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NRRI TECHNICAL REPORT

INTELLECTUAL PROPERTY IN THE NRRI HYBRID POPLAR PROGRAM – INVENTORY, COMMERCIALIZATION PLAN, AND PROGRESS REPORT

Submitted by:

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Abstract

Intellectual property in the NRRI hybrid poplar program was analyzed, and elite clones were prioritized for plant patent applications to the USPTO. Clones were selected in two hybrid categories, *Populus deltoides x Populus nigra* (D x N, DN) and *Populus deltoides x Populus deltoides* (D x D, DD). Positive traits attributed to these clones include fast and stable growth, broad adaptability (geo-robustness), disease resistance, good rooting ability, good vigor in stoolbeds (cutting orchards), and good performance in phytoremediation applications. Six Generation 1.0 improved clones were selected for possible patenting, four DN and two DD, out of 13,000 1st generation genotypes tested, a selection intensity of 0.0005 (0.05 %). Market size is discussed, a patent strategy is formulated, and a commercialization action plan and timeline compiled. We are working with University of Minnesota Technology Commercialization (TC) on a patenting and licensing evaluation. One improved DN clone has been selected for initial commercialization, a one-page marketing flyer on the clone has been designed, and selected private and public nurseries are being offered free cuttings of the selected clone for propagation testing as a prelude to potential licensing.

Brief history of NRRI hybrid poplar breeding program

The NRRI Hybrid Poplar Program has selected and bred poplar (*Populus*) families and clones and planted field tests annually in Minnesota and other areas of the USA for all but two years since 1996. We select for improved growth and for disease resistance. The main disease concern in our program is cankering caused by S*phaerulina musiva,* formerly known as *Septoria musiva*. Our first generation (Gen 1.0) improved clones exhibit up to a 70 percent increase in volume growth over commercially available genotypes (Nelson et al., 2018; Nelson, Berguson et al., 2019; Nelson, Meilan et al., 2019). The overall genetic strategy for our poplar genetic tree improvement program is described in Berguson et al. (2017).

NRRI's hybrid poplar breeding program began in 1996. We field tested different types of poplar intra- and inter-specific hybrids in our early tests (1996–2005), but since 2006 have focused on *Populus deltoides x Populus nigra* inter-specific hybrids (for commercially-deployable clones) and *Populus deltoides x Populus deltoides* intra-specific hybrids (for parent population improvement objectives) as having the best adaptability and other traits for the Midwest U.S. region.

Even though the selection, breeding, and testing process for hybrid poplars is shorter than for most other tree species due to poplars' fast growth and amenability to cloning (asexual vegetative propagation or reproduction), 20 or more years are still required for one generation of genetic improvement. The multi-step NRRI hybrid poplar improvement system, a sequential test process (Libby, 1987), is diagrammed in Figure 1. We are currently at Generation 1.5 (Gen 1.5) in our breeding program; i.e., we have completed Family Field Trials (FFT) and Clone Trials (CT) and some Yield Block Trials (YB) for Gen 1.0 improved clones, and some FFT and CT are underway for Generation 2.0. FFT test full-sib (from controlled pollination of specific parents) families with clones replicated within each family. CT further evaluate clones that performed well in the FFT. YB are considered the final stage of field testing and consist of monoclonal blocks of single clones meant to approximate commercial conditions and to estimate biomass yield. Most of the clones in the YBs are those that have performed well in the FFTs and CTs. Nursery stoolbeds (cutting orchards) are pruned, shrub-like trees of each clone that can provide a supply of cuttings for field tests and to licensed nurseries for further propagation.

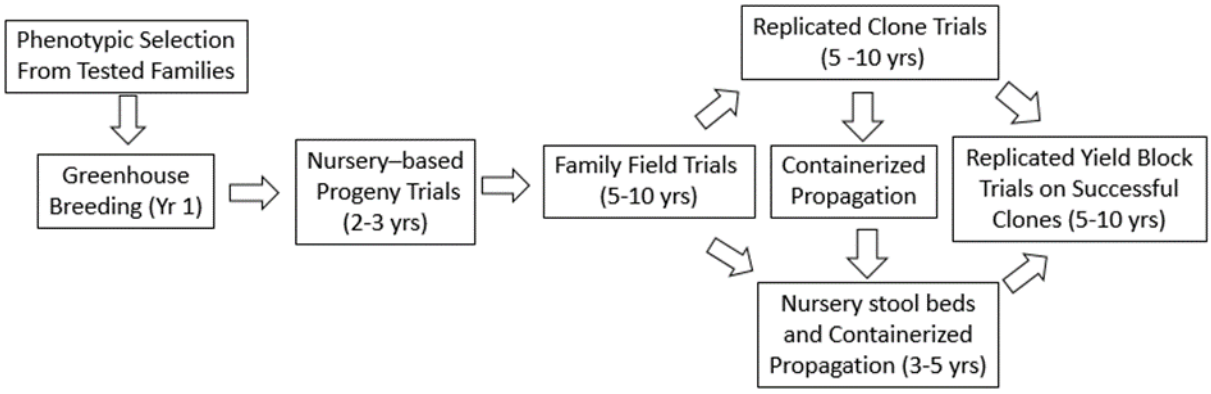

Figure 1. The NRRI hybrid poplar breeding and testing process.

More details on the breeding and testing process are described in Nelson et al. (2021).

In addition to the NRRI breeding and testing process, our clones have also been tested in phytoremediation applications (removal of pollutants from soil) in cooperative tests at several Midwestern U.S. sites (Wisconsin and Michigan UP) under the direction of Dr. Ron Zalesny, USFS Northern Research Station, Rhinelander, WI, under a UM Plant Material Transfer Agreement, which protects our intellectual property.

Plant patents

Plant patents are the appropriate choice for protecting the intellectual property in our hybrid poplar program. Plant patents require newness (**novelty**). NRRI clones that are candidates for plant patents are **novel** for greatly improved growth rate combined with disease resistance, and in some cases, broad geographic stability and stable growth performance across sites of varying soil quality and mean productivity, and good performance in phytoremediation applications. These novelty traits are based on extensive replicated field trials. Plant patent rights can only be lost through commercial release prior to patenting. All releases of NRRI clones have been for research purposes only under Plant Material Transfer Agreements, which protect our patent rights. A plant patent excludes unauthorized reproduction or sale of the protected clones in the United States for 20 years from the date on which the patent application was filed with the U.S. Patent and Trademark Office.

Determining inventors

The inventor of a plant patent is one who makes the asexual (clonal) reproduction. The definition of this inventorship criterion in our case would probably be who decides to make the specific asexual reproduction that produces the clone. Bernard McMahon and William Berguson of the NRRI are the individuals most closely associated with producing the hybrid poplars resulting from breeding and selection within the NRRI hybrid poplar program. Clones selected and tested by others prior to being tested by NRRI are excluded from patenting. Determining inventorship will depend upon discussions with plant patent experts at the University of Minnesota Technology Commercialization (TC) office.

Inventory

NRRI clones that are candidates for patenting are *Populus deltoides x Populus nigra* interspecific hybrids (DxN, DN) and *Populus deltoides x Populus deltoides* intra-specific hybrids (D x D, DD) that have been produced by NRRI selection and controlled pollination breeding and have shown superior growth and disease resistance in FFT and CT and/or YB. Some clones have further attributes based on these tests, including broad geographic adaptability (*Geo-Robust Clones)* (Nelson et al., 2019*)* and stability (stable growth performance across sites of varying soil quality and mean productivity) (Nelson et al., 2018). Clones in our tests originating in other programs are excluded from patent consideration. We have field tested over 13,000 genotypes (families, clones) over the 25 years of the NRRI Hybrid Poplar Program.

Strategy

We have not patented any hybrid poplar clones for a variety of reasons. One reason is that North American hybrid poplar feedstock production programs have been disappearing since about 2012, so that there is currently an absence of a significant market for planting stock for hybrid poplar biomass plantations in Canada and the United States. We did not want to start the period of patent protection (20 years) to begin without a market or the expectation of one. Another reason is that the 1st generation of our improved clones was not attained until about 2015.

Even though there still is only a small market for hybrid poplar planting stock (cuttings), there are now reasons to move ahead with some patenting. There is a developing market for hybrid poplar for ecosystem services such as phytoremediation of brownfields and landfills, stream buffers, water treatment, and solid waste disposal (Zalesny et al., 2016; 2019). We have also seen interest in hybrid poplar plantations for carbon sequestration by large corporations and their consultants for carbon credits in the carbon market and for building corporate images as green companies. Tree planting for carbon sequestration could become a large market, i.e., see https://www.cnbc.com/2019/04/08/oil-giant-shell-has-a-new-carbon-footprint-plan-millions-of-trees.html. Green Trees is a company that is on the cutting edge of this market, and according to the company they currently have 120,000 acres enrolled in carbon contracts with private landowners in the southern United States. Their model is to plant cottonwood trees interspersed with hardwood trees on marginal agricultural land. Enrollments are increasing at a rapid pace, and according to the company they currently grow 10 million cottonwood cuttings per year. We believe this business model could be successful in the upper Midwest using hybrid poplar clones interspersed with white spruce, red pine, or Northern red oak.

There also is a nascent bioeconomy that may develop over the next decade that will require dedicated biomass and timber sources. We have recently seen interest from multiple established companies that are considering Minnesota for wood-using plants based upon hybrid poplar plantations. One of the companies was focused on when our clones might be patented and available for licensing. The feasibility and profitability of such wood production plantations heavily depend on rapid growth and high yields (Lazarus et al., 2015), which our improved genotypes can provide.

Another important reason for proceeding to patent clones is that our federal agency sponsors (DOE, USDA) would like to see patented improved clones out of our program as a product of the federal funding we have received. One of the main DOE (U.S. Department of Energy) officers overseeing our previous grants under the DOE Sun Grant Program encouraged us to patent our best clones.

Our strategy should be to apply for plant patents for a limited number of clones (maybe 2 – 4) at this time, due to the current lack of a large market for hybrid poplar planting stock. This would allow us to save other elite clones for future patenting as markets develop. This plan is feasible, because we have many tested elite clones from Gen 1.0 and will have many more from Gen 1.5 and 2.0. At least one clone chosen for patenting now should be a tested D x D clone to serve the ecosystem services market, as native species are often preferred for such applications. At least one D x N clone should also be patented now. D x D clones will be deployed in the market as rooted cuttings, whereas D x N clones can be planted as lower cost unrooted cuttings. The minimum number of clones to use in a regional planting program is uncertain without very large field tests and commercial plantations monitored over decades in several geographic areas, a scenario that does not exist. In the absence of this definitive information, for large biomass production operations we recommend that at least six clones should be used in any one industrial program to provide genetic diversity and avoid the risks of monoculture, based on the theoretical reasoning in Libby (1987). If we patent three D x N clones, there are probably at least three acceptable clones in the public domain that could be combined with our patented clones in a biomass production plantation. Thus, our optimum strategy may be to patent one D x D and three D x N clones. However, the funding available for patenting may determine how many plant patent applications we file and whether we file all at once or in a staggered manner. It may be best to start with two patent applications to test the market, one D x N hybrid clone and one D x D hybrid clone. If our market experience is favorable, we can then make additional plant patent applications in the future.

Market Size

Publicly available market surveys on the size of the U.S. nursery industry are not nearly granular enough to help us determine the current market for hybrid poplars. Instead, we must depend on our experience, anecdotal information from knowledgeable contacts, and custom surveys. The current market is relatively small, but the potential future market may be large.

Discussions with a consultant involved in projects using hybrid poplars and with nurseries currently selling poplars in the U.S. and other anecdotal information indicate that sales of 100,000 to 500,000 cuttings per year of improved poplar clones are currently possible in North America. One nursery that we are aware of has averaged about 50,000 cuttings per year in sales of an old unimproved poplar clone over the last twenty years. This estimate of 100,000 – 500,000 cuttings is also based on the senior author's 11 years of experience as the CEO of a nursery business selling hybrid poplars and other genetically-improved forest tree seedling planting stock. Assuming 500,000 cuttings, with half unrooted at $0.25/cutting and half rooted at $0.33/cutting (prices based on current published price lists from nurseries selling poplars), revenue to the grower(s) would be $145,000. At a 10% royalty rate, royalty income would be $14,500 per year. The upside is much larger than the current small market, as one dedicated biomass plantation of 1,400 acres per year, about the minimum acreage to establish enough biomass for a relatively small bioproducts plant by the end of five years, would require 610,400 cuttings per year. The former Verso Paper Poplar Program in Minnesota established 2,000 acres of hybrid poplar plantations per year on agricultural land over 17 years to supply fiber for their paper mill in Sartell, MN, providing a successful example of biomass feedstock development on this scale. Another example of a potentially large market that could develop quickly is the use of poplars in phytoremediation of contaminated land (brownfields). Simons (1998) estimated that there were 500,000 to 600,000 non-residential brownfield sites in the U.S. in 1998. Extrapolating from his data, these brownfields occupied over 600,000 acres. There are different definitions of what is a brownfield, and the number of unremediated brownfields has probably decreased somewhat since 1998, but the acreage quoted above

gives a relative idea of the magnitude of the opportunity. If only 5% of these brownfields were planted with poplars for contaminant removal, this would be a market for 13 million poplar cuttings. And as described above, there is a developing market for tree planting for carbon sequestration, which could become a very large market.

Prioritization

The process we used to prioritize D x N clones for patenting is as follows: 1) Fast-growing, stable, geo-robust, canker-resistant clones receive the highest weight; 2) Within the geo-robust clones identified in Table 8 in Nelson, Berguson et al. (2019), those appearing in the list of fastest-growing clones in Minnesota clone trials (Table 9 in Nelson et al. (2018) got the highest weight; 3) Within list #2, clones within at least the top 10th percentile in growth in one of the IN, MI, Cornell, NY or Tully, NY clone trials (Nelson, Berguson et al., 2019) got higher weight; and 4) In a tie, we went by the rank in the Minnesota clone trials in Nelson et al. (2018). Some of the chosen clones were stable, as well as fast-growing and geo-robust (Nelson et al., 2018). We will coordinate patent candidate clones with our 2020 stoolbed expansion so that we can ensure a cutting supply to licensees of our plant patents. This ranking process for our D x N hybrids gave the following list of 12 D x N clones for initial consideration:

Prioritizing stoolbed expansion for additional tests in next two/three years for D x N clones that are initial candidates for patenting.

Clone (all DxN)	Sex	Description*,**	MN CTs growth rank* out of 69	Geo-Robust growth percentile**	Priority for stoolbeds and patenting
'99059016'* **	M	Fast-growing, stable, geo-robust	1	MN 10th, MI 10th	1
99038005	F	Fast-growing, unstable, geo-robust	2	MN 10th, MI 25th	4
99038003	F	Fast-growing, unstable, geo-robust	3	MN 10th, MI 25th, Cornell NY 25th, Tully NY 10th	5
31500	?	Fast-growing, unstable	4	Not geo-robust	11
'99038022'	F	Fast-growing, stable, geo-robust	5	MN 10th, IN 10th	2
'9732-24'	F	Fast-growing, stable, geo-robust	6	MN 10th, Cornell NY 25th	3
22033045	?	Fast-growing, unstable	7	Not geo-robust	12
'9732-11'	F	Geo-robust	12	MN 25th, Cornell NY 10th	6
99008002	M	Geo-robust	53	MI 25th, Tully NY 10th	8
99038013	F	Geo-robust	29	IN 25th, Cornell NY 25th	10
41700	F	Geo-robust	17	MN 25th, MI 10th, Tully NY 25th	7
99007116	M	Geo-robust	9	MN 25th, IN 25th	9

*Biomass and Bioenergy. 2018. 118: 115-125 (stability paper). Fast-growing refers to MN CTs only, Table 9. Table 4 has growth ranks of other clones in the MN CTs.

**Silvae Genetica. 2019. 101-110. (Discovery geo-robust clones paper). Geo-robust refers to Table 8.

Highlighted clones of a single color are from a single full-sib family.

***Cultivar name – 'NextGen"

Tradename – InnovaTree™

Any D x N clones with a mean canker score ≥ 1.0 in any field test were excluded from the patent list, based on our NRRI categorical ordinal canker scoring system: 0 = cankers absent, 1 = cankers present but rare, 2 = cankers present with multiple areas of sunken, necrotic tissue on main bole or branches. All geo-robust clones had to meet that canker score limit. However, we found an error in Table 8 in Nelson, Berguson et al. (2019), wherein clone 99038003 should not have been included in the list of geo-robust clones, as it had a canker score of 1.61 in the Minnesota clone trials (see Table 4 in Nelson et al., 2018), even though it met the canker criteria in the MI and NY clone trials. Accordingly, we have excluded clone 99038003 from patent consideration. The field tests with canker scores for the candidate D x N clones

were all clone trials and included six sites in Minnesota described in Nelson et al. (2018), as well as Hemming and Waseca (MN), Port Wing and Ashland (WI), Escanaba (MI), and Tully (NY). Stand age at the time of canker scoring ranged from 5 to 13 years, i.e., one-half to full rotation.

Clone 9732-24 had a canker score of 1.33 at seven years in the Hansen (MN) clone trial (Nelson et al., 2020), but this is considered an outlier, as its canker score was < 1.0 on every other site on which it has been tested and scored for cankers [Schultz (MN) CT, Ashland and Port Wing (WI) CTs, Escanaba (MI) CT, and Tully (NY) CT]. Thus, we consider clone 9732-24 to be canker resistant and have kept it on the patent consideration list.

We have also excluded five D x N clones (99038005, 41700, 99008002, 99038013, 31500) on the initial patent priority list because cutting material was unavailable for the 2020 expansion of our Grand Rapids, MN nursery stoolbeds (cutting orchard). The most common reason for unavailability is poor rooting. Two additional D x N clones were also excluded: 99007116 due to heavy *Melampsora* rust on the foliage, and 22033045 due to reduced vigor in our Grand Rapids, MN nursery stoolbeds over time. This leaves four DN clones on the patent priority list: **99059016, 99038022, 9732-11, 9732-24**. Within this group of four clones, 99059016 and 99038022 have priority over 9732-11 and 9732-24, as the latter two clones ranked relatively low in a Yield Block test in Minnesota (Hansen YB), i.e., 15 and 17, respectively, out of 22 clones.

No NRRI D x D clone has been tested outside Minnesota. The best D x D NRRI clones for growth performance in our MN clone trials were '**9608-17'** (rank 2 out of 60 clones at age 8 in the Hemming CT, rank 8 out of 69 at 5 years in the Waseca CT, rank 1 out of 67 at 9 years in the Hansen CT, rank 1 out of 63 clones at 10 years in the Schultz CT, rank 11 out of 42 at 7 years in the LEA Grand Rapids CT) and '**9605-35'** (rank 3, 2, and 3 in the Hansen (9 years), Schultz (10 years) and LEA Grand Rapids (7 years) clone trials, respectively). Cankers are not a significant disease issue in D x D clones. As female clones can produce a seed nuisance ("cotton") in residential areas, male D x D clones will be preferred. Male clones will be more marketable for landscape applications and ecosystem services plantings in or near towns and cities.

Our evaluation process for patents also considers the recently released results of the performance of our clones in phytoremediation studies with Dr. Ron Zalesny, USFS Northern Research Station (Ghezehei and Zalesny, 2020). These field experiments were phytoremediation buffer systems to reduce surface runoff and belowground water flow at 16 closed landfills within the Lake Superior and Lake Michigan watersheds.

Through our extensive field tests we have winnowed the more than 13,000 genotypes tested down to four D x N clones and two D x D for patent consideration, the most elite fast-growing, broadly adapted, and disease-resistant genotypes in our program to date. This is a selection intensity of 0.05%.

Clones to patent in order of priority within each type of hybrid – clone numbers and description of traits

D x N inter-specific clones

'99059016'
Taxon/cross combination: *Populus deltoides x Populus nigra* (an interspecific 'D x N' first-generation hybrid)
Parent information: D123 (University of Minnesota female) x N949-2 (University of Toronto male)
Floral (sex): Male clone
Noted attributes and characteristics of interest: Fast-growing, stable, and broadly adapted (geo-robust). In University of Minnesota field tests on six sites in Minnesota (Nelson et al., 2018), the clone grew 64% faster in bole volume growth than commercially available clones NM6 and DN5, 93% faster than the commonly sold hybrid poplar *Eugenei* (DN34), and 49% faster than the whole population of hybrid poplars in the same tests. Male clone (seedless, cottonless). *Geo-robust* means this clone grew faster than commercially available clones on test sites throughout the northeastern quarter of the United States, from Minnesota through Michigan and into upstate New York and as far south as southern Indiana (Nelson et. Al, 2019; Nelson, Meilan et al., 2019). Resistant to stem canker. Vigorous in stool bed production with low incidence of sylleptic branching. Good late season leaf retention. Above average rooting ability from unrooted cuttings. Good growth performance and tree health in phytoremediation studies in Wisconsin and Upper Michigan (Ghezehei and Zalesny, 2020). Phytoremediation is removing pollutants from soil and ground water with tree plantings.

'99038022'
Taxon/cross combination: *Populus deltoides x Populus nigra* (an interspecific 'D x N' first-generation hybrid)
Parent information: D200 (University of Minnesota female) x N944-4 (University of Toronto male)
Floral (sex): Female clone
Noted attributes and characteristics of interest: Fast-growing, stable, and broadly adapted (geo-robust). Resistant to stem canker. Vigorous in stool bed production with moderate incidence of sylleptic branching. Good late season leaf retention. Good rooting from unrooted cuttings. Scored high in growth performance in phytoremediation studies in Wisconsin and Michigan (Ghezehei and Zalesny, 2020).

'9732-24'
Taxon/cross combination: *Populus deltoides x Populus nigra* (an interspecific 'D x N' first-generation hybrid)
Parent information: D125 (University of Minnesota female) x N946-2 (University of Toronto male)
Floral (sex): Female clone
Noted attributes and characteristics of interest: Fast-growing, stable, and broadly adapted (geo-robust). Resistant to stem canker. Moderate to above average vigor in stool bed production, with moderate incidence of sylleptic branching. Good late season leaf retention. Above average rooting ability from unrooted cuttings (93 – 94% survival in replicated Minnesota field trials).

'9732-11'
Taxon/cross combination: *Populus deltoides x Populus nigra* (an interspecific 'D x N' first-generation hybrid)
Parent information: D125 (University of Minnesota female) x N946-2 (University of Toronto male)
Floral (sex): Female clone

Noted attributes and characteristics of interest: Above average growth and broadly adapted (geo-robust). Resistant to stem canker. Moderate to above average vigor in stool bed production with moderate incidence of sylleptic branching. Good late season leaf retention. Above average to excellent rooting ability from unrooted cuttings (93 – 98% survival in replicated Minnesota field trials).

DD intra-specific clones

'9608-17'
Taxon/cross combination: *Populus deltoides x Populus deltoides* (an intraspecific 'D x D' first-generation hybrid)
Parent information: D132 (University of Minnesota female) x D113 (University of Minnesota male)
Floral (sex): Male clone
Noted attributes and characteristics of interest: Very good growth, highly ranked among cottonwood clones in replicated clone field trials in Minnesota. Male clone (seedless, cottonless). Absence of stem canker. Moderate to high incidence of sylleptic branching. Rust incidence is late in the growing season. Established in breeding archive for continued observation and potential use as a future parent tree. Male gender makes it the best choice of the two candidate DD clones for planting in or near cities and towns.

'9605-35'
Taxon/cross combination: *Populus deltoides x Populus deltoides* (an intraspecific 'D x D' first-generation hybrid)
Parent information: D129 (University of Minnesota female) x D124 (University of Minnesota male)
Floral (sex): Female clone
Noted attributes and characteristics of interest: Average to slightly above average growth in replicated clone trials (Minnesota). Absence of stem canker. Moderate to high incidence of sylleptic branching. Rust incidence is late in the growing season. Established in breeding archive for continued observation and potential use as a future parent tree.

Action Plan – Estimated Timeline for IP process – NRRI Poplar Program

Task	Timeline	Responsible Party
Inventorship discussion with Tim White, Anne Hall, B. J. Haun TC	3Q 2020-continuing	Nelson, Berguson, McMahon, Jackson, DuPlissis, White, Hall, Haun
File invention disclosure with TC	1Q 2021	McMahon, Berguson, Nelson
Evaluation	4Q 2020 – continuing	TC
Contact potential licensees, provide propagation material under PMTA, discuss licensing	1Q 2021 – continuing	Jackson, McMahon, Haun
Develop marketing materials (1-pager)	4Q 2020 – 1Q 2021	Haun, Nelson, White, McMahon, Jackson, Berguson, DuPlissis
Choose name for first selected clone. Do trademark search.	1Q 2021	McMahon, Berguson, White, Jackson, Nelson, TC, patent attorney
Protection decision on first selected clone	2021–2023	TC
Determine inventors and file plant patent	2021–2023	TC, inventors
Patent issued by USPTO	2021-2023	USPTO
Marketing	4Q 2020 – continuing	TC/NRRI/Inventors
Licensing	1Q 2021 – continuing	TC/NRRI/Inventors
Commercialization (sales)	Beginning 2022 or 2023	Licensee(s)
Revenue distribution	Beginning 2023 or 2024	TC

Trademarks

An effective, trademarked name for each patented clone is an essential licensing, marketing, and sales tool. According to the UM Landscape Arboretum experience, the cost to file and get a registered trademark is $3,000 – $4,000. TC and NRRI will identify a good name for each patented clone and decide which type of trademark to use. Common law trademarks are free and may be the best choice for our clones.

Licensing

Licenses for plant patents are typically non-exclusive. Our target should be private and public tree nurseries as well as industrial bioproducts companies that are establishing dedicated captive hybrid poplar plantations. The NRRI team surveyed three private tree nurseries in 2019 to discuss hybrid poplar sales. All nurseries stated that their hybrid poplar sales were either holding steady or increasing. Those that are seeing increased demand attribute it to phytoremediation projects, mine land reclamations, and conservation plantings. All nurseries indicated that a University of Minnesota patented clone should sell for a higher price than the clones they currently sell, though the licensing fees would have to be in line with their tight margins. One nursery owner commented, “Depending on the cost, we would be

interested in trying out a new clone. If the new clone displayed substantially better qualities, we would be interested in marketing it differently and pricing it such that we could accommodate a royalty payment."

Patent enforcement

Genetic DNA fingerprinting is used for some patented agricultural crops to protect against patent infringement and enforce the patents. Some private genomics companies provide this service, as well as some government and academic labs. This approach would be expensive for poplars due to the lack of defined SNPs for *Populus*. Electrophoresis (protein-based) may be a cheaper approach to genetic fingerprinting. Many plant patents are for visible unique phenotypes that provide for patent enforcement without genetic fingerprinting. Our poplar clones probably will not be visually unique, so this method of detecting unauthorized reproduction or sale of our patented clones is not likely to be available. Upon consultation with TC, we have decided to fingerprint our patented clones only if and when we suspect patent infringement.

Progress Report

In discussions with UM TC, we have decided to initially focus on just one D x N clone ('99059016'') and one D x D clone ('9608-17') for patent consideration. Subsequently, we determined that there were not enough cuttings of '9608-17' to proceed with potential patenting of that clone at this time. Consequently, we made plans to propagate clone '9608-17' in our NRRI greenhouse in Spring 2021 to produce rooted cuttings that will be planted in our stoolbeds at NCROC near Grand Rapids, Minnesota in June 2021. We expect that stoolbed expansion to provide enough future cuttings to allow us to proceed with possible propagation testing with nursery partners and patenting of '9608-17' in 2023 or 2024. Therefore, in 2021 we will only move ahead with the DN clone, '99059016.'

In further discussions with UM TC, we have mutually decided to offer cuttings for propagation testing under a Plant Material Transfer Agreement (PMTA) of our top DN patent candidate, '99059016,' to select nurseries in the Midwest U.S. whom currently sell hybrid poplar and cottonwood planting stock (rooted and unrooted cuttings). The PMTA protects our rights to the clone and prohibits the recipient from offering for sale or selling the listed clone. We concurrently developed a one-page flyer describing and promoting this clone, which is being sent to these candidate nurseries. Contact with nurseries under this campaign began in January 2021.

NRRI stakeholders for clone '99059016' suggested names for this clone, and a vote was held in January 2021. The name selected is 'Double Diamond'™ hybrid polar. Further evaluation of this name is underway and will be completed before a final decision is made on accepting the name.

The strategy developed with TC is for nurseries to test '99059016' in their operation before we offer them an opportunity to license the clone and sell it. We will request TC approval to apply for a plant patent when we receive a request from one or more nurseries to license the clone.

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References

Berguson, WE, BG McMahon and DE Riemenschneider (2017) Additive and non-additive genetic variances for tree growth in several hybrid poplar populations and implications regarding breeding strategy. Silvae Genetica 66: 33-39. https://doi.org/10.1515/sg-2017-0005

Ghezehei, S and RS Zalesny (2020) Adopting hybrid poplars based on end product, and new hybrid poplar clones for phytotechnologies. SRWG inter-lab virtual webinar discussion, September 23. 2020. https://drive.google.com/file/d/1iusgZyxapMjm_XqFz5YrcMyLLrw5P7gB/view?usp=sharing

Lazarus W, WL Headley and RS Zalesny (2015) Impacts of supplyshed-level differences in productivity and land costs on the economics of hybrid poplar production in Minnesota, USA. Bioenergy Research 8(1):231–248. https://doi.org/10.1007/s12155-014-9520-y

Libby WJ (1987) Testing for clonal forestry. Annales Forestales 13(1–2):69–75.

Nelson ND, WE Berguson, BG McMahon, M Cai and DJ Buchman (2018) Growth performance and stability of hybrid poplar clones in simultaneous tests on six sites. Biomass & Bioenergy 118:115–125. https://doi.org/10.1016/j.biombioe.2018.08.007

Nelson, ND, WE Berguson, BG McMahon, M Cai and DJ Buchman (2021) Vectors of efficiency in hybrid poplar genotype testing. Silvae Genetica (provisionally accepted, *pending)*

Nelson ND, WE Berguson, BG McMahon, R Meilan, LB Smart, FE Gouker, P Bloese, R Miller, TA Volk, M Cai and D Buchman (2019) Discovery of geographically robust hybrid poplar clones. Silvae Genetica 68(1):101–110. https://doi.org/10.2478/sg-2019-0018

Nelson ND, R Meilan, WE Berguson, BG McMahon, M Cai and DJ Buchman (2019) Growth performance of hybrid poplar clones on two agricultural sites with and without early irrigation and fertilization. Silvae Genetica 68(1):58–66. https://doi.org/10.2478/sg-2019-0011

Simons, RA (1998) How many urban brownfields are out there?: An economic base contraction analysis of 31 U.S. cities. Public Works Management and Policy 2(3):267–273. https://doi.org/10.1177/1087724X9800200310

Zalesny RS, WL Headlee, G Gopalakrishnan, EO Bauer, RB Hall, DW Hazel, JG Isebrands, LA Licht, M Cristina Negri, E Guthrie Nichols, DL Rockwood and AH Wiese (2019) Ecosystem services of poplar at long-term phytoremediation sites in the Midwest and Southeast, United States WIREs Energy Environ. 8:e349. https://doi.org/10.1002/wene.349

Zalesny, RS Jr., JA Stanturf, ES Gardiner, GS Bañuelos, RA Hallett, A Hass, CM Stange, JH Perdue, TM Young, DR Coyle and WL Headlee (2016) Environmental technologies of woody crop production systems Bioenerg. Res. 9:492–506. https://doi.org/10.1007/s12155-016-9738-y