evident to all who worked with Aguilera. He was the person that would drop everything, even on a weekend, to come in and help a customer or deal with an emergency at the nursery. He also noted great leadership as a reason for staying so long, specifically from Reforestation Team leader Joe Vande Hey. Aguilera said, "he really appreciated Joe actually getting involved in the work." For example, Aguilera noted the time Vande Hey helped with establishing the Red Pine Orchard at the Hayward Nursery during a rainstorm.

Aguilera was a dedicated employee and true asset to the Reforestation Team and entire Department. He most assuredly is a large reason why the Reforestation Program is in the positive position it is today.

Finally, the Reforestation Team has continued to work towards creation of the new Seed Extractory and Lab at the Hayward State Nursery. Funding has been secured for the project and work with civil engineers has begun. Vande Hey and Nessler made trips to Illinois and Minnesota in 2023 to view their seed extractory set-ups and nurseries to determine what equipment and facilities would be most ideal for the Reforestation Team's purposes in Hayward. Work will continue on this project with the hope to have it finished in the coming years. Updates will be included as they happen and will be reflected in next year's Annual Report.



This row of red maple seedlings at the Wilson State Nursery in Boscobel dazzled with fall colors on a sunny fall day in mid-October. The nursery beds provided a quick compact glimpse into the spectacular colors produced by this species.

Photo credit: Grace Hershberg



Wisconsin Reforestation Program 2023 Annual Report

Updated July 15, 2023

