Wisconsin's Reforestation Programs
2015 Annual Report

Wisconsin Department of Natural Resources
Reforestation Program

and

University of Wisconsin-Madison
Department of Forest and Wildlife Ecology

THE UNIVERSITY of WISCONSIN MADISON

WISCONSIN STATE NURSERY PROGRAM

WISCONSIN DEPT. OF NATURAL RESOURCES

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Introduction

The Wisconsin Department of Natural Resources' (WDNR) reforestation effort is comprised of three parts within the Reforestation Program:

1) The Tree Improvement Program (TIP) is a WDNR collaboration with the UW-Madison Department of Forest and Wildlife Ecology which works to ensure WDNR tree seedlings are well adapted to Wisconsin growing conditions and have a high potential for survival and growth;

2) The State Nursery (formerly the State Forest Nursery Program) produces and ships native forest tree seedlings for reforestation projects to customers throughout Wisconsin, and sells seed to private nursery stock producers for use in Wisconsin;

3) The Reforestation Monitoring Program monitors reforestation plantings to assess seedling survival, growth, and long-term health and productivity.

Historical Overview of the Tree Improvement Program

The Wisconsin Forest Tree Improvement Program, with the long-term support of the state forest nurseries, develops and manages tree seed orchards using selection of superior seed sources, parents and families, breeding, and subsequent progeny and family testing. Tree seed orchards are the principal technology used to produce genetically improved seed in quantities large enough to support nursery production programs. They also provide for a broad genetic base that conserves the native diversity of Wisconsin's forests during reforestation. This program works to ensure that improved genetics practices contribute to state reforestation efforts.

Seed orchards typically start as evaluations of selected forest tree seedlings from Wisconsin and the surrounding Lake States. The planting, often termed a 'family test', or 'progeny test', is spaced closely to fully occupy a site, and to allow for evaluation of many trees under relatively uniform conditions. As data is collected and superior families and individuals identified, these tests are thinned to remove the less productive trees while retaining the top performers, allowing the remaining trees ample space to become productive seed producers. The principal criterion for selection is potential productivity as measured by height and diameter, but trees may also be selected for tree form, disease tolerance/resistance, and adaptability. The thinned plantings are then managed as seed orchards to produce improved seed for that species.

There are currently 1st and 2nd generation progeny tests and/or seed orchards established for jack pine (*Pinus banksiana*), red pine (*Pinus resinosa*), white pine (*Pinus strobus*), and white spruce (*Picea glauca*). Two 3rd generation seed orchards also have been established for jack pine. Additionally, there are grafted selections of butternut *(Juglans cinerea*), in a

'clone bank' reserved as a source of future seed (and seed orchards) for these valuable hardwoods.

New generations of improved trees are drawn from progeny arrays following crosses among selected parents identified in previous generations. The resulting progeny combine the best traits (and presumably, genes) of these top performing trees. A variety of mating designs are used in the Wisconsin program depending upon the biological and reproductive attributes of the species, the ease (or difficulty) of pollen collection, and the degree of genetic identity required in subsequent generations.

Relative to agronomic crops, progress in selective breeding of forest trees is a slow process. When planning for a new generation of improved trees, several years at a minimum are needed to evaluate and select parent trees, pollinate, harvest seed, grow seedlings, and transplant the seedlings to the final test location. Typically, these young orchards do not even start to produce useful amounts of seed for at least 10 years (jack pine), or more commonly 15-20 years with other species. During this time, the plantings must be maintained, measured, thinned, pruned, and protected. Problems such as deer browse, buck rubbing, rodent girdling, insect feeding, and disease infestation may need to be addressed. Significant resources and labor are invested in a planting before the first seed is produced. The orchards then need proper and timely management to remain productive and accessible. Good yields of seed do not happen every year, and it can be several years between significant cone or nut harvest cycles. Good seed orchards require careful planning, consistent management, and patience to be successful.

Seed orchards can also be started by grafting scions (cuttings) from select trees identified in plantings already in existence, or from selections of phenotypically superior trees from other sources. These grafted trees can then ultimately be used as a source of improved seed based on the observed attributes of the mother tree.

Figure 1: Grafted white spruce seedling at Hayward Nursery

Current Status of the Wisconsin Tree Improvement Program

More than 200 acres of various genetics test plantings have been established and managed since 1965, with 125 acres of seed orchards actively managed today. These are divided among the four conifer species included in the program, plus 6 acres of hardwoods located at Bell Center. Active seed orchards are discussed later in this report. Management tasks vary greatly from one planting to another depending on age, site conditions, and current use. Among these tasks is removing understory vegetation, monitoring flowering to anticipate the timing of cone harvests, data collection on growth and performance, thinning, and harvesting mature trees for final cone collection.

The seed orchards and progeny test plantings are widely scattered throughout Wisconsin, so organizing equipment and personnel at the various sites can be logistically challenging. The DNR and the TIP coordinate how and with what resources this work gets accomplished.

At the annual meeting of the TIP leadership group in January of 2016, the status and needs of all actively managed orchards were reviewed. A work plan for accomplishing required management was prepared outlining the goals for 2016, including the tasks for which DNR assistance is needed.

2015 Tree Improvement Program Highlights

The Tree Improvement Research Specialist position is housed at the Department of Forest and Wildlife Ecology at the University of Wisconsin-Madison. This specialist manages the day-to-day activities of the program in collaboration with DNR reforestation managers. David Stevens, TIP Specialist since 2003, resigned in spring of 2015 for a position with the UW-Madison Arboretum. Stuart Seaborne was hired on July 1, 2015, as the new TIP Specialist. A significant part of the work this past year was devoted to orientation and the learning necessary to complete this transition.

Field Tasks Accomplished in 2015

Jack Pine

- Cones were harvested in August at the Ten Mile II seed orchard with DNR crew from Griffith Nursery. Top branches of the most productive trees were cut off so that thirteen bushels of cones could be harvested from the ground.
- An effort to remove the dense understory of tree seedlings and brush at Ten Mile II has been started

Red Pine

- The dense understory beneath the red pine seed orchard at Ten Mile II was bush-hogged in preparation for a future cone harvest and possible termination of the orchard. Many understory trees were 10’-15’ tall.

White Pine

- Developed thinning maps for Lake Tomahawk white pine progeny test.
- Marked 13 acres of trees at Lake Tomahawk to selectively remove approximately 40% of the trees in this planting. DNR crew from Griffith Nursery assisted.

White Spruce

- David Stevens had grafted scions from elite white spruce onto seedling rootstocks at the Nevin Greenhouse in Fitchburg in preparation for planting at Hayward Nursery. Stuart Seaborne assisted Hayward staff with transplanting 68 surviving grafted seedlings and then mapped the planting.

Black Walnut, Butternut, and Red Oak (hardwoods)

- A number of black walnut grafts completed in early 2015 by David Stevens were transplanted at Bell Center during April.
- The Bell Center site containing numerous oak, black walnut, and butternut grafts was mowed in November.

Greenhouse

- White spruce, white pine, and black walnut rootstock were dug with Wilson Nursery staff for winter grafting activities at the Nevin Greenhouse.

Other Tasks Accomplished

- Conducted an overall assessment of the needs and status of all the active or recently inactive seed orchards and progeny tests.
- Documented this assessment with photos, together with breeding and source information, in a PowerPoint presentation to DNR leadership team.
- Met with USFS genetics staff in Rhinelander and Oconto River to discuss program collaboration and gather background information on their white pine, jack pine, and white spruce programs.
- Wrote the TIP Spring/Summer Work Planning Agenda for 2016

Status of Active Genetics Plantings (by species)

Jack Pine (*Pinus banksiana*)

Given the large stores of genetic variation for numerous traits, including growth rate, stem form, and wood specific gravity, opportunities for genetic improvement with jack pine are excellent. In addition, jack pine flowers at an early age, produces regular cone crops, and is adapted to a wide range of sites.

- Hancock (Waushara County) – Planted in 1979 on 5 acre sites as a 1st generation 'index population', this planting is nearing the end of its useful life. It is scheduled to be harvested and the cones collected during the next heavy cone crop.
- Ten Mile II (Wood County) – This was planted in 1996 on about 5 acres as a second generation 'index population' using seed from crosses made at Hancock (1st generation population). It has been 'rogued' to seed orchard density. Cones were harvested in 2015 by cutting off 1-2 top branches for cone collection.
- Ten Mile III (Wood County) – This orchard was planted on 1.5 acres in 1999 as a 2nd generation 'breeding population' using seed from crosses made in the (now defunct) Ten Mile I population. It was thinned to seed orchard spacing in 2013, leaving only superior selections from each family. Cones were harvested here in 2014 by pollarding some remaining trees and removing the upper 1/3 of each tree's crown. Flower production is thereby forced lower in the crown and future cones are easier to collect.
- Greenwood (Waushara County) – Planted in 1997 on 4.5 acres, this 2nd generation seed orchard was created using seed from single parent crosses from four 1st generation breeding populations (Ten Mile I, Monico, Ashland, Bean Brook).
- Black River Falls (Jackson County) – This was planted on 5 acres in 2011 as a 3rd generation 'index population' using seed from crosses among the best trees identified in the Hancock and Ten Mile II 'index populations'.
- Hayward Nursery (Sawyer County) – 960 trees were planted on 1.7 acres in 2014 to create this 3rd generation 'breeding population'. Crosses among superior parent trees in the Ten Mile III 'breeding population' provided the seed for this future seed orchard.

Figure 2: Greenwood jack pine 2nd generation seed orchard

Red Pine (*Pinus resinosa*)

Historically, red pine has been the primary conifer used for reforestation purposes in the north-central United States. Although it has a reputation for poor natural regeneration, its ease of planting, excellent form, and high productivity on pine sites has long made it a preferred reforestation species.

From a genetic standpoint, red pine is an anomaly among pines in possessing comparatively little genetic variation. Results from provenance studies demonstrate that small, though significant, differences in growth rate can be detected among red pine seed sources, but the range of genetic variation observed is much less than that found in other pines.

A red pine tree improvement program was begun in Wisconsin in 1965. The basic justification for the program was that even small genetic gains, when applied through large reforestation programs, can have substantial cumulative benefits.

- Avoca (Iowa County), Lake Tomahawk (Oneida County), Ten Mile (Wood County) – Three 15-acre seed orchards were planted, one at each of these sites, in 1970 using open-pollinated seed collected from 310 selected trees located throughout Wisconsin. These orchards were thinned in 1980 and again between 2004 and 2006 to retain the tallest families and best-formed trees for seed production. Now 44 years old, they are starting to decline, requiring the creation of 2nd generation orchards to provide a red pine seed source into the future. These sites were located in a north, a central, and a southern location in the event that Wisconsin might be divided into separate seed zones, providing seed suitable for each zone. Current information indicates that this is unnecessary and that Wisconsin can be considered one seed zone for red pine. Given the greatly reduced demand for red pine seedlings in recent years, a decision was made to create a single 2nd generation seed orchard composed of progeny from the best selections present in all three existing orchards.
- Hayward Nursery (Sawyer County) – Open-pollinated seed from the best 185 families in the three older red pine orchards (above) were sown in the Nevin Greenhouse at the WDNR South Central Region headquarters during the winter of 2013. Of these, 155 families produced sufficient seedlings to be included in this new planting. In July of 2014, 930 trees (6 trees/family) were transplanted at a wide spacing at an 11 acre site at the Hayward Nursery. This Hayward Nursery orchard will be the future seed source of select red pine once the three original orchards described above are 'retired'.

Eastern White Pine (*Pinus strobus*)

Currently, there are three white pine seed orchards totaling 37 acres under active management. The oldest one (Sawyer Creek) was established in 1983 using clones of 20 selections that showed putative resistance to white pine blister rust in USFS screenings. The two younger seed orchards were established in 2002 and 2003 and contain open-pollinated families drawn from across northern Wisconsin, northeastern Minnesota, and the Upper Peninsula of Michigan. They were chosen for superior growth characteristics, tree form, and to provide a representative sample of white pine germ plasm from native sources. The short-term benefit of this research will be the identification of superior white pine seed sources appropriate for use in Wisconsin reforestation efforts. The long-term goal is the development of two seed orchards for future seed production, together with genetic resource conservation of Lake States white pine.

- Sawyer Creek (Washburn County) – This is a clonal seed orchard started in 1983 on 12 acres using materials provided by the Forest Service. The original planting has been thinned to seed orchard density. Two progeny tests using open pollinated seed from the original planting were established between 1994 and 1999. Results from the progeny tests for blister rust resistance are considered inconclusive because of issues with methodology (non-replicated, non-randomized, uneven sample sizes and ages), and because the seeds were open pollinated and probably received some pollen from surrounding native white pine.
- Black River Falls (Jackson County) – Established in 2003 on 10 acres, this planting consists of 240 families grown from seed collected within natural populations throughout Wisconsin, northern Minnesota, and the Upper Peninsula of Michigan. A broad range of genetic variation was sampled in the expectation that it would be adapted to northern Wisconsin conditions. Based on height data from 2008, a 67% difference in average height was observed between the tallest and shortest families. Of the 8000 trees originally planted, some 4800 were 'rogued' by TIP staff during 2013 and 2014. The slash remaining from this thinning operation is scheduled for burning in early 2016.
- Lake Tomahawk (Oneida County) – Planted in 2002 on 15 acres, this is a companion planting to the one at Black River Falls. These white pine originated from seed 0f 256 families collected from the same natural populations as were propagated at Black River Falls. This planting was marked for thinning in the fall of 2015 by TIP and DNR staff, and removal of trees is scheduled as soon as the appropriate equipment is made available, hopefully in early 2016.

White Spruce (*Picea glauca*)

Three mature white spruce seed orchards (converted from family tests) and one small clonal planting are currently managed by TIP staff. Harvest of some trees within the mature orchards is awaits a good cone year, but cones were mostly absent in these plantings in 2015. Collecting cones will involve felling some large trees so that cones can be harvested form the ground, as using a lift truck is inefficient and costly. TIP will monitor flowering in the spring of 2016 so that we can prepare to harvest if some trees have a good cone crop.

- Lake Tomahawk (Oneida County) – Planted in 1969, this is a 6-acre test of 92 families selected by the USFS from the Lake States and Ottawa Valley region of Ontario. The planting was 'rogued' to the best 25% of families in 1987, and was evaluated by USFS staff (Forest Sciences Lab at Rhinelander) in 2004 using a volume index devised by USFS scientists. Future cone harvests will involve felling mature trees and collecting cones from the tops. The understory is scheduled for mowing in 2016.
- Mead Wildlife Area (Marathon County) – Established in 1982, this is another test of families selected by the USFS. The orchard was thinned in 2004 and again in 2007, and was marked for additional thinning in 2010. Trees are mature, and cone collection will involve felling trees and harvesting cones from cut tops. The understory is scheduled for mowing in 2016.
- Sawyer Creek (Washburn County) – This is another progeny test of Lake States and Ottawa Valley white spruce established by the USFS in 1989 on 10 acres. It was last thinned in 2008. The understory is scheduled for mowing in 2016.
- Hayward Nursery (Sawyer County) – Recognizing that new seed orchards needed to be established to replace aging ones, a clonal seed orchard was initiated in 2015 at the Hayward Nursery. Scions from top performing trees at the Sawyer Creek seed orchard were grafted onto seedling rootstocks by David Stevens. Seventy grafts were then transplanted in July, 2015, by TIP and Hayward staff. Spruce is notoriously difficult to graft, and the new planting will be monitored for growth and grafting success.

Black Walnut (*Juglans nigra*), Butternut (*Juglans cinerea*), and Red Oak (*Quercus rubra*)

Wisconsin is on the northern edge of black walnut's natural range, and its distribution has been historically limited to the southwestern one-third of the state. However, it remains a species of great importance to some landowners and the forest products industry in southern Wisconsin. Research indicates that trees sourced from locations south of the planting site have a growth advantage, but are more likely to suffer winter injury if moved too far north. Therefore, our limited program is focused on selecting superior quality trees in natural stands from Wisconsin and northern Illinois.

Butternut, a close relative to black walnut, is a native tree found throughout the state except for the northernmost counties. It is prized for its quality lumber, as well as its nuts for both wildlife and human consumption. There has been a marked decline of the species since the exotic butternut canker disease (*Ophiognomonia clavigignenti-juglandacearum)* was first reported here in 1967. Trees infected with the fungus develop branch and stem cankers that eventually girdle and kill the tree. The Tree Improvement Program has partnered with the USFS to establish a butternut genetic conservation project. Scions from putatively resistant trees are grafted onto black walnut rootstock that is resistant to the canker disease, eliminating possible infection of the graft from the rootstock. Successful grafts are then used to build a clone bank for future seed and clone production.

Grafted red oak was planted at Bell Center from 2004-07. Parent trees were selected from within superior populations and were deemed above average from a forestry standpoint – straight trunk, defect free, large DBH, height to first fork (i.e. number of 8' logs). No new grafts are currently being made owing to high potential for graft incompatibilities, according to information received from Mark Coggeshall, assistant research professor in the Forestry Department at the University of Missouri.

- Bell Center (Crawford County) – Started in 2004, this hardwood 'clone bank' now contains approximately 5 acres of grafted red oak and black walnut, with an additional 1 acre of butternut from selected seed. The trees are in various stages of development, and the younger trees (especially) require regular mowing. Deer damage is a major problem here. A plastic fence installed to keep out the deer has been ripped in numerous spots and needs to be replaced. The process for obtaining bids and getting approval for a new, more durable fence will proceed in 2016.
- Hayward Nursery (Sawyer County) – Sixty-six butternut scions from trees identified by USFS staff were grafted onto black walnut rootstock and planted in spring of 2013. These trees are better protected at the Hayward Nursery and are able to be watered as necessary. An evaluation will be completed in 2016 to identify those trees where the grafted scion has died and only the rootstock remains.

Figure 3: Bell Center hardwood clone bank and seedling orchard

Reforestation Monitoring

Introduction

Over the past 8 years, the Division of Forestry's Reforestation staff has examined a sample of the artificially regenerated forest plantations during their 1st year of planting, and subsequently revisited a portion of these sites again after their 3rd and 7th growing season. The sites include both publicly and privately owned sites, large and small acreage, and with a single species or a mixture of species. This monitoring allowed for interaction with hundreds of landowners and land managers beyond the early spring telephone conversation, and facilitated a statistically valid assessment of the successes and failures of tree planting throughout the state of Wisconsin. The reforestation team gathered data about the landowners, planting sites and conditions, and individual seedlings and their growth in a portion of each plantation visited. This collected data was entered into a database and analyzed with the help of our partners in the Bureau of Science Services.

Their task was to answer a number of hypotheses proposed by reforestation staff (see Appendix A: Reforestation Monitoring Hypotheses and Results). After analysis, it was determined that the data could answer 16 of the 18 proposed questions. However, it was also apparent that while the initial reason for the data collection was to determine the challenges landowners were facing in establishing a tree plantation and how to mitigate those challenges, there was a slight mismatch between the data collected and the answers we sought. We were, however, able to make some broad statements:

1. A vast majority of landowners follow the nursery's advice as it pertains to caring for the seedlings prior to planting. They receive the seedlings as early as possible following lifting, plant them relatively soon after pick-up, keep them in ideal conditions prior to planting, and, barring any catastrophic climatic conditions, are rewarded with a relatively well-stocked stand of seedlings after the initial growing season (>80% survival).

2. While initial success was higher than expected, subsequent years did not yield as much seedling development as expected. At years 3 and especially 7, many of the seedlings had not grown enough to be considered free from competition or herbivory and, therefore, take full advantage of the site.

3. Many of the challenges we believed would impact success proved to be not as important to seedling development, or the data were collected in a manner not conducive to answering some hypotheses.

As a result of this analysis, the Reforestation team, in conjunction with members of the Bureau of Science Services, adjusted the previous protocol and decided to further evaluate our efforts. We are now collecting data that continues to track plantations (and landowners), as well as tailoring reforestation studies to get answers to specific questions. A pilot program was initiated this past field season where we established fixed plots that can be used to monitor specific nursery stock over several years. These fixed plots will allow us to more closely follow seedlings and their development.

As the Reforestation Program has settled into its new organizational structure, the previously adhered to boundaries between geographic distribution areas have been eliminated. The state now is viewed as a whole, rather than broken into areas for each assistant manager to concentrate his/her efforts. The regeneration specialist is directing a team of limited term employees (LTEs) as they visit plantations throughout the state. In 2015, we hired two new LTEs, Michael Ard and Alexander Anderson, to travel the state and implement the new protocol. As the season progressed, we tweaked the protocol to make it more efficient and effective. The structure of the protocol, however, is sound.

Weather Conditions

Planting and growing conditions were uniform statewide in 2015. The season started normally, cool and wet in late March/early April, giving way to moderately dry conditions in May. The summer provided adequate precipitation throughout the state, coupled with widespread warm conditions. A narrow band extending from southwestern Wisconsin, northeast to Green Bay experienced moderately dry conditions, but overall seedlings had good conditions for their first growing season. The autumn brought more warm temperatures with adequate precipitation. Most of the new seedlings should enter winter in very good condition.

Landowners

As in years past, the majority of seedlings ordered are planted on public property - state forests/lands and county forests. However, private landowners always prove to be interested in our work, open to discussing and exhibiting their plantations, and asking to be included in the site visit. These requests are accommodated to the best of our ability.

Site Selection

Historically, we selected any site for monitoring that met our criteria of greater than 3000 seedlings covering approximately 3 acres of property. With the new protocol, we decided to narrow these criteria, including only those sites that were intended to be established as ‘forest’. Other goals, including wildlife habitat and erosion mitigation plantings, could be included, but the management techniques had to be similar to those employed in establishing a forest. This required a more in depth interview during our initial landowner

contact. However, even with this added scrutiny, on more than a few occasions we interviewed landowners and visited their properties only to find out the site did not meet our criteria. In such cases, we continued on with the landowner, offering advice and viewing the planting, but did not record any data. As in the past, we continue to install plots on both public and private properties.

Plot Installation 2015

During this inaugural year of the new assessment protocol, we were unsure of what to expect with regard to production. Establishing permanent, 1/50th acre plots, marking individual trees and drawing detailed site maps required more time and effort than our previous experiences. With that in mind, we viewed this 2015 season as experimental. During the course of the field season, our team of LTEs visited 34 sites representing 29 different ownerships having plantings just beginning their first season of growth (Year 0). Of these sites, 19 were located on public lands and 15 were on private property. After training in mid-May, our pair of LTEs established plots in a number of counties (Adams-2, Burnett-3, Clark-1, Columbia-1, Douglas-3, Florence-3, Fond du Lac-1, Grant-2, Jackson-2, Juneau-2, Marinette-1, Monroe-3, Oconto-1, Portage-2, Sauk-2, Shawano-1, Rock-1, Vilas-2, and Waupaca-1). We experimented with ways to mark the site and seedlings, and settled on wooden corner posts and flagging for the plots and bright blue and pink plastic 'whiskers' held in place by nails for the individual trees. We hope to revisit some of these sites during the next growing season to determine the effectiveness of the markers.

Finally, at the end of the field season, we re-measured 5 sites previously visited in 2009 and 2011 (Door- 1, Jackson-1, Manitowoc-1, and Waupaca-2). The LTEs did not install any post or tree markers on these sites, as we don't plan to return. However, it is we may reconsider this policy in the future, depending on how the recently established 3 year sites develop during the next 4 growing seasons.

Data Analysis

Data analysis confirmed the anecdotal evidence we received as we walked plantations statewide. Overall, we recorded data on 3197 seedlings. About 90% of all seedlings planted were living or slightly damaged. A majority, 87%, of seedlings were planted correctly. Moderate to heavy deer browse only impacted 3% of the seedlings (a total of 90 seedlings, half of which were oak seedlings). Overall, the 2015 seedlings are doing very well, and the limited deer herbivory, proper planting, and favorable climatic conditions allowed them to enter the winter in relatively good health.

It is difficult to compare results from the 3rd and 7th year sites measured under the previous protocol with results from the data collected with the current protocol. However, we can make a few general observations:

- 3rd Year: These sites were mostly scattered in central and eastern Wisconsin. Growing conditions were quite favorable during the establishment year of 2013. Data was collected at 23 sites, representing 16 unique ownerships. Of those, 15 were found on public land and 8 on private. The majority of the species observed were pine (jack pine: 595 seedlings, white pine: 283 seedlings, and red pine: 182 seedlings). Of these, 42% are greater than 3' tall, a very good indicator that the seedlings are well-established and free to grow. However, 10% are less than 1' tall, suggesting that they have suffered a considerable amount of damage, very little of which appeared to result from deer browse (~1%). It will be interesting to follow these sites into their 7th growing season.
- 7th Year: These sites were in central to eastern Wisconsin. Growing conditions were quite favorable during the past seven years, aside from a few dry spells. The seedlings reacted accordingly. The jack pine is doing very well, with no sign of browse and all seedlings measured at greater than 5' in height. The same can be said for red and white pine, with very little browse pressure and the vast majority of trees being greater than 5' tall. Other minor conifers seem to be growing, albeit a bit slower than the pine.
- Some deer browse is affecting the white cedar. Only 21 hardwood or shrub seedlings were measured; the majority (13) were swamp white oak. This oak seems to be growing well, with a third affected by light deer browse. Just under half of the seedlings are greater than 5', typically considered above the browse line of white tailed deer. Overall, the 7th year seedlings seem to have captured their respective sites. We hope to measure more 7th year sites in the future, especially as the new protocol is established.

Future Considerations

The modifications made to the reforestation monitoring protocols may need some more tweaking to make them more efficient, effective and meaningful, but there is no doubt that this new format will yield data more amenable to analysis. The Reforestation Program anticipates at least one more year of 'trials' to ensure the protocol is appropriate.

Conclusions

The Reforestation Monitoring operations have undergone much change in the past few years. Now, with a new staffing structure, a reinvigorated focus and a mandate to assist landowners and land managers with their reforestation needs, we look to the future with confidence and a sense of mission.

2015 Nursery Operation Highlights

Program changes have not impacted the nursery vision to insure a consistent supply of high quality seedlings of desirable species at an economical price to encourage reforestation in Wisconsin. The Nursery Operation works very closely with the Reforestation Program to address the challenges of reforestation, including natural regeneration.

Declining sales in recent years has led to the program consolidating the seedling production from three seedling producing nurseries down to one. Hayward Nursery houses the conifer seed extraction equipment, a seed storage cooler, and an assortment of experimental trials and seed orchards. It is also used as a hub for distribution of seedlings to northern landowners during the spring. Griffith Nursery in Wisconsin Rapids is still growing its remaining stock, but has not sown new seedbeds since 2014. The last of its inventory will be liquidated in the spring of 2017. It also remains a distribution hub for central Wisconsin. All 2015 seeding took place at Wilson Nursery, in Boscobel.

Griffith Nursery Highlights

The year 2015 ushered in one of the earliest starts for spring lifting at Griffith Nursery, with a small crew lifting trees beginning on March 25. Finding enough laborers to fill both a lifting and grading crew proved to be a problem, until the arrival of a contract lifting crew on April 7. With the nursery providing tractor drivers and other logistical support, this contract crew made three trips to the nursery, lifting trees for a total of five days. In that time, they were able to lift 1.7 million trees, and even spent part of a day helping on the grade belt. Overall, Griffith lifted 2.5 million trees for the spring, and graded about 1.7 million of those.

Fall saw the return of the contract crew, this time to fall-lift stock for spring 2016 distribution. The staff from Wilson and Hayward nurseries travelled to Griffith on November 3 to help lift stock. A scheduling mistake left us without a contract lifting crew, but we pushed on with three workers from Wilson, three from Griffith, and one from Hayward. Since most of the crew had substantial travel time invested already, we lifted anyway, and got many of the shrubs and other small lifts done. We even found time to grade several species. When our contract lifting crew finally arrived on November 4, we dove into some of the larger lifts, and in addition to our earlier lifting, managed to get 375,000 trees dug and prepped for winter storage in Wilson Nursery's coolers.

Wilson Nursery Highlights

The year 2015 was a busy one for Wilson Nursery. Lifting started on March 24, and continued until April 24. Overall, the entire period was great lifting weather, with only a couple days lost to conditions that were below freezing or too hot and windy to lift. Wilson lifted 2.2 million trees for the season. Of that, nearly nine hundred thousand were lifted in 2-½ whirlwind days with the same contract lifting crew that helped with spring lifting at Griffith Nursery. With the trend of decreasing use of bulk stock, we found ourselves with the daunting task of needing to grade 2.1 million of the 2.2 million trees we dug. With the help of grading crews from the Wisconsin Secure Program Facility (WSPF) prison across the highway from the nursery, we were able to finish our grading. We even graded a little extra to help Griffith through a tight spot in their schedule. Wilson's total grade for the year was 2.36 million. Of that, the WSPF crew graded seven hundred thousand.

The year 2015 provided a fairly routine summer at Wilson Nursery, despite some shakeup in the management of the nursery. Nursery manager Joe VandeHey took over as the Reforestation Program supervisor, leaving most of the day-to-day operations management to assistant manager, Roger Bohringer.

Despite a few missed herbicide applications, and a threatening *Diplodia* outbreak, the growing season went well. Frequent fungicide applications kept the *Diplodia* outbreak in check, and rigorous testing of the red pine seedlings this fall by the Forest Health team proved that it was a lot of lost sleep over nothing. Testing for asymptomatic infection showed *Diplodia* levels well below management thresholds.

September and October saw Wilson Nursery planting for the entire statewide seedling needs. Ten acres were prepped for planting, with a total target of 5.2 million seedlings available for distribution over the next 3 years. Most of this seed was planted in the fall, but some will be spring seeded immediately after the 2016 distribution season.

While most of the fall lifting was done at Griffith Nursery, November did bring one day of fall lifting at Wilson Nursery as well. The nursery's regular seasonal crew spent their last day digging a variety of wildlife shrubs, allowing us to fall grade them and get a more accurate inventory to sell from. These shrubs, along with the 375,000 trees fall-lifted at Griffith Nursery, were graded by the WSPF crew and packed for winter cold storage in one of Wilson Nursery's coolers.

Hayward Nursery Highlights

The Hayward Nursery staff was busy with a variety of projects in 2015. In addition to the normal work load of collecting, processing, cleaning and storing conifer and hardwood seed, the staff also maintained the new red pine seed orchard, planted and maintained white spruce grafted seedlings, assisted in planting and monitoring a shrub study in conjunction with UW-Superior, and inventoried the seed in our storage facility.

Much of 2015 was spent cleaning the 2014 jack pine and balsam fir cone crops. 25 bushels of balsam fir cones yielded 88 pounds of clean seed, while 1716 bushels of jack pine cones yielded 418 pounds of clean seed. The Reforestation Program purchased over 600 bushels of jack pine cones from private collectors in 2015. Over the past number of years, the network of cone suppliers has remained strong, due in no small part to the relationships created by staff.

Hayward Nursery distributed nearly 300,000 seedlings to 80 customers. Staff also packaged and distributed almost 195 lbs. of tree and shrub seed for sale to private landowners, public land managers, and other private or public nurseries and researchers.

A thorough inventory of all stored seed was performed in 2015, and records were brought up to date. This included the time consuming task of running new germination tests for each stored seed lot.

The red pine seed orchard was laid out in late spring by Reforestation program leader, Joe VandeHey. The seed to produce the red pine came from a selected seed source. The seedlings were originally grown in the Forest Health greenhouse. Rey Aguilar and Stan Klais meticulously planted, irrigated, maintained and inspected each seedling on the 15' x 30' offset grid. This diligence paid off as only 2 out of the 954 seedlings didn't survive. These seedlings will eventually develop into a source of red pine seed for the nurseries to utilize.

White spruce grafts were created using material from our improved seed orchard near Sawyer Creek. Scion wood was collected from the tops of the best spruce, and then grafted onto rootstock lifted from the Wilson Nursery seedling beds. The grafts were planted on 15' x 30' offset spacing, with a total of 70 trees planted. Former UW Tree Improvement Specialist, David Stevens, fastidiously pieced together the notoriously finicky spruce grafts to create a new orchard filled with only the best selections of white spruce. Eventually, these spruce will be measured, analyzed, and their offspring used to grow more improved white spruce seedlings for Wisconsin landowners.

The Division of Forestry's Reforestation program entered into an agreement with the Division of Lands staff to grow prairie grasses for establishing grasslands on state owned property in Wisconsin. Staff periodically sprays herbicides to control broadleaf weeds.

Staff assisted UW-Superior staff in planting 900 more selected American hazel and American highbush cranberry seedlings. These plants are being tested for cold hardiness.

Staff also harvested 30 bushels of winter rye seed from 8.5 acres for nursery cover crop use.