
Photo Credit: Grace Hershberg, Wisconsin DNR

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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

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REFORESTATION PROGRAM

Reforestation Monitoring

Introduction

Since 2007, the Wisconsin Department of Natural Resources (DNR)'s Division of Forestry's Reforestation Program (RP) 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. The sites included are public and privately owned, large and small acreages and single or mixed species plantings. This monitoring also allows for interactions and discussions with landowners and land managers.

Personnel

Regeneration Specialist Jeremiah Auer directed a team of limited term employees (LTE) in 2022. Michael Ard participated in his eighth field season and Landon Goble in his first. While Jeremiah accompanied on occasion, the LTE 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 early summer, northwest, west and far southern Wisconsin experienced significant periods of drought, including some areas of moderate drought in early to mid-summer. Eventually, most of the state received precipitation, except some parts in the far west and northwest. Overall, the temperatures were cooler than normal.

Site Selection And Plot Installation

Sites are selected from among landowners who order a minimum of 3,000 seedlings, a volume that can cover approximately three acres of land, from the Wisconsin DNR tree nursery program. 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 site is selected, plots are installed randomly within the planted area. Areas greater than 10 acres receive six plots, and sites with less than 10 acres receive three plots. Each

plot center is marked with a wooden stake and orange flags. 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 of which is blue, with red whiskers designating the other seedlings) and is mapped to ease data collection in the third and seventh years.

Plot Installation 2021

The 2022 field season was finally free of all COVID-19 limitations. Staff established plots on 37 sites, representing 36 ownerships. Of these sites, 18 are located on public lands and 19 on private property. The counties with sites established in them are Adams (1), Bayfield (1), Buffalo (1), Burnett (2), Calumet (1), Chippewa (1), Door (2), Douglas (1), Dunn (1), Iowa (1), Iron (1), Juneau (2), Lafayette (1), Lacrosse (1), Lincoln (1), Marathon (1), Marquette (2), Monroe (2), Ozaukee (1), Pepin (1), Polk (1), Portage (2), Sauk (2), St. Croix (1), Taylor (1), Vernon (1), Washington (1), Waukesha (1), Washburn (1) and Wood (1). This allows us to monitor seedling growth and development in a wide variety of soils and conditions.

After the growing season, staff also remeasured monitoring sites on plantations from 2020, after their third growing season. Staff revisited all 18 sites, representing nine public and nine private properties. These sites were in the counties of Adams (1), Bayfield (1), Burnett (1), Chippewa (1), Columbia (1), Door (1), Douglas (1), Jackson (2), Rusk (1), Sawyer (1), Taylor (1), Trempealeau (2), Vilas (2) and Waupaca (2).

Finally, staff visited 29 sites after their seventh growing season. They were originally established in 2016 and remeasured in 2018. This is the second year that the new protocol was fully utilized. These sites are found in Bayfield (1), Burnett (1), Brown (1), Columbia (1), Dodge (1), Door (1), Douglas (1), Dunn (1), Eau Claire (1), Forest (1), Grant (1), Iowa (1), Jackson (1), Juneau (1), Kewaunee (1), Marathon (1), Marinette (2), Polk (1), Portage (1), Richland (1), Rock (1), Shawano (1), Sheboygan (1), Vilas (3), Walworth (1) and Washington (1) counties. There are 18 public and 11 privately owned sites. One site wasn't visited as the landowner sold the property and staff could not contact the new owners.

Data Analysis

Year 0

Data was collected on 2,502 newly planted seedlings at 37 sites. All seedlings originated at a DNR nursery.

	Public Lands		Private Lands	
	Seedlings	%	Seedlings	%
Healthy	778	71.2	929	65.9
Light Damage	148	13.5	143	10.1
Heavy Damage	91	8.3	171	12.1
Dead	76	7.0	166	11.8
Total	1093	100.0	1409	100.0

Table 1: Seedling Health Year 0 (2022)

Overall, seedlings had a survival of 79.8%. A further breakdown shows 68.2% are considered healthy and 11.6% 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 20.2%. A further breakdown of this shows that 10.5% 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 9.7% were dead. Compared to previous years, 2022 seedling survival is slightly below the average.

Public lands: Public land sites are typically planted with more conifers than hardwoods, and plantings tend to be larger in size. This tendency was true for 2022. Of the 1,093 seedlings sampled on public lands, 55% were conifers and 45% hardwoods. Overall, seedling health was slightly above the overall average of 80.7%. The conifers did well, with 84% reported as healthy or exhibiting light damage. 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, not surprisingly, no seedlings exhibited signs of browse. Unfortunately, over 32% of seedlings were planted deeper than suggested. While this doesn't typically impact survival or health in the first growing season, it can be detrimental in later years. Hardwoods tend to be more susceptible to browse in summer, especially oaks and maples. Just over 73% of hardwoods had little to no browse evidence. However, the remaining 27% are dealing with severe browsing to a point that without some intervention, the seedlings will have a difficult time getting above it.

Private lands: Private lands tend to have smaller plantings. In 2022, this trend continued. Of the 1,409 seedlings sampled, most were conifers. The seedlings did well. The overall rate of healthy and slightly damaged trees was 76%. As most seedlings were conifers, browse was minimal. When it did occur, sugar maple seemed to be subject to the most pressure. Over 40% of the sugar maple seedlings are dealing with oppressive browse. The other hardwoods have only been minimally impacted to this point.

Year 3

2020 sites were planted at the height of the COVID-19 pandemic. This limited the availability of staff and the available sites. However, we did establish plots on 18 sites, representing 15 ownerships. Of these sites, nine were located on public lands and nine on private property.

	2020, Year 0		2022, Year 3	
	Seedlings	%	Seedlings	%
Healthy	969	78.8	796	64.7
Light Damage	124	10.1	64	5.2
Heavy Damage	33	2.7	68	5.5
Dead	104	8.5	282	22.9
Unknown	0	0.0	20	1.6
Total	1230	100.0	1230	100.0

Table 1: Comparison of Seedling Health from Year 0 (2020) to Year 3 (2022)

The sites were in several counties across the state: Adams (1), Bayfield (1), Burnett (1), Chippewa (1), Columbia (1), Door (1), Douglas (1), Jackson (2), Marathon (1), Rusk (1), Sawyer (1), Trempealeau (2), Vilas (2) and Waupaca (2). Two of the public land sites used non-DNR containerized seedlings. We were able to revisit each site in 2022.

In Year 0, data was collected on 1,230 newly planted seedlings. Of these, 959 originated at

a DNR nursery. The other 271 were from private nurseries (195 containerized, 76 bare root). Overall, seedlings had a survival of 88.9%. A further breakdown shows 77.8% were considered healthy, 10.1% were lightly damaged but growing and expected to survive, 2.7% suffered from heavy damage and 8.5% were dead. In Year 3, a total of 1,210 seedlings were measured on the 18 sites. Of the seedlings that were remeasured, 64.7% were healthy, 5.2% were slightly damaged, 5.5% were heavily damaged, 22.9% were dead and 20 seedlings were not able to be located and measured. There was one plot that completely disappeared as we could not find any indication it existed and another where two trees also vanished from the plot. The number of surviving and thriving seedlings dropped from 969 to 796 from Year 0 to Year 3.

Year 7

These sites were established in 2016 and remeasured in 2018. These are the final measurements to determine if the sites developed to a point where they could be considered successful or unsuccessful.

	2016, Year 0		2018, Year 3		2022, Year 7	
	Seedlings	%	Seedlings	%	Seedlings	%
Healthy	2026	85.2	1299	54.6	1230	51.7
Light Damage	164	6.9	218	9.2	103	4.3
Heavy Damage	47	2.0	211	8.9	146	6.1
Dead	141	5.9	605	25.4	745	31.3
Unknown	0	0.0	45	1.9	162	6.8
Total	**2378**	**100.0**	**2378**	**100.0**	**2378**	**100.0**

Table 2: 2016 Comparison of Seedling Health from Years 0, 3 and 7

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, 30 sites had plots established. Then, in 2018, we revisited each of the sites to ascertain seedling survival and growth. In the final year, staff revisited 29 of the original sites. The site that wasn't visited was sold and the new owners were not available. Overall, of the 29 sites, 18 are public and 11 are privately owned. There are 10 successful public land plantings and eight unsuccessful. There are seven successful private land sites and four unsuccessful. This represents a success rate of 56% on public lands and 64% on private lands; an overall rate of 59%.

Success of Forester-Provided Planting Plans: All public properties are required to have a planting plan. As previously mentioned, the public lands success rate was 56% of the 18 site plantings. The reasons that eight sites failed are typical: two had drought conditions during their first growing season, one was planted in a very wet site with standing water, and heavy competition and deer browse plagued the others. The one underplanting did not have the overstory removed, so, coupled with heavy deer and rabbit browse, the seedlings fared poorly. Only two of the 11 private lands sites did not have a written plan; one was successful. Six of the nine others with written plans were successful and three were not. The three unsuccessful sites were impacted by heavy deer browse on the hardwoods and heavy competition. Based on these results, the trend shows that sites with planting plans perform better over the seven-year study than those without.

Overall Conclusions

This is the eighth year with the current regeneration monitoring protocol, and two full measurement cycles (first, third and seventh years of growth) have now been completed. Our conclusions are as follows:

1. Plantations with professionally created planting plans tend to do better than those without, see table 4 below.

		2012		2013		2014		2015		2016		Totals	
		+	-	+	-	+	-	+	-	+	-	+	-
Public Lands	With planting plan	6	4	13	2	8	2	11	9	10	8	**66%**	**34%**
	Without planting plan	0	0	0	0	0	0	0	0	0	0	**0%**	**0%**
Private Lands	With planting plan	2	3	4	0	8	0	4	2	6	3	**75%**	**25%**
	Without planting plan	4	5	0	1	0	0	2	1	1	1	**47%**	**53%**

Table 3: Plantation success and failure rate with and without planting plans
(+) Successful plantings (-) Unsuccessful plantings

2. Seedlings planted on public lands by private contractors are more likely to be planted deeper than what is suggested, see table 5 below. Contract crews are planting over 90% of the public land sites, mostly by hand. Since 2015, an average of 40.8% of seedlings planted on public lands were planted deeper than suggested (greater than 2" below the root collar). While planting depth has improved in recent years, it is still high. Hopefully, this downward trend of deep planting will continue. Deeply planted seedlings can be susceptible to fungal infection in the lower stem.

Public Lands Planting 2015-2022			
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%
Average	**54.8%**	**40.8%**	**4.4%**

Table 4: Public Lands Planting 2015-2022

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 2022 field season was a success in that our staff was able to visit a variety of diverse plantings. Further 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 also undertake experiments to test the efficacy of herbicides used in site preparation, chemicals that claim to mitigate deer browse, seedling lifting and storage techniques, etc. In 2021, the RP repeated a previously established trial that measured the impacts of extended storage on seedling survival.

Extended Summer Storage

Historically, it was assumed that bare root seedlings must be planted in early spring to take advantage of ideal weather conditions and give the seedling the best chance for survival. However, the floodwaters of some bottomland sites do not recede until late spring or early summer. The RP performed a storage trial in 2019 to test the effects of long-term storage on bottomland tree species and seedling performance after mid-summer planting. The trial determined that extended storage did not have a significant impact on the survival of aspen (*Populous spp*.), silver maple (*Acer saccharinum*) or swamp white oak (*Quercus bicolor*). However, it did impact the survival of white birch, red maple, tamarack and black spruce. The 2021 trial will have the final measurements taken in spring 2023 and documented in next year's report.

Red pine seedlings being packaged for storage.

Photo credit: Grace Hershberg, Wisconsin DNR

SEED COLLECTION

Seed Production And Collection

The seed production and collection in 2022 was exciting. During late May, most of the state experienced favorable weather. The spring-seeded species—silver maple, red maple, American elm, cottonwood, aspen and river birch—had great crops, and seed collectors were able to harvest a few of the species we need in good quantities. The summer weather was cooler than normal, but favorable in most places instilling a cautious optimism on the development of mast crops. The members of the white oak group produced heavily across the mid-section of the state, even better than the huge crop of 2021. The RP met and exceeded our bur and white oak purchase goals easily. Even though we didn't procure as much swamp white oak as we had hoped, it was still a good crop. Red oak produced a good crop of acorns, although it was considerably later than usual. Black walnut was plentiful, and the bushels of raw seed yielded high. Hazelnut had another bumper crop. The highbush cranberry was also stellar.

While some conifers were plentiful, collecting them has become a challenge as experienced collectors have dwindled. White pine had a good crop, and a few pickers were able to capitalize. Unfortunately, we fell short on red and jack pine. Red pine seed has become highly prized in the Upper Midwest, with many nurseries, public and private, searching for it. The RP will need to increase its efforts next year as our supply has dwindled and there seems to be a good crop. See table 6 below for our 2022 seed collection totals.

Conifer and Hardwood Seed Collection 2022

Species	Nursery Goals	Direct Seeding Needs	Total Needs	Purchases	Surplus/ Deficit
Hemlock, Eastern	12.0 bu	0.0 bu	12.0 bu	0.25 bu	-11.75 bu
Pine, Jack	1,200.0 bu	0.0 bu	1,200.0 bu	340.3 bu	-859.7 bu
Pine, Red	720.0 bu	0.0 bu	720.0 bu	20.1 bu	-699.9 bu
Pine, White	450.0 bu	0.0 bu	450.0 bu	365.8 bu	-84.2 bu
Spruce, Black	12.0 bu	0.0 bu	12.0 bu	2.3 bu	-9.7 bu
Tamarack	25.0 bu	7.1 bu	32.1 bu	1.4 bu	-30.7 bu
Birch, Yellow	10.0 lbs	0.0 lbs	10.0 lbs	19.2 lbs	+9.2 lbs
Butternut	20.0 bu	2.0 bu	22.0 bu	23.0 bu	+1.0 bu
Cherry, Black	1,200.0 lbs	0.8 lbs	1,200.8 lbs	652.1 lbs	-548.7 lbs
Hackberry	300.0 lbs	300.0 lbs	300.0 lbs	379.2 lbs	+79.2 lbs
Oak, Bur	170.0 bu	9.0 bu	179.0 bu	185.9 bu	+6.9 bu
Oak, No. Red	150.0 bu	37.4 bu	187.4 bu	191.7 bu	+4.3 bu
Oak, Swamp white	225.0 bu	1.0 bu	226.0 bu	101.1 bu	-124.9 bu
Oak, White	285.0 bu	46.5 bu	331.5 bu	415.5 bu	+84.0 bu
Walnut, Black	660.0 bu	105.0 bu	765.0 bu	900.0 bu	+135.0 bu
Cranberry, Highbush	100.0 lbs	0.0 lbs	100.0 lbs	232.3 lbs	+132.3 lbs
Hazelnut, American	92.0 bu	0.0 bu	92.0 bu	112.3 bu	+20.3 bu
Plum, American	48.0 bu	0.0 bu	48.0 bu	34.1 bu	-13.9 bu

Table 6: Sample of species collected by reforestation program seed collection efforts in 2022

Seed Sales

In addition to seed collected and stored for use in producing nursery stock, any seed volumes above our need threshold (typically seven years for conifers and three years for hardwoods) are made available for direct seeding efforts on public or private lands and nursery stock destined for reforestation efforts or research efforts. In the fiscal year 2022, the reforestation program provided over 500 pounds of stored seed (mostly conifer with a small amount of hardwood) and over 109 bushels and 49 pounds of fall-produced seed (hazelnuts, acorns and walnuts). This seed is destined for direct seeding on state and county forest lands, state forests (over 210 pounds of jack and white pine), university research projects, private and public nurseries (over 250 pounds of white pine and white birch), Native American tribes and private landowners.

Swamp white oak acorns

Photo credit: Grace Hershberg, Wisconsin DNR

NURSERY PROGRAM

DISTRIBUTION

Spring 2022 distribution was refreshingly routine, following the two previous years of Covid-19 disruptions. The spring distribution season started on Nov. 1, 2021. Beginning on that date, the nursery used a contract labor crew provided by Northwoods Forestry to lift 400,000 conifers and 400,000 hardwoods/shrubs. The fall lifting and grading work lasted three weeks, allowing us to go into spring with actual physical counts of the inventory available for many species, rather than relying on questionable bed-run estimates. This allows us to sell stock with confidence and greatly reduces the number of orders needing to be modified or canceled due to inventory shortages. These seedlings were stored in cold storage over winter for distribution in the spring.

The contract for the spring lifting and grading was awarded to Superior Forestry Service again, who supplied us with two crews. One was a dedicated grading crew, while the other primarily lifted trees and graded as needed. About 2.78 million seedlings were lifted in the spring. The crew averaged 231,000 seedlings per day. About 2.11 million seedlings were graded with a daily average of 131,000 seedlings per day. Another 681,600 seedlings were packed for bulk orders. Lifting began on March 28, and by April 19 all stock was lifted and graded, and the contract crews were free to move on to their next job. However, the nursery crew still had two weeks of order packing to finish, until the final semi departed the loading dock on May 4 bound for northeast Wisconsin. A total of 3,555,520 seedlings were distributed in 2,829 orders. Of that, 42,750 seedlings in 571 orders were packed for the 4th Grade Arbor program. See the 2022 Distribution Report for more details.

SPRING SEEDING

As seedling distribution was winding down, it was time to turn to spring sowing. Historically, most sowing was done in the fall when fresh seed is available and nursery workers have more time to perform sowing operations. Seed sown in the spring needs to be artificially stratified (hydrated and pre-chilled). Each species has different stratification requirements, lasting from a few days to several weeks, and failure to properly stratify means the seed will not break dormancy and germinate. Fall planting gets around this problem, allowing the seed to stratify naturally in the cold, damp ground and germinate when the soil temperature hits the proper range. However, fall sowing is not without risk. During snow-free periods, fall sown beds are exposed to wind and water erosion. They are also vulnerable to temperature extremes and depredation by squirrels, mice, birds and other hungry seed eaters. Because of this, the nursery has gone to spring sowing for several small-seeded conifer species that

have shown poor performance with fall sowing. In addition to this, there are multiple species that disperse their seed in the spring, and these are spring sown.

The following table shows the species sown and the date sowing began. Planting of some species may have been spread over several days due to the volume involved, or to the late arrival of freshly collected seed. The date listed is merely when seeding began for each species. White spruce was intentionally split between fall and spring sowing, to not “put all of our eggs in one basket”. White spruce is also a labor-intensive species to sow, and this spreads out the workload. Note that tamarack and white cedar have a “replant” date. This is because both experienced very spotty, delayed germination. Since both have relatively short stratification requirements, and we had ample seed in storage, the decision was made to immediately begin stratifying new seed and replant as soon as possible.

Species (fall-sown)	Sowing start date	Species (spring-sown)	Sowing start date
Basswood	09-30-21	Tamarack	05-02-22
Walnut	09-30-21	White Spruce (planned spring beds)	05-04-22
Winterberry	10-01-21	Black Spruce	05-05-22
Highbush Cranberry	10-01-21	Bald Cypress	05-10-22
Grey Dogwood	10-04-21	Speckled Alder	05-10-22
Hawthorn	10-04-21	River Birch	05-10-22
Bur Oak	10-04-21	Sycamore	05-24-22
Red Osier Dogwood	10-05-21	Quaking Aspen	05-24-22
Silky Dogwood	10-05-21	Cottonwood	06-09-22
Hazelnut	10-06-21	Bigtooth Aspen	06-09-22
Ninebark	10-06-21	Tamarack (replant)	06-10-22
White Oak	10-12-21	Silver Maple	06-10-22
Wild Plum	10-12-21	White Cedar (replant)	06-10-22
Black Cherry	10-12-21	American Elm	06-20-22
Fire Cherry	10-14-21	Red Maple	06-20-22
Choke Cherry	10-14-21	Willow	06-21-22
Elderberry	10-14-21		
Hackberry	10-15-21		
Yellow Birch	10-18-21		
White Birch	10-18-21		
White Spruce	10-19-21		
Balsam Fir	10-19-21		
White Cedar	10-19-21		
Red Pine	10-20-21		
Swamp White Oak	10-20-21		
Hard Maple	10-21-21		
White Pine	10-22-21		
Red Oak	10-24-21		
Jack Pine	10-25-21		
Southern Pin Oak	10-25-21		
Bitternut Hickory	10-25-21		
Buttonbush	11-23-21		

Table 9: 2021-22 Seed sowing schedule

GERMINATION

Fall-sown seed typically begins germinating soon after frost leaves the ground and a couple of sunny, early April days bring the soil surface temperature up a few degrees. Hard maple and a handful of 'early bird' shrub species are the first to germinate, with jack pine usually just a few days later. Most species germinate in late April into early May, and bitternut hickory is usually the last species to germinate, breaking the surface in late May. If other fall planted species haven't come up by then, it is probably a failed crop. Spring sown species typically germinate within a few days of sowing but can take up to three weeks. A bed inventory to assess germination success is done in early to mid-June. This data is used to assess seedlot performance, sowing rates and planning for the next planting season can then be adjusted based on the success or failure of any particular species. Stock will be inventoried again at the end of the growing season to assess the amount of stock that actually made it to saleable size.

With 45 different species sown, and multiple seedlots of most species, there are sure to be a few failures, but overall spring germination was quite good. Most seedlots germinated at or above target density, see table 8 below. A couple conifer seedlots required some hand thinning due to extremely high density, but most above-target beds were close enough to target that they were allowed to naturally self-thin down to the desired density, avoiding the need for labor-intensive thinning. Others, such as quaking aspen, are so shade-intolerant that they will quickly find optimum density on their own.

Species (conifer)	Percent of target bed density	Species (hardwood)	Percent of target bed density
Bald cypress	54%	**Aspen, bigtooth**	204%
Cedar, white (fall sown)	43%	**Aspen, quaking**	458%
Fir, balsam	98%	**Basswood**	23%
Hemlock	376%	**Birch, river**	168%
Pine, jack	183%	**Birch, white**	82%
Pine, red	136%	**Birch, yellow**	266%
Pine, white	167%	**Cherry, black**	163%
Spruce, black	238%	**Hackberry**	111%
Spruce, white (fall sown)	118%	**Hickory, bitternut**	55%
Spruce, white (spring sown)	205%	**Maple, hard**	127%
Tamarack	79%	**Maple, red**	0%
Tamarack (replant)	69%	**Maple, silver**	65%
		Oak, bur	114%
		Oak, red	137%
		Oak, southern pin	82%
		Oak, swamp	98%
		Oak, white	81%
		Walnut	111%

Table 5: Successful seed germination of target bed density

Note that the tamarack sown on May 2, which was replanted due to poor initial germination, eventually ended up near target, whereas the beds replanted on June 10 performed poorly. The early seeding was sown too deep, which severely delayed germination, but many of the seedlings did eventually emerge and produced a much better stand than expected. The June 10 reseeding was emerging during hot, dry summer weather in late June, which took a heavy toll on the tender young seedlings.

NURSERY TRIALS

White oak is a very in-demand tree species, but Wisconsin is at the northern edge of its range, making it difficult to consistently propagate under bare root nursery conditions. Wilson Nursery has grown very successful white oak crops, but there have also been numerous years of failed germination. To correct this, we have been experimenting with various methods of mulching the seedbeds. 2021 was an exceptional white oak mast year in southern Wisconsin, and with seedling demand high, the nursery purchased over 400 bushels of white oak acorns for fall sowing. That's enough acorns to sow over 3.5 acres of white oak seedbeds that should produce about 800,000 seedlings. With this much ground in white oak production, it was the perfect time to establish side-by-side trials to compare various mulching treatments. The three treatments in the trial included:

1. 4 inches of fluffed rye straw, tacked down with ½ oz/ft^2 of aspen fiber hydromulch. This was burned off in the spring just prior to germination.

2. Cover with a commercial polypropylene frost blanket (germination fabric), which was removed in the spring at the first signs of germination.

3. Cover with a living mulch of winter wheat, sown into the bed with the acorns, and reaching a height of approximately 3-4 inches prior to freeze-up. This wheat cover was sprayed off with glyphosate about a week prior to expected germination.

Results were assessed based on the number of saleable trees per square foot at the time of the September saleable stock inventory, since a saleable 1-0 seedling is the ultimate goal for hardwood beds. While all treatments were well below target bed density of 8.3 saleable seedlings per square foot, the straw/hydromulch treatment was the clear winner at 3.5 saleable seedlings per square foot. The commercial germination fabric was a close second, at 3.1 saleable seedlings per square foot. The living mulch performed much poorer, at 2.1 saleable seedlings per square foot.

Treatment	Germinated seedlings per square foot	Saleable seedlings per square foot
Straw	8.4	3.5
Germination fabric	7.5	3.1
Winter wheat	4.8	2.1

Table 9: Nursery trial treatment distribution

While the straw/hydromulch combination was the clear winner in the assessment, it is also by far the most expensive and labor-intensive mulching option, and we are reliant on good

burning weather in the spring to clear the straw from the beds. The living mulch is the easiest and cheapest option, but it is less reliable. Cold fall weather can delay germination of the wheat, leaving the crop to go into winter with no cover at all. This is especially problematic if we have snow-free conditions, which is a relatively common occurrence in southwest Wisconsin. Of the three options, the commercial germination fabric rises to the top when considering cost, ease of application and maintenance and results. Future operational plans will continue mulching a few beds with straw, as insurance against an open, extremely cold winter, but cover most of the white oak beds with germination fabric.

In the nursery trial, commercial germination fabric was found to be the most effective solution to promote white oak acorn germination. Germination fabric quickens seed germination by keeping seeds warm while allowing light and water to reach the seeds.

Photo credit: Grace Hershberg, Wisconsin DNR

Another operational nursery trial that began in 2022 is the manufacture and use of biochar in the seedbeds. Wilson Nursery has a fine sandy soil, and it is extremely hard to hold organic matter. We regularly add large volumes of sedge peat to keep the organic matter at 2%. This organic matter is necessary to help retain nutrients in the seedlings' root zone. Without it, nutrients quickly leach away into the sand. Biochar was procured from a kiln set up on site using nursery brush piles as feedstock, and it is being tested as a supplement to this organic matter. Even at relatively low application rates, the porous char provides a greatly increased surface area for microbes to colonize, meaning more nutrients can be captured and held in the root zone. Depending on results, it could even be an eventual replacement for the frequent sedge peat applications. The biochar project in Wilson Nursery is being led by Brian Zweifel, a member of the Wisconsin DNR Forest Products Team. So far, char has been incorporated into test plots in the seedbeds of hazelnut, silky dogwood, black walnut, black cherry, hard maple, white oak, white spruce, red pine and white pine. The US Forest Service Rocky Mountain Research Station is planning to install monitoring instruments in the spring. Upon germination, results will be monitored and compared to the control beds.

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. This study will subject the nursery seedbed to various environmental stressors to see how the microbial population responds. This 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 into 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.

WEATHER CONDITIONS

2021 ended with a very warm December, but 2022 began with a very cold January. However, due to good snow cover at the time it didn't seem to have any major negative effects on the seedbeds or nursery stock. The summer was below normal for rainfall, but what rain we did receive was well-timed, so drought stress was never a major issue.

The standout weather features for nursery operations were a very warm mid-May followed by a light frost May 23, a cool July and August, and a very dry fall. The warm May was overall a positive event, although the five days of 90 degrees or above did make it very difficult to keep germinating spring-seeded beds from desiccating. The relatively cool July and August weather made it more difficult to get 1-0 hardwood and shrub seedlings up to saleable size. Typically, most hardwood species do the bulk of their growing in the warm days and nights of July and August. Cooler weather, especially cool nights, leads to less growth and higher seedling cull rates.

Month	Average high (F)	Average low (F)	Precip. (in)	Temp. Range	Days at 90F or above	Days at 0F or below
December (2021)	40.7	21.5	1.25	8 to 72		
January	25.5	1.5	.65*	-23 to 46		19
February	31.8	10	0.12	-11 to 54		5
March	46.4	25.8	3.89	3 to 77		
April	54.9	34.7	2.83	20 to 82		
May	74.5	49.7	1.99	32 to 97	5	
June	82.5	55.4	2.07	46 to 98	7	
July	84.5	60.5	5.02	51 to 92	4	
August	80.7	58.9	5.77	55 to 90	1	
September	73.8	50.5	1.4	30 to 91	1	
October	64.5	35.3	0.99	20 to 83		
November	49.4	26.6	3.18	10 to 77		
December (2022)	31	15.3	2.61	-11 to 51		9

Table 9: 2022 weather conditions in Boscobel, WI
*January precipitation estimated due to gaps in local weather station data

The dry fall conditions in September and October were helpful for the process of hardening off stock before winter, but by October soil moisture conditions were getting extremely dry. This had a large impact on fall sowing operations, as the dry sand was sifting into the planting furrows, making it impossible to control seed depth. To get around this, we were forced to irrigate bare ground prior to seeding, and then re-winterize the irrigation system, which added a considerable workload to an already busy season. The dry conditions also delayed the germination of fall cover crops, so winter wheat failed to reach the desired three to four inches of growth before freeze-up. The winter wheat acts as a living mulch, protecting the seedbeds from wind erosion. It is sprayed with glyphosate in the spring prior to germination of the seedlings.

MONTHLY NURSERY WALKS

In 2021 we started monthly nursery walks with nursery staff and the DNR Forest Health team to monitor stock during the growing season. The walks were a success, so we resumed the practice in 2022, May through September. After two summers of monthly visits, the forest health staff is much more familiar with our operations. This helps greatly when we have problems because every visit included collecting numerous samples to be analyzed in the Forest Health lab. Nursery management decisions can be made based on confirmed lab results, instead of mere assumptions of what might be causing the problem.

SEEDLING HEALTH

In general, seedling health was good this year. Annually, all red pine beds in the nursery are lab-tested for asymptomatic diplodia infection. Red pine seedlings can look perfectly healthy and exhibit no outward signs of infection but still contain the Diplodia sapinea pathogen in their tissues. Once outplanted, these asymptomatic seedlings tend to suffer higher mortality when they come under the inevitable drought stress. Except for one small block of 2-0 seedlings (A29), asymptomatic infection rates were quite low across all age classes of red pine. The block with the higher diplodia infection was spring seeded, which is not typical practice for growing red pine in Wilson Nursey. It is suspected that this may have played some role in the higher incidence of diplodia in that block, as it was germinating during peak diplodia spore dispersal but was not receiving the same prophylactic fungicide applications as the rest of the red pine seedlings. Because of the higher incidence of asymptomatic diplodia within block A29, it will be withheld from the saleable inventory and not distributed.

Age Class		No. of positive samples	Positive samples (%)
1-0 red pine		2 of 252	0.8%
2-0 red pine	Block A29	7 of 72	
	Blocks B20-B22	1 of 236	
	Total from all blocks	**8 of 308**	**2.6%**
3-0 red pine		5 of 276	1.8%

Table 10: Seedling samples testing positive for Asymptomatic Diplodia

Another disease tested for on an annual basis is eastern pine gall rust Cronartium quercuum. This test consists of a meticulous visual inspection of 1,000 seedlings each of 1-0 and 2-0 jack pine, searching for the presence of galls. Wilson State Nursery typically has a very low incidence of gall rust, but it is easily screened for, and testing provides us with the assurance that we are not shipping diseased stock. 2022 sampling of 1,000 1-0 jack pine revealed no visible galls and 3 seedlings with suspicious swelling were potted to grow for further monitoring. 1,000 2-0 jack pine seedlings yielded 15 visible galls, for an infection rate of 1.5%. Seedlings sold as counted and graded stock are inspected for defects on the grading line, and most galled seedlings are discovered and culled, so the actual percentage of gall rust infected trees leaving the nursery is much lower still.

One disease problem that did turn up in the nursery in mid-June was an incidence of downy mildew in the 2-0 highbush cranberry. This is not the first time this pathogen has been found on cranberry beds in the nursery. An outbreak several years ago destroyed nearly the entire cranberry crop in a matter of days. So, when nursery technician Mark Caldwell reported watery, wilting leaves on part of a cranberry bed, downy mildew was the first suspect. The nursery superintendent and assistant manager were both away for a two-day meeting and unable to investigate but based on Mark's assessment an immediate application of Mefenoxam was ordered, and it seemed to stop the outbreak in its tracks.

A follow-up treatment of Dithane (mancozeb) was made two weeks later, and no further sign of downy mildew was found for the rest of the summer. Even heavily wilted cranberry seedlings recovered and put on a fresh flush of growth.

FUMIGATION AND FALL SEEDING

A little over 16 acres were prepped for fall sowing and fumigated in August. This prep work included the addition of 400 pounds per acre of Sulfur 90 to help with the nursery's rising pH rates. It also included the addition of 20-50 yards per acre of sedge peat, based on soil testing data, to further lower pH and reach a minimum 2% soil organic matter. Most conifer ground (4 acres) was treated with straight chloropicrin (Tri-Pic 100) at 175 pounds per acre. The other 12 acres of prepped ground were treated with a 67% methyl bromide/33% chloropicrin mixture (MBC-33) at a rate of 300 pounds per acre.

After the fumigation contract was already established, a computing error was discovered in the seeding plan. The actual acreage needed for the seeding plan was nearly 19 acres, not the 16 acres we were contracted to treat. Because of this, additional fields were prepped for sowing, but not fumigated. These unfumigated beds were planted to swamp white oak and red oak. These two oaks are relatively easy to grow and tolerant of pre-emergent herbicides, and the seedlings tend to close canopy by early summer, suppressing any weeds that may escape the herbicide barrier. Being in unfumigated ground, it may be a little more challenging to get the trees saleable in one growing season, but experience shows that it should be possible with these species. Meanwhile, the fumigated ground is available for the slower growing, less herbicide tolerant species.

As the sowing date table on page two shows, fall sowing began on Sept. 30, and was largely wrapped up by Oct. 25. Of the 19 acres needed to fulfill the entire seeding plan, about 15.5 acres were fall sown, with 14 acres of that being fumigated ground. Approximately two acres of fumigated ground remain to be spring sown. The other 1.5 acres missing from the 19 acres

seeding plan total are unplanted swamp white oak beds. Despite raising the price paid for swamp white oak acorns, and a herculean effort by some of our most dedicated seed collectors, the nursery was only able to acquire 101 bushels of swamp white oak acorns. This was well short of our 225 bushels goal, despite a moderately good mast crop, and no fall flooding to hamper seed collection. It appears that the demand for swamp white oak is outstripping the seed supply on all but the very best mast years.

FALL LIFTING AND GRADING

Fall lifting began on Nov. 3, 2022, with the lifting of several ‘odd’ beds by the nursery crew. These were mostly small lifts of shrubs or poor, low-density beds that are inefficient to lift with a large contract crew. By cleaning these up ahead of the contract crew’s arrival, we get a chance to make sure all equipment is in proper working order and everyone is comfortable with their job assignments. It also improves the overall efficiency of the lifting operation, allowing us to concentrate on large lifts with the contract crew, reducing the amount of time wasted hopping from one small lift to the next.

On Nov. 7, an 11-man contract crew from Champion Forestry arrived at the nursery and began lifting seedlings. Over the course of three and a half days, they lifted 700,000 trees and shrubs, before switching to grading operations. Grading operations wrapped up on Nov. 23, with a final tally of 658,000 trees graded. As is commonly the case, some species graded out to fewer seedlings than what the inventory indicated, which accounts for the discrepancy between the lift and grade numbers. This was somewhat fewer trees than we had hoped to lift and grade, but cold weather put frost in the nursery beds and did not allow for further lifting. The fall lifting and grading is still valuable in reducing the spring workload. It also allows us to get solid inventories on some species with smaller inventories and test the accuracy of other species with large inventories to make adjustments where needed.

A contracted crew follows closely behind the lifter, gently grabbing and separating seedlings as they are lifted out of the ground.

Photo credit: Becca Young-Fluur, Wisconsin DNR

TREE IMPROVEMENT PROGRAM

2022 HIGHLIGHTS

The Wisconsin Tree Improvement Program (TIP) had an active year completing required tasks to advance various priority projects. Highlights of work accomplished include:

- Grafting white spruce scion from Sawyer Creek onto spruce rootstock in the greenhouse at a much-improved success rate over previous attempts.
- Updating data sheets and field maps from four plantings to identify top trees and families, improve data access for analysis, and document trees remaining after rogueing operations.
- Marking trees and collecting OP cones from the top jack pine in each family at Hayward and Black River Falls to use as sources for the planned fourth generation progeny tests.
- Laying out and flagging the Grant County white oak progeny test site, planted in 2023.
- Collaborating with USFS personnel to conduct a canker lesion evaluation of the 2019 butternut canker trial at Bell Center.
- Collecting cones in a first-ever harvest of the 2014 red pine orchard at Hayward Nursery.
- Maintaining orchards through mowing and pruning to facilitate access for priority activities such as cone collection, and to control understory growth.

Details of these highlights are described in the following sections. For a specific summary of the tasks completed at each of the TIP orchards, see the accompanying document *2023 Work Plan Wisconsin Tree Improvement Program.*

The 3rd generation jack pine orchard at Black River Falls on June 21, 2022

Photo Credit: Stuart Seaborne, UW-Madison

JACK PINE CONE COLLECTION

A Wisconsin Jack Pine Breeding Group was formed in early 2020 to discuss what the future goals and objectives of jack pine breeding in Wisconsin should be and to determine what needed to be done to attain those goals and objectives within the limits of the resources available. The group tasked with writing a new jack pine breeding plan for Wisconsin was Joe Vande Hey (DNR - Reforestation Team Leader), Greg Edge (DNR – Silviculturist), Stuart Seaborne (UW-Madison – TIP Research Specialist), Carrie Pike (USFS – Regeneration Specialist), and Scott Rogers (USFS – Oconto River Seed Orchard Manager).

The group wanted to take advantage of our advanced generation populations, avoid inbreeding among families, and maintain a high amount of genetic diversity. The modified jack pine breeding plan will develop a base population using genotypes currently in the program. This base population will be rogued to the best performers to ultimately become a seed orchard. Progeny from this seed orchard then will be evaluated for regional performances to identify adaptability (generalists vs. specialists, northern vs. southern) as well as productivity in the families chosen.

Seed from open-pollinated cones will be used to establish the 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.

The trees at all three sites were planted in four tree row plots. The likelihood of sib-crossing between trees in the same family is greatly reduced if only one of the four family trees in each rep remains, and roguing to achieve this was completed at Hayward and Black River Falls in 2020. Cones pollinated in spring 2021 were mature in August 2022 and eligible for collection to use as part of the planned progeny tests. Care was taken not to collect any cones that would have been pollinated prior to the spring of 2021.

Height data was collected at Hayward and Black River Falls in 2020, and this data was used to select the top trees in each family. Field maps were created to update which jack pine remained after roguing at each orchard, and which trees to collect cones from. The tallest tree in each family as well as the second tallest tree in the top half of families were then marked in the field at both orchards using ribbons.

A cone harvest was conducted at Black River Falls on Aug. 18, 22 and 25, 2022. Only cones maturing in 2022 on the selected trees were collected. Tools used were hand snips, a ladder and a pole pruner to pull the branches closer for clipping off the cones. Stuart Seaborne and crews from Griffith Nursery did the harvesting. The cones from each tree were put in a separate bag that was marked with the date of collection, family number, family rank and whether the cones were serotinous or non-serotinous. These were then taken to Hayward Nursery for seed extraction.

The cone harvest at Hayward Nursery began later due to cool weather in 2022 that delayed cone ripening. The OP cones were collected on Sept. 6 and 7 by Ray Aguilera and Stan Klais into separate bags marked with collection date, family number and family rank. The extracted seed from both orchards will be put into cold storage until the program is ready to start propagating seedlings for planned progeny tests.

WHITE SPRUCE GRAFTS

Grafting more white spruce to create a new seed orchard at Hayward Nursery has been a goal of the Tree Improvement Program for several years. Prior to this year, the number of successful grafts had been disappointingly low, and attempts to improve the environment and techniques had not produced the desired results. Changes made for 2022 were to use newer and wider grafting bands to maintain adequate pressure on the graft union site and also to use parafilm tape instead of pruning sealer to prevent loss of moisture and desiccation of the graft union site.

White spruce grafted seedling at Forest Health greenhouse on May 15, 2022

Photo credit: Stuart Seaborne, UW-Madison

The results of these changes are very encouraging. Seventy-eight grafts were attempted in March 2022, and the number of successful grafts observed on June 7 was 37. Some of these have since failed, but the much higher success rate indicates that the greenhouse environment and methods used can propagate new grafted seedlings.

Grafting white spruce will happen again in 2023 with hopes to duplicate this success. The white spruce currently at Hayward were planted in July 2015. These trees were incorrectly grouped so that trees from the same clone are next to each other, which is not desired due to the higher likelihood of seed coming from crosses within the same clone. Plans are for the orchard to be redesigned, mixing individuals so that trees originating from the same clone are spread out and not planted near each other. Replanting of the current orchard using existing trees and newly grafted spruce will be done in June 2023.

WHITE OAK PROGENY TESTS

The White Oak Initiative is a group of partners including industry, nonprofit and government interested in working together to ensure the long-term sustainability of white oak. The White Oak Genetics and Tree Improvement Program (WOGTIP) led by Laura DeWald, Tree Improvement Specialist for the Department of Forestry and Natural Resources at the University of Kentucky, is partnering with this effort. She is organizing WOGTIP's acorn collection efforts, propagation of acorns into seedlings and establishment of progeny tests.

The Wisconsin DNR Reforestation Program determined that the project fit our strategic goals for forest genetics and agreed to oversee the collection of white oak (*Quercus alba*) acorns in 2021 from across the white oak range of Wisconsin and in northeastern Iowa where white

oak is native. The collected acorns were shipped to Kentucky to be propagated, and these bare-root seedlings are scheduled to be sent back to Wisconsin for planting at two progeny test sites in May 2023.

The two Wisconsin test sites are located on the DNR Munz tract in northwestern Grant County in far southwestern Wisconsin, and within the Clark County Forest west of Neillsville in the west-central part of the state. Preparing and marking each site for planting was the primary task required for 2022.

The Grant County site was an abandoned ridge top prairie. Parts of this site had already been planted to oak that are performing well. Site prep included mowing the site in July 2022, completed by Bob Roe, DNR Wildlife Technician at Boscobel. The site was allowed to regrow, and the local cooperative was contracted to complete a burn down with Glyphosate and 2, 4-D in September. The perimeter was measured and marked with flags on Oct. 20, 2022, by Stuart and Joe. On Nov. 1 and 8, Stuart and Tammy Trumm flagged the individual planting spots for all the progeny test oaks and the border trees.

The Clark County site needed heavy site prep. Twelve-year-old oak and maple regen was becoming well established after a red pine plantation was harvested in 2009. Greg Edge, DNR Silviculturist, and Joe Vande Hey identified the boundaries of the six-acre future progeny test site within the 20 acres of regen. Jeremiah Auer and Griffith Nursery staff took the lead in preparing the site. This included basal bark treatment with Garlon in August. A contractor was then brought in with a forestry mower to clear the site. All but the larger trees were removed. Clark County Forestry staff assisted with the larger trees, treating with Garlon before the trees were felled. A chipper was brought on site to chip material the forestry mower was unable to mow. Remaining material was piled out of the planting area and will be burned this winter.

2023 will see the establishment of the two new progeny tests and management of the sites by the Reforestation Team.

White oak progeny test site in Grant County was flagged for planting in early November 2022.

Photo credit: Joe Vande Hey, Wisconsin DNR

BUTTERNUT CANKER TRIAL

A five-acre butternut canker trial was planted at Bell Center in May 2019 as a collaboration between the USFS, the Hardwood Tree Improvement, and Regeneration Center at Purdue and the Wisconsin Tree Improvement Program to evaluate selections for tolerance to butternut canker in native butternut (*Juglans cinerea*) and non-native butternut varieties. 1,944 butternut trees representing 40 families plus an additional 1,056 sacrificial trees as inoculants for a total of 3,000 trees were planted.

An evaluation of the trial for butternut canker was conducted on Nov. 2 and 3, 2022. USFS personnel James Jacobs (forest pathologist), Nick Labonte (regional geneticist) and Paul Berang (retired geneticist) along with Stuart Seaborne performed the work of clearing weeds away from the tree bases and counting canker lesions on the stems and branches. This was the second evaluation of the trial, the first having been conducted in July 2021.

Nick Labonte, James Jacobs, and Stuart Seaborne conducting the butternut canker trial evaluation in November 2022

According to the data collected by James Jacobs and analyzed by Nick Labonte, the overall infection rate is rising rapidly, with true butternut families far more susceptible than the hybrid types. In 2021, the overall incidence of visible canker infection was 5%; in 2022 it was 20%. Only 2-5% of hybrids had any canker lesions at all. The true butternut had a canker present in 20-35% of trees for most families, with only four families having less than 10% of the trees infected.

The evaluation also showed that 36 trees displaying cankers in 2021 did not have any in 2022, indicating the possibility of trees healing from small infections. Trial conditions are excellent, with a survivor rate three years after planting at 98%. Another evaluation of the butternut trial is scheduled for fall of 2023.

RED PINE CONE COLLECTION

930 red pine seedlings were planted at orchard spacing on 11 acres at Hayward Nursery in 2014. The sources of these seedlings were selected trees from the seed orchards at Lake Tomahawk, Ten Mile and Avoca, all planted in 1970. For the first time, cones were collected from the Hayward red pine orchard by Stan Klais in September 2022. The total yield was 6.6 bushels of cones. This young red pine orchard is on its way to becoming a key source of improved seed to the Wilson State Nursery at Boscobel for many years to come.

Red pine cones and seed orchard at Hayward Nursery on July 7, 2022
Photo credits: Stuart Seaborne, UW-Madison

TOUR OF THE SEED ORCHARDS

Reforestation team leader Joe Vande Hey, regeneration specialist Jeremiah Auer and tree improvement specialist Stuart Seaborne travelled around the state on July 6-7 to visit as many of the tree improvement orchards as possible. The purpose was for the team to evaluate the condition of each orchard and identify future work needs. Six orchards were visited each day.

The first day started at the Mead white spruce orchard where the group met with forest health specialist Alex Feltmeyer to assess the health of the orchard and examine a small pocket of dead trees. While there was evidence of spider mites and spruce budworm, Alex assured us that the infestations were normal for a 40-year-old spruce stand and not cause for concern.

The future white oak progeny test site in Clark County was the next stop, where it was noted that the dense growth of trees would need a lot of work to clear using a Fecon and herbicide treatment. We also visited the Sawyer Creek white spruce orchard, where the trees rogued in 2021 by a feller training class were still lying in the stand like pick-up sticks. The hope is after another year or two on the ground, they will be easier to forestry mow. The site will need to be cleaned up before another harvest can occur.

The group then went to the jack pine third generation index population at Black River Falls. Overall, the orchard health looked good, and it seems to have recovered from the windthrow that occurred in the early years of establishment. This is one of the three jack pine plantings that will be used as a seed source for future progeny tests. It was determined that there were cones available to collect in August, and that the top tree in each family needed to be identified and marked in the field so it was clear which trees to collect cones from and what family they were from.

On July 7, Paul Cigan, DNR Plant Pest and Disease Specialist, met our group at Hayward Nursery to examine the jack pine and help diagnose why some of the trees had inexplicably tipped over from their base for no apparent reason. His careful observation and sample analysis determined that the cause was the pine root collar weevil (*Hylobius radicis*). To

control the pine root collar weevil and prevent further damage, the vegetation was removed from around the base of each tree. Each tree was also pruned up to allow more sunlight around the base of the tree. These steps were done to reduce the desired habitat. The base and soil out to the drip line was sprayed with permethrin in mid-August according to the pesticide label. A follow up treatment will be applied in mid-May 2023. Attention should be given to the possibility that the pine root collar weevil may be present in other pine plantings, particularly younger ones.

The Hauer Springs jack pine site was visited next. There are rogued trees there from a feller training class which need to be moved out of the orchard. The top tree remaining in each family needs to be marked for future cone collection to be used in the jack pine progeny tests.

Paul Cigan exposes the root collar of a Hayward Nursery jack pine infected with pine root collar weevil on July 7, 2022

Photo credit: Wisconsin DNR

The group also went to the Lake Tomahawk red pine and white pine orchards which have been marked for rogueing since May 2021 and need to have a contractor hired to do the work. Following up on this, Stuart and Jeremiah met with Northern Highland American Legion State Forest Team Leader Chase Christopherson, USFS Forestry Tech emeritus Ed Bauer and USFS Forestry Tech Adam Wiese on Oct. 25 to assess what other trees at this orchard complex might be included in a timber sale where this rogueing work would be completed.

DATASHEETS AND FIELD MAPS

An important function of the Tree Improvement Program is to collect and preserve height, form, and disease incidence data from each of its test plantings and orchards. This is analyzed to select which trees are to be kept for breeding purposes and as seed sources. The data needs to be organized into spreadsheets that make desired information accessible, such as which are the top performing families, or which are the tallest trees in a family, or how many individuals from any given family are still alive in a planting.

After removal of trees through rogueing or death, maps need to be updated and top performing trees indicated so they can then be located in the field as sources of cones for seed or scion wood used in grafting.

Files for the following orchards were created or updated:

- **Lake Tomahawk white pine**: new data sheets for analysis, updated field map
- **Black River Falls jack pine**: new data sheets and field maps for progeny test tree selection
- **Hayward jack pine**: new data sheets and field map for progeny test tree selection
- **Hauer Springs jack pine**: new data sheets, updated field map after 2021 rogue
- **Sawyer Creek white spruce**: new data sheets, updated field map after 2021 rogue

Creating data sheets and updating field maps to reflect ongoing changes in the plantings is an ongoing process. More files are scheduled for updating in 2023.

ORCHARDS AND TRIALS

Maintenance tasks include mowing with a tractor mounted brush-hog and the DR mower for understory control, pruning branches for improved access, and occasional herbicide spraying for understory control at specific sites. Prioritization of tasks and locations depend on other activities planned (e.g., cone and nut harvest, thinning) and urgency of understory control. Some plantings are more open (e.g., Bell Center hardwoods) or have more vigorous growth under the tree canopy (e.g., Mead white spruce). Other plantings (e.g., Black River Falls white pine, Sawyer Creek white spruce) are more closed and shaded, so the understory needs less control.

The brush-hog was used to mow the perimeters and open areas within the orchards at Black River Falls, along with Greenwood jack pine, Mead white spruce, Bell Center hardwoods and Black River Falls white pine. The DR mower performed a complete mowing within the jack pine orchard at Greenwood and twice in the Bell Center hardwoods.

Pruning was performed using long-handled loppers to remove dead branches at Black River Falls and Greenwood jack pine orchards for better access for the DR mower and future cone harvests. The younger butternut trial at Bell Center was pruned to remove lower branches and to shape the young butternut into a more tree-like form.

Bell Center butternut trial before side-branch pruning in November 2022

Photo credit: Stuart Seaborne, UW-Madison

2023 WORK PLAN CALENDAR

Most of the tasks listed below will be accomplished in coordination with other members of the reforestation program. A detailed report of accomplishments in 2022 and work planned for 2023 can be found in the *2023 Tree Improvement Program Work Plan,* which accompanies this annual report.

Winter

- Prune Bell Center butternut canker trial trees (January - February)
- Write *2022 TIP Annual Report* and *2023 TIP Work Plan* (January - February)
- Update data sheets and maps for various orchard files (February - March)
- Collect scion from white spruce at Sawyer Creek, graft in greenhouse (February - March)
- Solicit bids for deer fence at Grant County white oak progeny test (February)
- Clear understory around Mirror Lake swamp white oak (March)
- Remove old butternut trial at Bell Center

Spring

- Clear downed jack pine trees at Hauer Springs (April)
- Remove dead lower branches at Black River Falls white pine (April)
- Plant Grant County and Clark County white oak progeny tests (May)
- Mow around red pine and white pine at Lake Tomahawk (May)
- Replant Hayward white spruce seed orchard along with newer grafted seedlings (May)

Summer

- Mow Bell Center black walnut, butternut and red oak (June)
- Control understory at Ten Mile red pine and jack pine (June - July)
- Clear downed white spruce at Sawyer Creek (June - July)
- Mow with tractor at Mead white spruce (July)
- Cone collection from jack pine progeny test source trees at Hayward, BRF, Hauer Springs (August - September)
- Other possible cone collections: Greenwood jack pine, Hayward red pine, white spruce (August - September)

Fall

- Tractor mowing at Bell Center, Black River Falls, Sawyer Creek, Mead (September - November)
- Mow Bell Center black walnut, butternut and read oak (September)
- Collect acorns and walnuts at Bell Center hardwood seed orchard (September)
- Grinding of remaining limbs and brush at Sawyer Creek white spruce and Lake Tomahawk red and white pine (October - November)

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WISCONSIN DEPT. OF NATURAL RESOURCES

THE UNIVERSITY of WISCONSIN MADISON