

Lake Superior Woody Biomass Initiative

Lake Superior Woody Biomass Production Trials 2009-2019

Project Report

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Background and Introduction

The Chequamegon Bay Region of Northern Wisconsin is a pilot Energy Independent Community and, as such, seeks to generate 25% of its energy use locally by the year 2025. Wood waste from mill residues, harvest residues, pre-commercial forest thinnings, and low-value timber species have been identified as likely feedstock for wood-to-energy systems and has the potential to replace a portion of coal and propane use for electricity and heat generation. Xcel Energy is currently using up to 250K green tons of waste wood and upon completion of the gasification unit at the Bayfront Plant in Ashland will use closer to 450K green tons. As aggregation, densification, and utilization technologies improve, it is likely demand for waste wood from other businesses such as pellet mills, school districts, and other large energy users will rise.

Short rotation woody biomass plantings have been proposed as an efficient and cost-effective means for sourcing woody biomass and could be an important agricultural crop for NW Wisconsin. Little is known, however, about the performance of woody biomass crops in NW Wisconsin. Research suggests the performance of commercially available woody crop cultivars is site specific. Thus, it is important that performance of a range of species and cultivars be evaluated. Furthermore, short rotation woody biomass production must be optimized to reduce input needs and potential deleterious environmental impacts. Finally, developing profitable production systems for growers will be necessary for a self-sustaining woody biomass supply chain.

To address these research needs, a series of woody biomass trials are being installed at two locations in Bayfield County and at the Spooner Research Station in Spooner. The trials are planned for ten years and are a mix of replicated research and demonstration. This report provides updates on the establishment work to date and provides basic plot maps and agronomic information on each trial.

An important objective of the biomass trials is to foster collaboration toward a fuller understanding of the benefits and risks of producing woody biomass for energy generation in the Chequamegon Bay region of Wisconsin. In particular, we are seeking partners with which to conduct collaborative and complimentary research in the following areas:

- Net energy gain and carbon cycling of wood-to-energy systems in NW Wisconsin.
- The impact of intensive woody biomass production on soil and water quality.
- The potential of intensive woody biomass production to reduce peak-flow events in area watersheds.
- The economic feasibility of woody biomass production.
- Evaluation and development of harvest, densification, and aggregation technology.
- Although site preparation for some of the biomass trial plantings has begun, the trials have been designed to accommodate changes and collaborative research.

To learn more about this project and how you can become involved contact:

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Trial Objectives

Objective 1. Evaluate advanced selections of hybrid poplar and hybrid willow to identify high-performing, locally adapted germplasm for the Lake Superior basin of Wisconsin.

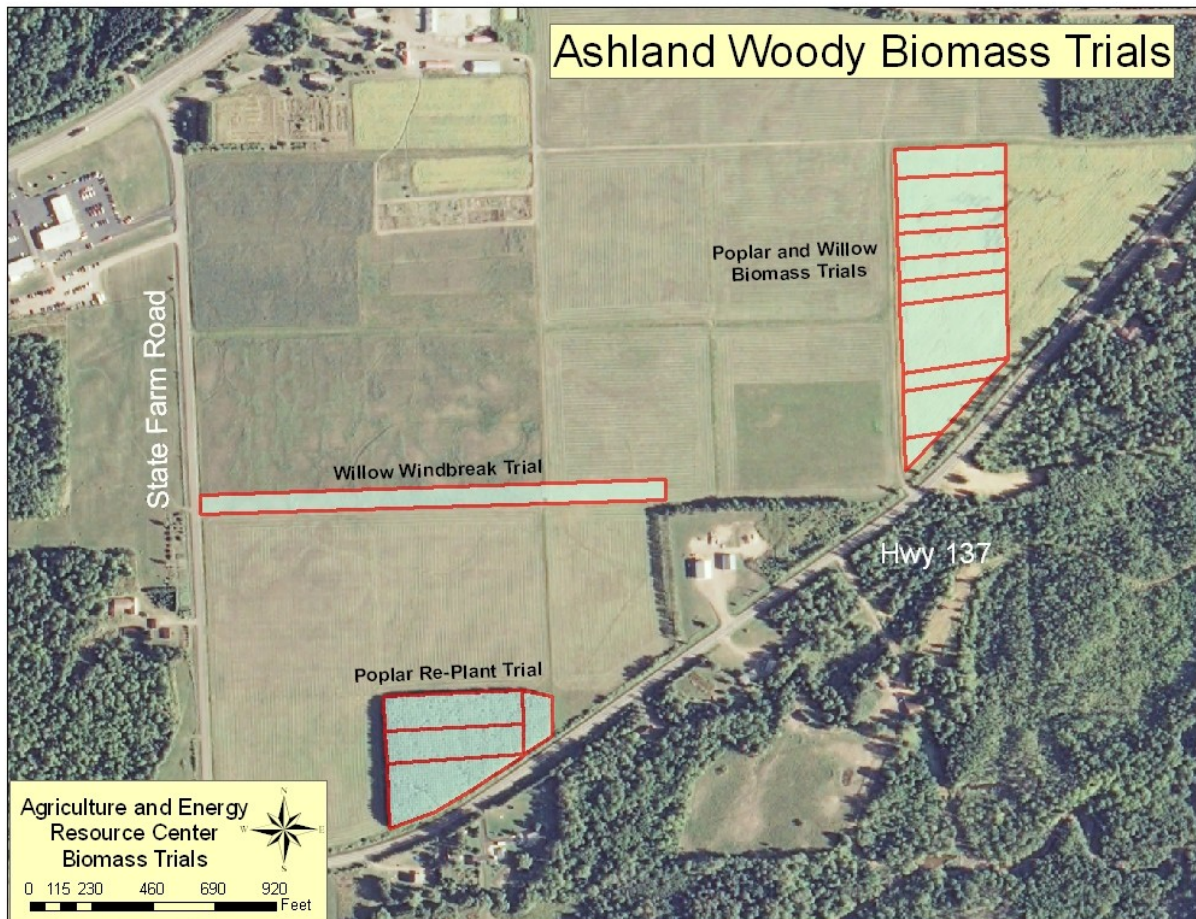
Objective 2. Demonstrate short rotation woody biomass management and production scenarios in support of scale-up of sustainable woody biomass production.

Objective 3: Evaluate post-harvest management and re-plant options for hybrid poplar plantations.

Research Trial Locations

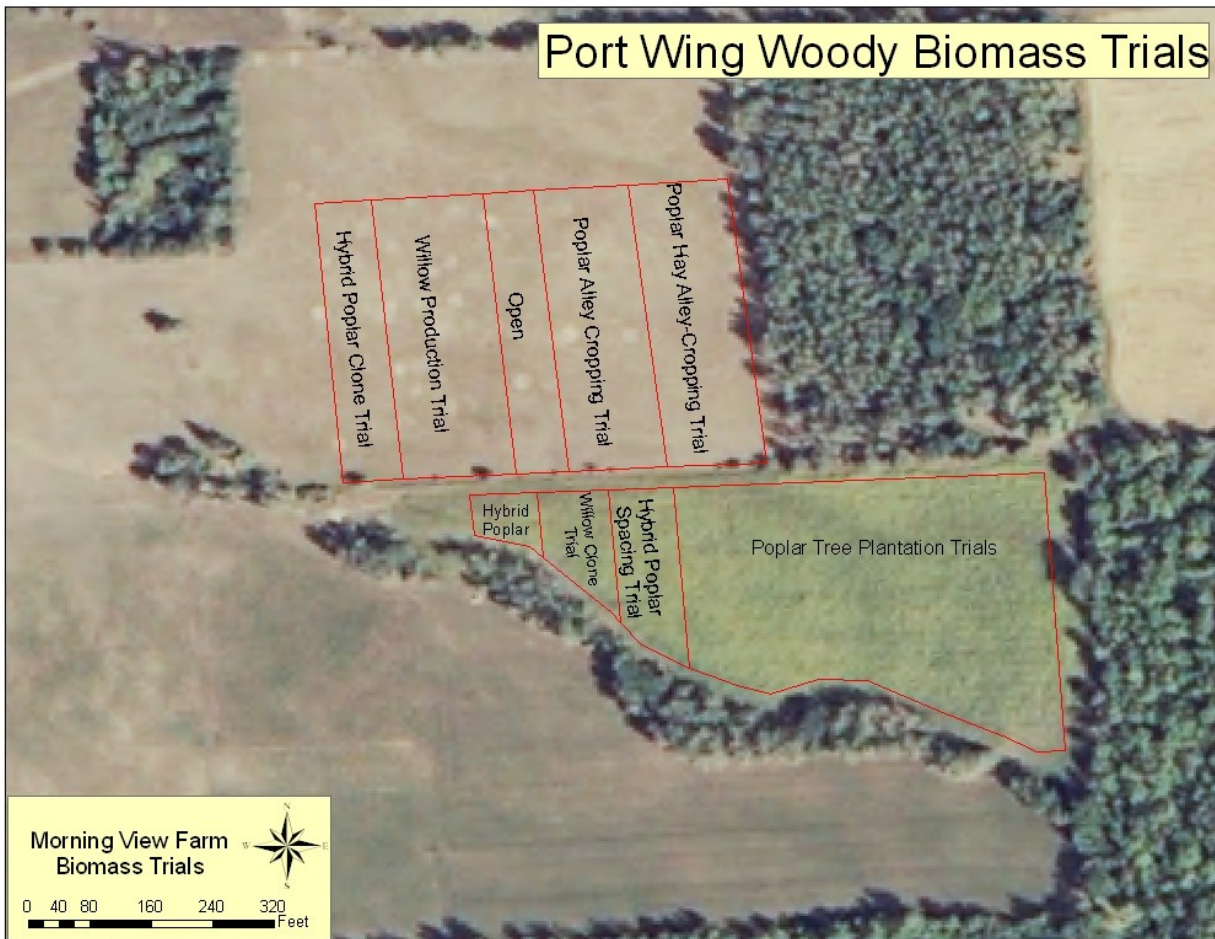
Trial Location #1: Agriculture and Energy Resource Center, Ashland, WI

Property Owners:	Ashland and Bayfield County (former Ashland Ag Research Station)
Property Legal Description:	Town of Eileen, T47N R5W, Section 11, NW ¼ SE ¼ NW ¼
Property Address:	On agricultural land on Hwy 137, approx. 1 mile from US HWY 2
Trial Soil Type:	480B Portwing-Herbster, moderately well-drained silt loam over clay
Cropping History:	2009: barley underseeded with sweet clover, 2008: sunflowers, 2007: canola



Trial Location #2: Morning View Farm, Port Wing, WI

Property Owners: Larry Fickbohm and Gayle Gonsior
Property Legal Description: Town of Portwing, T49N R8W, Section 18, SE ¼ NW ¼
Property Address: 79730 Evergreen Rd, Port Wing, WI 54865
Trial Soil Type: 262B Amnicon-Cuttre, moderately well-drained silty loam over clay
Cropping history: North Field: mixed hay pasture; South Field: 2009-spring wheat



Trial Location #3: Spooner Agricultural Research Station, Spooner, WI

Property Owners: University of Wisconsin
Property Legal Description: T39N R12W Section 33 NE NW
Property Address: W6646 Hwy 70, Spooner, WI 54801
Trial Soil Type: 368B Mahtomedi-Cress, excessively-drained loamy sand over sand
Cropping history: NM6 Hybrid Poplar 1999-2010

Willow Trials

Willow Production Trials

Trial Objective: To demonstrate willow production, generate cost and revenue enterprise data, and accommodate future management research.

Established: June 8, 2010

Four varieties of hybrid willow sold by Double A Willow of New York were planted in blocks at both the Ashland and Port Wing trial sites. At the Ashland site, 12 rows of each of Fish Creek, Canastota, Fabius, and SX 61 were planted on June 8, 2010. Each row was 400' long with a total block size for each variety of 0.34 acres. At the Port Wing site, 12 rows of each of Fish Creek, Canastota, Fabius, and SX 61 were planted on June 8, 2010. Each row was 350' long with a total block size for each variety of 0.30 acres. The willow was planted with an Energy Planter operated by Double A Willow (Photo 1) with the rows arranged as shown in Appendix 1. Table 2 lists the soils information, site preparation, and maintenance actions to date.

Clone Name	Species
Canastota	<i>S. sachalinensis</i> x <i>S. miyabeana</i>
Fabius	<i>S. viminalis</i> x <i>S. miyabeana</i>
Fish Creek	<i>S. purpurea</i>
Millbrook	<i>S. purpurea</i> x <i>S. miyabeana</i>
Sherburne	<i>S. sachalinensis</i> x <i>S. miyabeana</i>
SV1	<i>S. dasyclados</i>
SX 1	<i>S. sachalinensis</i>
SX 64	<i>S. miyabeana</i>
Tully Champion	<i>S. viminalis</i> x <i>S. miyabeana</i>

Table 1. Willow Varieties Included in Lake Superior Woody Biomass Trials.

	Ashland	Port Wing
Soil Type	480B Portwing-Herbster silt loam over clay	262B Amnicon-Cuttre silty clay loam over clay
2009 Crop	Barley underseeded with yellow sweet clover	Sheep pasture (grass)
Fall 2009 Site Prep	Chisel plow and disk	Moldboard plow and disk
Spring 2010 Site Prep	Disk April 14 and June 1	Disk May 20, Drag June 8
Planting Date	8-Jun-10	8-Jun-10
Weed Control to Date	flumioxazin (10oz/ac) on June 10	flumioxazin (10oz/ac) on June 10

Table 2. Willow Production Trial Site and Establishment Information



The Energy Planter was used to mechanically plant 8" cuttings. With good soil conditions, the planter works efficiently and quickly.



Fish Creek Clone, Ashland, July 6, 2010



Fish Creek Clone, Ashland, July 22, 2010

Willow Windbreak Trial

Trial Objective: To demonstrate a willow windbreak for possible use on producer farms.

Established: June 8, 2010

Four rows of Fish Creek hybrid willow were planted on June 8, 2010 at the Ashland site parallel to a field road. The windbreak hedgerow was 1700ft in length and was planted with the Energy Planter by Double A Willow. The four rows were arranged as shown in Figure 1. The site was in grass and alfalfa the last six years and was moldboard plowed and disked on May 10, 2008. It was disked again on June 4. Sureguard (flumioxazin) was applied on June 13 at 10oz per acre.

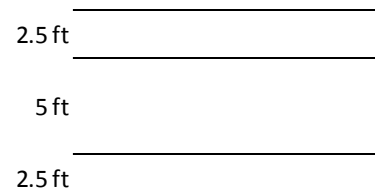


Figure 1. Arrangement of willow rows in windbreak planting.

Willow Clone Trial

Trial Objective: To evaluate the establishment and growth of clones of hybrid willow.

Established: Ashland: June 9-10, 2010; Port Wing: June 17, 2010

A willow clone trial was planted at both the Ashland and Port Wing sites. The trial was planted by hand at the Ashland site on June 9 and 10 and at the Port Wing site on June 17. The trial was arranged as a RCB with 3 replications of each of the clones. Each plot consisted of two 30ft rows spaced 2.5' apart with 2' between plants for a total of 30 plants per plot. The two-row plots were spaced 5' apart. A two-row border was planted around the perimeter of the trial at both locations. Table 3 summarizes the variety entries and agronomic information for the trials. See Appendix 1 for plot maps.

	Ashland	Port Wing
Soil Type	480B Portwing-Herbster silt loam over clay	262B Amnicon-Cuttre silty clay loam over clay
2009 Crop	Barley underseeded with yellow sweet clover	Spring wheat
Fall 2009 Site Prep	Chisel plow and disk	Disk
Spring 2010 Site Prep	Disk April 14 and June 1	Disk May 20
Planting Date	June 9 and 10	17-Jun-10
Weed Control to Date	flumioxazin (10oz/ac) on June 13	fluazifop-P-butyl (12 fl oz/ac) on June 21
Variety Entries	Fish Creek, SX 61, Fabius, Canastota, SV1, SX64, Tully Champion, Sherburne, Millbrook, Native Willow, DN5 Poplar	Fish Creek, SX 61, Fabius, Canastota, SV1, SX64, Tully Champion, Sherburne, Millbrook, Native1, NM6 Poplar

Table 3. Willow Clone Trial Site and Establishment Information.

Willow Nitrogen Trial

Trial Objective: To evaluate the response of various clones of hybrid willow to different rates of spring-applied urea fertilizer.

Established: June 9, 2010

In order to develop nitrogen rate guidelines for willow biomass production, a nitrogen trial was established at the Ashland site. The trial was established immediately adjacent to the willow clone trial with the same site preparation, planting dates, and weed control. The trial was arranged as a RCB with a strip-strip plot design with three replications. The strip-plots are nitrogen rate of 0, 40, 80, 120 units of N and the split plots are willow variety. Each strip-plot consists of two, 60' rows spaced 2.5' apart with a 2' in-row plant spacing. Willow varieties include: Fish Creek, Fabius, SX 61, Canastota, and NM6 poplar. The nitrogen treatments will be applied in the spring of 2011. See Appendix 1 for a plot map.

Hybrid Poplar Trials

Hybrid Poplar Clone Trials

Trial Objective: To evaluate the establishment, growth, and disease resistance of select hybrid poplar clones from the NRRI breeding program.

Established: May 18-20, 2010

Biomass yield data from a five-acre planting of NM6 poplar established in 1999 at the Ashland site suggests NM6 may not be the most productive poplar clone for the soils and climate of the region. A 2.5 dry ton/ac/yr biomass yield is less than reported for other poplar plantations. In order to determine more suitable clones for the region, a clone trial was established at both the Ashland and Port Wing site. Each trial site is planted with six replications of 70 different clones. The clones are from the NRRI breeding program coordinated by Bill Berguson. At both sites, the rows are 10' apart and the plants are 8' apart within the rows. Table 4 summarizes the site preparation and maintenance actions to date.

	Ashland	Port Wing
Soil Type	480B Portwing-Herbster silt loam over clay	262B Amnicon-Cuttre silty clay loam over clay
2009 Crop	Barley underseeded with yellow sweet clover	Sheep pasture (grass hay)
Fall 2009 Site Prep	Chisel plow and disk	glyphosate followed by disk
Spring 2010 Site Prep	Disk April 14 and June 1	Disk May 20
Planting Date	May 18-19	May 19-20
Weed Control to Date	clopyralid (Transline at 0.5pt/ac) strips on June 7, spot hand- weeding in strips on July 7, cultivator on July 17	fluazifop-P-butyl (Fusilade DX 12 fl oz/ac) on June 7, spot hand-weeding on July 9, mowing July 15

Table 4. Hybrid Poplar Clone Trial Site and Establishment Information.

Poplar Mulch Trials (Planned for 2011)

An alternative to a living smother crop for weed control and soil quality protection is a mulch crop. Sorghum-sudangrass was broadcast seeded at a rate of 25lbs/ac on a disked field and rolled with a cultipacker. The sorghum-sudangrass will be allowed to grow all year to be killed by the winter. In the spring the biomass will be rolled to create a mulch. The hybrid poplar and willow will be hand-planted into the mulch.

Poplar Spring Grain Alley-Cropping Trial (Ashland only)

Trial Objective: To evaluate and demonstrate an alley-cropping woody biomass production system.

Established: May 10, 2010

Alley-cropping is an agroforestry practice that takes advantage of lighter winds and higher humidity between rows of woody perennials to boost productivity of annual crops. The primary advantage of alley-cropping is utilization of growing space that is otherwise wasted as the woody row-crops mature. Hog fuel markets make alley-cropping more viable, because the increased branching of the woody perennials created by the wide row spacing in alley-cropping is acceptable in contrast to boltwood production where clear bolts (minimal branching) are desired.

The primary objective of the trial is to quantify and demonstrate the tradeoff of a reduction of biomass yield in return for revenue from annual crops during the establishment years. The high cost of establishment and the delayed return on investment is the primary roadblock to more widespread adoption of hybrid poplar production. Revenue from a cash crop during the establishment years via alley-cropping may make the production scenario more attractive to potential growers. Table 5 summarizes the site preparation and management actions to date.

For this trial, oats were seeded in the spring of 2010 and hybrid poplar was planted on May 10 in rows spaced 18' apart. The 18' will accommodate a small self-propelled combine. Within rows, the poplar was spaced 4', 8', or 12' apart. Yellow sweetclover was underseeded in the previous year's barley crop and despite tillage, persisted into the 2010 season. Transline (clopyralid) was applied in a 4' strip application when the poplar had 4 leaves (June 7) to kill the yellow sweetclover. Fusilade DX (fluazifop) was applied as a 2' strip application when the poplar had 8 leaves (June 24) to kill the competing oats. Ideally, the Transline and Fusilade DX should have been applied as a tank mix in the 4' strip application to fully release the poplar. As a result the 2' strip application of Fusilade was insufficient to release the poplar from competition from the oats. To simulate the wider application, the oats were mowed on either side of the poplar row on July 15 to create a 2' vegetation free strip on either side of the poplar. The oats will be harvested at maturity and field peas will be seeded in 2011.



Oat Alley-Cropping, July 6, 2010



Oat Alley-Cropping, July 22, 2010

Poplar Hay Alley-Cropping Trial

Trial Objective: To evaluate and demonstrate an alley-cropping woody biomass production system.

Established: Ashland: May 10, 2010; Port Wing: May 15, 2010

An alternative to growing row crops in alley-cropping systems is producing a forage crop. Such a system would be particularly applicable to the Lake Superior region where there is considerable forage production. The trial was established at both the Ashland and Port Wing sites.

At Ashland, the trial was established exactly the same way as the spring grain trial. On July 9, the alleys were mowed and the oat/sweetclover hay was baled. The 18' row-spacing would be perfect for a self-propelled discbine. However, the only equipment available was a traditional off-set haybine. Given the spacing, the operator was not able to harvest all the hay between the poplar rows. So, to simulate the haying, any areas missed by the haybine were mowed with a flail mower.

At the Port Wing site, 4' wide strips were sprayed with glyphosate in the fall of 2009 to kill the grass sod. In the spring of 2010, a one-bottom plow was used to open a planting furrow in the middle of each strip. The strip was then dragged immediately prior to planting. The DN5 poplar was planted on May 15 with DN5 with 18' row spacing and 4', 8', or 12' plant spacing within the rows. See Appendix 1 for a full plot layout. The rows were spot-weeded by hand on July 15 and the alleys were mowed.

Poplar Winter Grain Trials (Ashland only)

Trial Objective: To evaluate the potential for establishing hybrid poplar in winter grains.

Established: May 7, 2010

A major concern of traditional hybrid poplar production with respect to soil erosion and carbon cycling is the clean tillage practiced in the establishment years. The clean tillage exposes the soil to erosion, oxidizes soil carbon, and requires significant energy inputs. The system does maximize poplar establishment and growth.

The objective of this trial is to determine whether hybrid poplar can be established in a winter grain that is allowed to mature and be harvested as a cash crop. The advantage of such a system is the winter grain acts as a smother crop and eliminates a need for weed control while providing a cash crop in the year of planting. The disadvantage is the obvious competition with the poplar. However, because the winter grain is typically harvested in late-July or early-August, there is still time for hybrid poplar growth assuming there is adequate moisture available and the poplar was able to establish while the grain was maturing.

For this trial, winter rye was seeded at 1 bushel/acre on October 1, 2009. The late and light seeding was done intentionally to minimize the rye stand density.

DN5 hybrid poplar was planted on May 7 with 18' row spacing and 4', 8', or 12' in-row plant spacing. The rye was allowed to grow and will be harvested when mature. The hybrid poplar has sprouted and has 6-8 leaves. There is clearly competition from the rye, as was expected. Total growth in 2010 and 2011 will be the primary measures of rye competition.

Tree Plantation Trials

Poplar and Pine

Trial Objective: To evaluate and demonstrate the use of hybrid poplar in pine tree plantations. To evaluate the growth of red pine and white pine compared to hybrid poplar.

Established: Ashland: May 10, 2010; Port Wing: May 15, 2010

Another potential use for hybrid poplar is as a nurse or short-rotation crop in a traditional conifer tree plantation. Establishing stands of pines is expensive with little to no revenue until the first thinning at year 15 or so. Alternating hybrid poplar rows with the conifer trees would allow for a poplar harvest as early as year 5.

For this trial, hybrid poplar was planted in alternating rows with white pine or red pine. Rows are spaced 10' apart and the plants are also 10' apart. See Appendix 1 for a full plot layout at each site.

Another problem with traditional tree plantations is the lack of biodiversity. For each pine block, a single row of poplar alternating with native aspen was established with a ten foot plant spacing. In 5 years, the poplar/aspen row will be harvested and the aspen will sucker to fill the row and possibly mix with the adjacent pine rows. The result should be a more natural-looking and more biodiverse tree planting with some revenue generated at year 5.

At the Ashland site, 4' strips were tilled into the barley stubble in the fall of 2009 with a three-bottom chisel plow. The underseeded yellow sweetclover was allowed to grow in the row-middles. In the spring of 2010, the rows were dragged to smooth the surface and the trees were planted in early-May. Clopyralid (Transline) was applied when the poplar had 4-6 leaves to kill the sweetclover that was growing in the tilled rows. One week following the herbicide application the row-middles were mowed with a flail mower. On July 10, the rows were hand-weeded and the 3' on either side of the hybrid poplar rows were rotovated.

At the Port Wing site, the entire field was disked in the fall of 2009 and again in the spring of 2010 immediately prior to planting during the week of May 10. Fluazifop (Fusilade DX) was applied on June 7 to control the dense populations of foxtail and patches of quackgrass. The entire area was mowed on July 17 and a follow-up application of fluazifop was applied on July 22 to control grass weeds.



Chisel-plowing strips for the tree rows rather than clean cultivation in the entire field allowed the underseeded sweet clover from the previous cropping season to serve as a cover crop, insectiary, and source of organic matter in the row middles. Furthermore, the strips were created with a small horsepower tractor, saving fuel. The chisel plowing was necessary to break up the compacted soils resulting from 3 years of previous annual row cropping.

Poplar and Larch

Trial Objective: To evaluate and demonstrate the use of hybrid poplar in tamarack and hybrid larch plantations. To compare the growth rates of native tamarack and hybrid larch.

Established: Ashland: May 10, 2010; Port Wing: May 15, 2010

Tamarack and hybrid larch have potential as a woody biomass crop, particularly on heavy clay soils. Mixed plantations of hybrid poplar and larch may be an option to increase diversity in a woody biomass plantation to hedge against insect and disease outbreaks or shifts in climate.

For this trial, hybrid poplar was planted in alternating rows with native tamarack or hybrid larch. As in the pine plantings the rows are spaced 10' apart and the plants within the rows are planted 10' apart. For each larch block, a single row of poplar alternating with native aspen was established with a ten foot plant spacing. In 5 years, the poplar/aspen row will be harvested and the aspen will sucker to fill the row and possibly mix with the adjacent larch rows. The result should be a more natural-looking and more biodiverse tree planting with some revenue generated at year 5.

	Ashland	Port Wing
Soil Type	480B Portwing-Herbster silt loam over clay	262B Amnicon-Cuttre silty clay loam over clay
2009 Crop	Barley underseeded with yellow sweet clover	Sheep pasture (grass hay)
Fall 2009 Site Prep	Chisel plow and disk	glyphosate followed by disk
Spring 2010 Site Prep	Disk April 14 and June 1	Disk May 20
Planting Date	10-May-10	15-May-10
Weed Control to Date	clopyralid (Transline at 0.5pt/ac) strips on June 7, spot hand- weeding in strips on July 7, rotovator on July 12	fluazifop-P-butyl (Fusilade DX 12 fl oz/ac) on June 7 and July 22, mowing July 15

Table 5. Tree Plantation Trial site preparation and management information.

Woody Biomass Re-Plant Trials

Hybrid Poplar Re-Plant Trials (Ashland and Spooner)

Trial Objectives: To evaluate the effect of site preparation and stump sprouting on establishment and growth of replanted poplar and willow in harvested hybrid poplar stands. To evaluate the potential for cop-pice harvest of willow and poplar mixtures.

Established: May, 2010

A potential revenue source for hybrid poplar is payment for carbon sequestration. Because the woody biomass will be harvested and burned directly or transformed into a burnable liquid fuel the majority of long-term carbon sequestration will occur in below-ground biomass. The amount of sequestered carbon is unknown, but it is clear post-harvest management, particularly site-preparation in advance of re-planting will be a key factor in the carbon cycle of the plantings.

A five-acre stand of NM6 hybrid poplar was planted in the same season at both the Ashland Agricultural Research Station and the Spooner Agricultural Research Station in 1999. These stands were harvested in February-March 2010 and are being used for the re-plant trial. The primary objective of the trial is to evaluate the establishment and yield of re-planted willow and hybrid poplar as affected by site preparation and management of poplar stump sprouts.

The full plot map of the trial at both sites is located in Appendix 1. The whole plot treatments are: DN5 hybrid poplar, Canastota willow, Fish Creek willow. The site preparation split-plot treatments are:

- Scraping to remove all surface residue, followed by two passes with a chisel plow equipped with a root blade, followed by a rotovator.
- Scraping to remove all surface residue, followed by one pass with a rotovator.
- No disturbance.

At the Spooner site, a disk was used instead of a chisel plow, however, there wasn't enough weight on the disk to achieve more than 2-3 inches of tillage.

In half the trial, the stump sprouts are controlled with herbicides or mowing and in the other half the stump sprouts are allowed to grow. In the poplar treatment plots, the replanted poplar were planted between the harvested poplar rows with a 10' plant spacing. In the willow treatment plots, the willow was planted between the harvested poplar rows with 2 rows spaced 2.5' apart with plants spaced 2' apart. In the poplar plots, Sure-guard was applied immediately after planting in spot



A four point chisel plow equipped with a root blade worked well to till and sever roots.



Site preparation following a poplar harvest will affect carbon cycling. In this trial, chisel plowing, rotovating, and no-till are evaluated as options when replanting poplar and willow.

applications around each plant. In the willow rows, Sureguard was applied immediately after planting in strip applications down each row.

The planting arrangement used for this trial creates some interesting harvest options. The stump sprouts from the harvested poplar will never make decent boltwood unless the sprouts are thinned and even then the sprouts will be weakly attached to the stump and likely susceptible to windthrow. However, the stump sprouts could be coppice harvested as hog fuel similar to willow production scenarios, either with the interplanted willow or as a separate harvest to release the willow. The biomass production volume from coppiced poplar stump sprouts is unknown. Although hybrid poplar is not supposed to sucker, it is clear thus far that significant sprouting is occurring from buried harvest residues and exposed root material at the Spooner site (see photo). This re-growth is likely to compete with the re-planted poplar and willow, but in the case of willow may be set back significantly by the coppice harvest at the end of the first year of the willow growth.



Rotovating to prepare for replanting may result in better willow establishment but seems to create higher weed pressures. Photo taken July 6. Ashland site.



Replanting willow directing into harvest residue may be a good option to follow a hybrid poplar harvest. It provides species diversity in time, maintains soil carbon, and reduces weed competition. The trial is evaluating the effect on willow establishment and growth. Photo taken July 6. Ashland site.

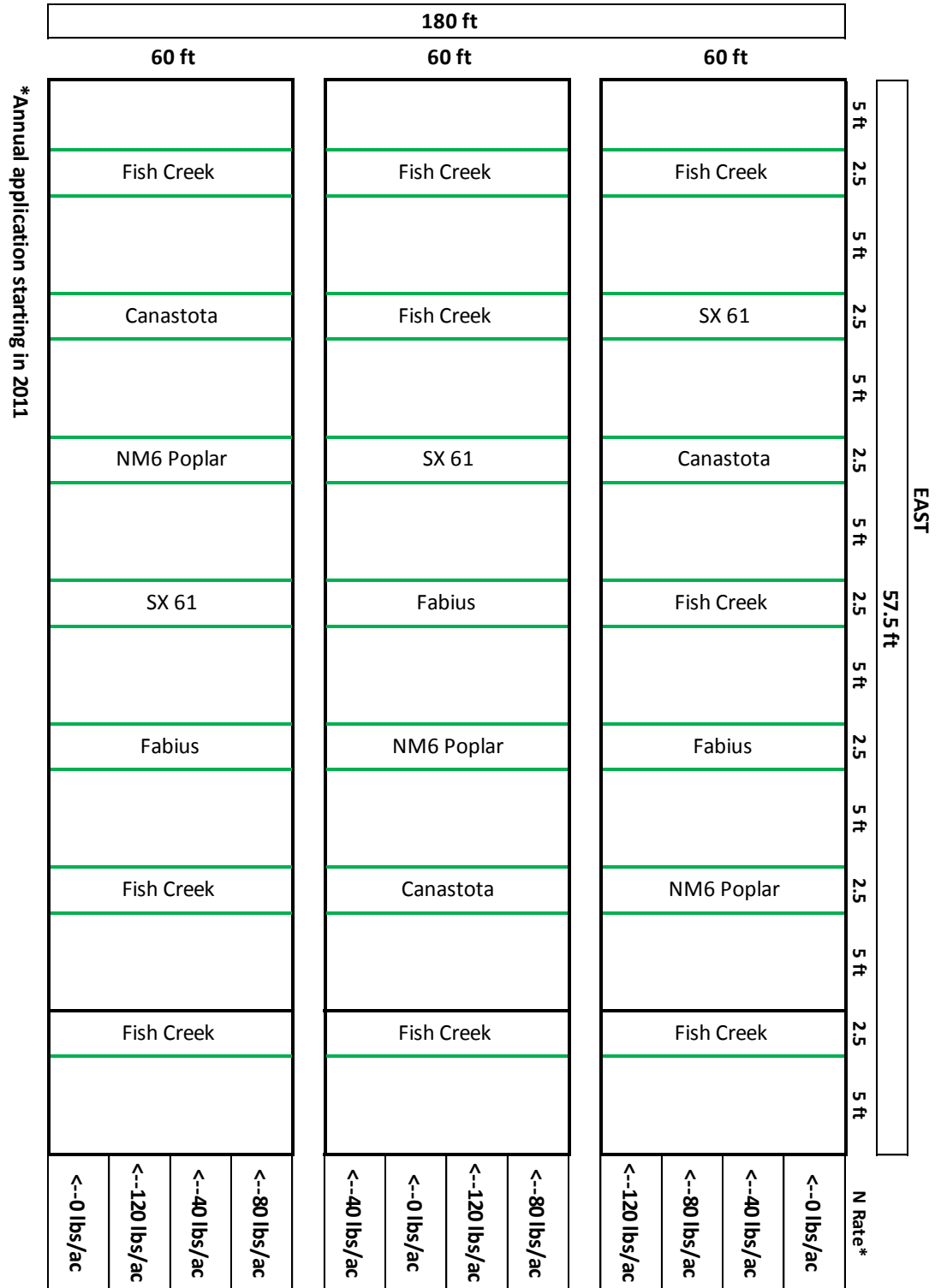


Rotovating at the Spooner site seems to have stimulated root suckering creating significant competition with replanted poplar and willow. The effect of a coppice harvest on the willow and poplar sprouts is unknown. Photo taken July 20. Spooner site.



The effect of the stump sprouts on the willow establishment and weed control is being evaluated in this trial. The sprouts in the foreground have been mechanically severed while the sprouts in the background are allowed to grow. Photo taken July 6. Ashland site.

Willow Nitrogen Trial—Ashland



Hybrid Poplar Alley-Cropping Trials—Ashland

NORTH			
Row #	4 ft plant spacing	8 ft plant spacing	12 ft plant spacing
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
400 ft			

**Spring Grain
Alley-Cropping**

**Winter Grain
Alley-Cropping**

**Hay
Alley-Cropping**

Hybrid Poplar Alley-Cropping Trials—Port Wing

			117 ft	117 ft	117 ft	Row
						1
						2
						3
						4
						5
						6
						7
						8
						9
						10
						11
						12
			4 ft plant spacing	8 ft plant spacing	12 ft plant spacing	

NORTH

18 ft row spacing

Hay Alley-Cropping

Grain Alley-Cropping

Hybrid Poplar Clone Trial Ashland

- Rep 4
- Rep 3
- Rep 2
- Rep 1
- Rep 5
- Rep 6

110 ft										
9732-48	99059019	23070 33014	99038003	99037051	21400	22021008	99037051			
99059016	9732-32	22033018	99037049	99008081	41700	99038013	99105088			
23001 03057	99007115	23076 21006	99038022	22021009	22057059	22057006	21700			
9732-40	99038036	23079 17041	9732-19	99037017	22021018	22033013	99008081			
99105008	99008002	22090013	99001111	22021051	99038002	99059043	99037017			
23071 33042	22021021	99007071	23070 02099	99008098	NM6	9732-24	22021009			
22091022	23079 17047	23300	22021048	22057002	DN5	9732-07	5912917			
22057011	99038007	99007116	99037046	5912917	23057 32006	23001 03071	99008098			
D113	9732-36	23070 27001	21700	252-4	9732-18	D124	21400			
99007108	23079 17069	9732-11	99105088	99008070	23059 32018	9732-31	22021051			
5912917	99008070	22033013	9732-24	23001 03071	23059 32018	9732-07	22021021			
99008098	99038013	22021018	99059043	NM6	DN5	9732-18	99037049			
23079 17069	99105088	21400	252-4	22021008	99038002	23057 32006	99105008			
23079 17041	22057011	D113	99007108	23070 27001	99059016	9732-11	99007115 extra fill			
9732-19	99038007	D124	9732-32	99059019	23079 17047	99105008	99037046		DN5	
9732-36	9732-40	99007116	23300	23070 02099	99037046	21700	23070 02099			
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23001 03057	99007115	99038022	99037049	99037017	9732-07	23059 32018	23071 33042			
D124	23070 27001	23076 21006	99105008	99105088	22057006	21400	22033018			
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9732-48	23300	99001111	252-4	22033013	9732-18	23059 32018	22091022	41700		
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D124	99059019	99008002	22057006	22021008	NM6	9732-24	9732-36	252-4		
9732-31	99038022	22021021	22057059	5912917	99059043	23057 32006	23079 17041	22021018		
9732-40	23076 21006	23070 33014	99008098	21400	99038002	23001 03071	99038003	99038002		
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9732-36	99038007	99038036	99105008	99038003	23070 02099	9732-19	9732-31	23059 32018		
D113	9732-11	99059016	22033018	99037049	22090013	22057011	23001 03057	23001 03071		
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D113	D124	99059019	99001111	99105088	99008070	9732-07	9732-19	22057059		
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22057011	23079 17069	99105008	22021021	22021009	22057006	9732-36	22057011	9732-18		
Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	Row 9	Row 10	Row 11

Hybrid Poplar Clone Trial—Port Wing

- Rep 4
- Rep 3
- Rep 2
- Rep 1
- Rep 5
- Rep 6

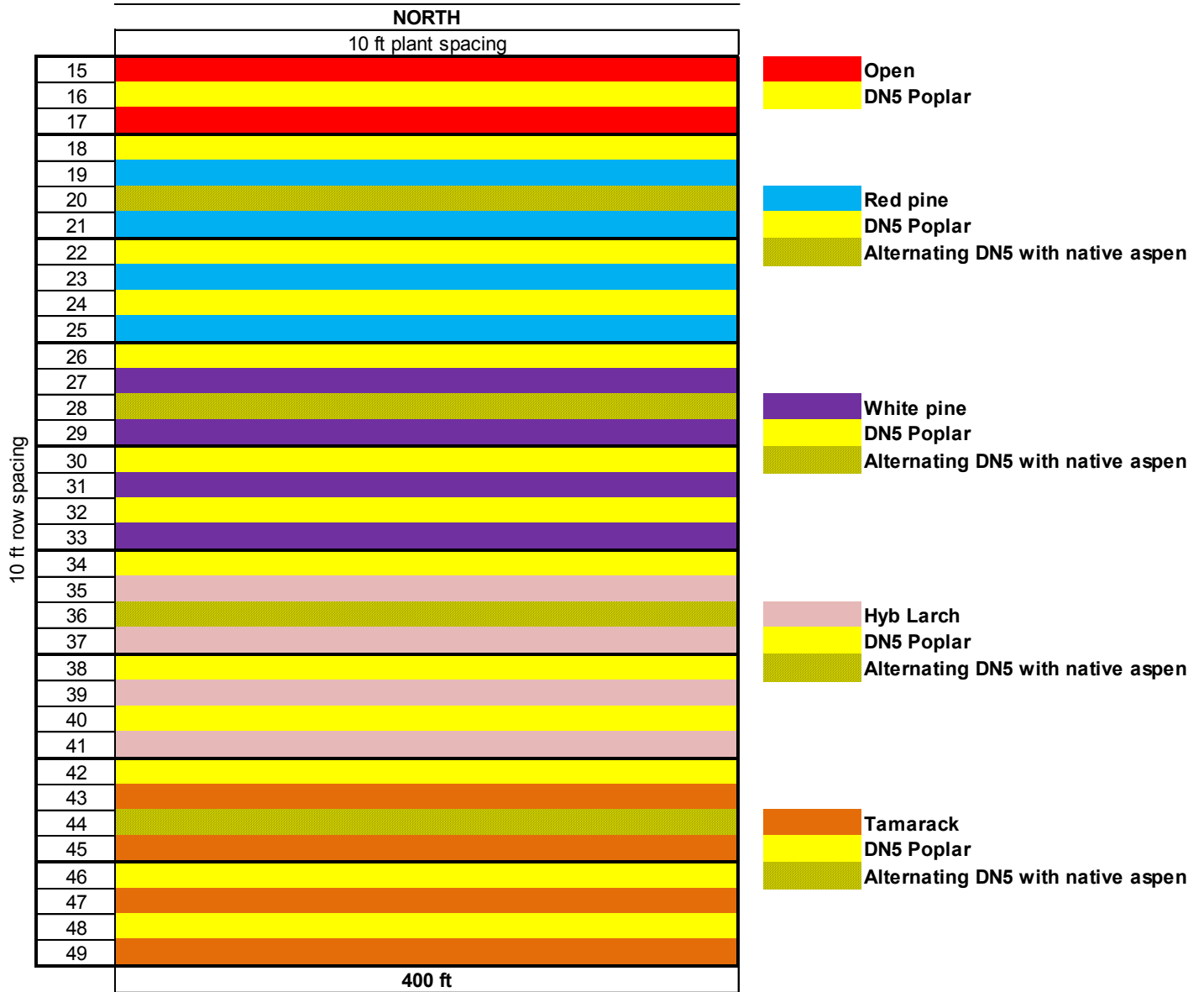
336'										
NM6 BORDER ROW										
Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	Row 9	Row 10	Row 11
5912917	99008070	22033013	9732-24	23001 03071	23059 32018	9732-07	22021008	41700		
99008098	99038013	22021018	99059043	NM6	DN5	9732-18	99038013	99038013		
23079 17069	99105088	21400	252-4	22021008	99038002	23057 32006	22057006	252-4		
23079 17041	22057011	D113	99007108	23070 27001	99059016	9732-11	22033013	22021018		
9732-19	99038007	D124	9732-32	99059019	23079 17047	99105008	99059043	99038002		NM6
9732-36	9732-40	99007116	23300	23070 02099	99037046	21700	9732-24	23057 32006		
9732-48	23001 03057	23076 21006	99037049	22021048	99037017	22021051	9732-07	9732-24		
22091022	99007115	99038022	99008002	99037051	22057002	41700	23001 03071	9732-07		
22033018	23071 33042	23070 33014	99038003	99008081	22057059	22057006	D124	23059 32018		
22021021	99007071	22090013	99001111	22021009	99038036	9732-31	9732-31	23001 03071		
23001 03057	99007115	99038022	99037049	99037017	9732-07	23059 32018	99037051	21400	99037051	22057002
D124	23070 27001	23076 21006	99105008	99105088	22057006	21400	99008081	41700	99105088	22057006
99059016	22091022	99007116	22033018	22021048	99008081	22021051	22021009	22057059	21700	22057059
99038007	9732-31	22057011	9732-36	23079 17069	9732-48	9732-11	99037017	22021018	99008081	99008070
9732-32	99059019	23079 17047	23070 02099	99037046	99008098	99008070	22021051	99038002	99037017	22021008
22090013	99038003	99001111	99037051	41700	22021018	99059043	99008098	NM6	22021009	22033013
22021021	99008002	99007071	21700	99038013	22033013	DN5	22057002	DN5	5912917	99059043
23300	23071 33042	23070 33014	22021009	5912917	99038002	9732-24	5912917	23057 32006	99008098	NM6
99038036	9732-40	D113	22057002	252-4	NM6	9732-18	252-4	9732-18	21400	DN5
23079 17041	9732-19	99007108	22057059	22021008	23057 32006	23001 03071	99008070	23059 32018	22021051	9732-18
9732-48	23300	99001111	252-4	22033013	9732-18	23059 32018	23070 33014	99038003	23071 33042	22021021
23070 27001	23079 17047	99007071	99038013	22021018	DN5	9732-07	22033018	99037049	22033018	99037049
D124	99059019	99008002	22057006	22021008	NM6	9732-24	23076 21006	99038022	23079 17069	99105008
9732-31	99038022	22021021	22057059	5912917	99059043	23057 32006	23079 17041	9732-19	D113	99007115 extra fill
9732-40	23076 21006	23070 33014	99008098	21400	99038002	23001 03071	99007071	99001111	22021048	99037046
23079 17041	99007116	23071 33042	22021009	22057002	41700	99008070	99007071	23070 02099	99001111	23070 02099
23079 17069	99007115	9732-32	99105088	99008081	99037017	22021051	23300	22021048	23079 17047	23300
99007108	23001 03057	22091022	22021048	99037046	99037051	21700	99007116	99037046	9732-11	99007115
9732-36	99038007	99038036	99105008	99038003	23070 02099	9732-19	23070 27001	21700	99038007	99059019
D113	9732-11	99059016	22033018	99037049	22090013	22057011	9732-11	99105088	99059016	23076 21006
9732-32	23079 17047	99037049	99008002	99037051	22057059	23057 32006	9732-48	99059019	D124	22091022
9732-11	23076 21006	99038022	22090013	21700	5912917	9732-18	99059016	9732-32	9732-32	99038022
D113	D124	99059019	99007115	99105088	99008070	9732-07	23001 03057	99007115	9732-19	9732-36
9732-31	23079 17041	99007115	23070 02099	22021051	NM6	DN5	9732-40	99038036	9732-40	23079 17041
23001 03057	23070 27001	99007116	22021048	99008098	99038002	23001 03071	99105008	99008002	99007071	99038003
9732-48	22091022	23300	99037046	22057002	22033013	23059 32018	23071 33042	22021021	99008002	22090013
99007108	99059016	22033018	99008081	99038013	22021008	9732-24	22091022	23079 17047	23070 27001	99007116
99038036	9732-19	23071 33042	99038003	41700	252-4	99059043	22057011	99038007	99007108	9732-48
99038007	9732-40	23070 33014	99007071	99037017	21400	22021018	D113	9732-36	99038036	9732-31
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NORTH

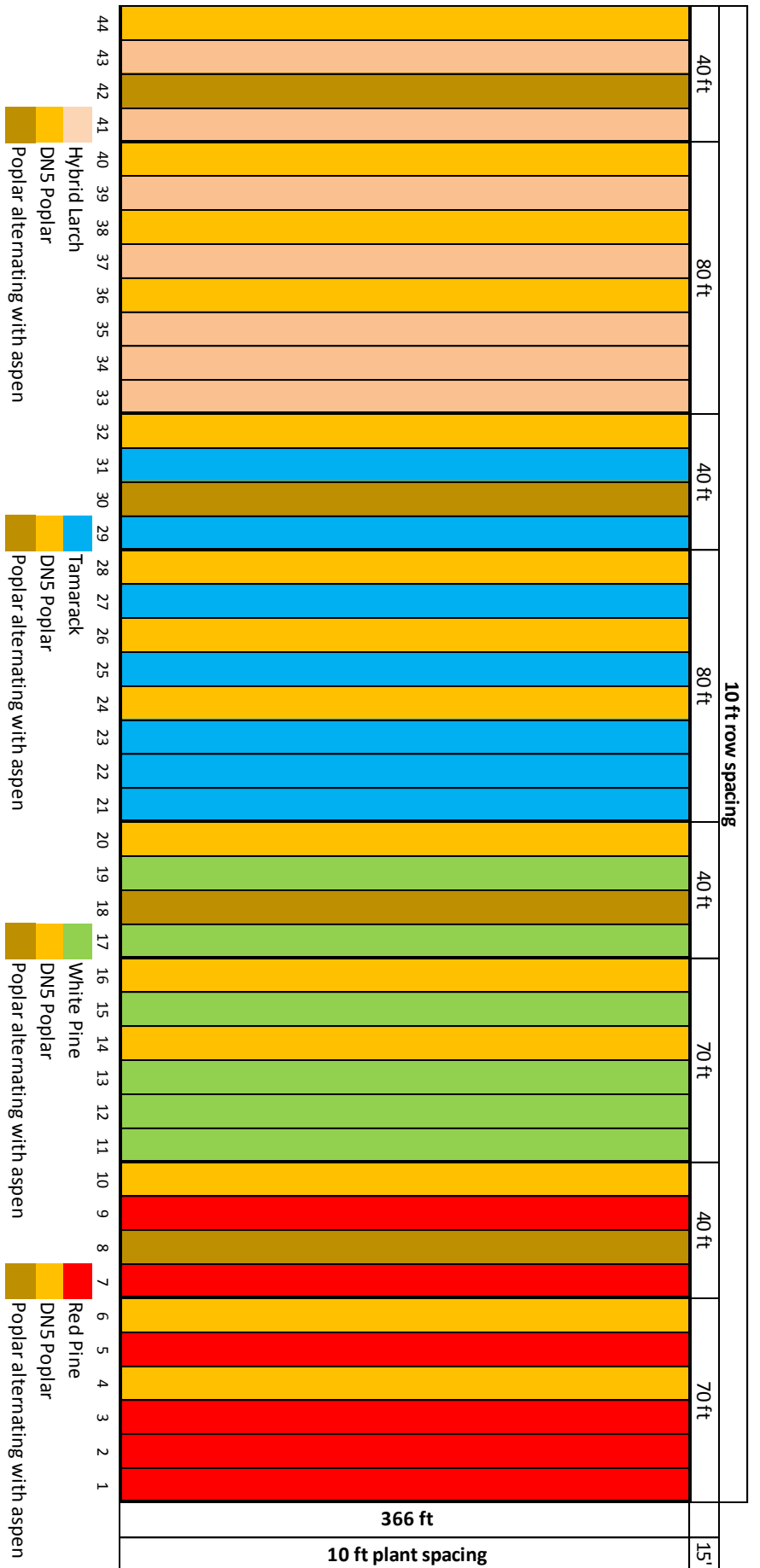
NM6 Border Row

NM6 Border Row

Tree Plantation Trials—Ashland

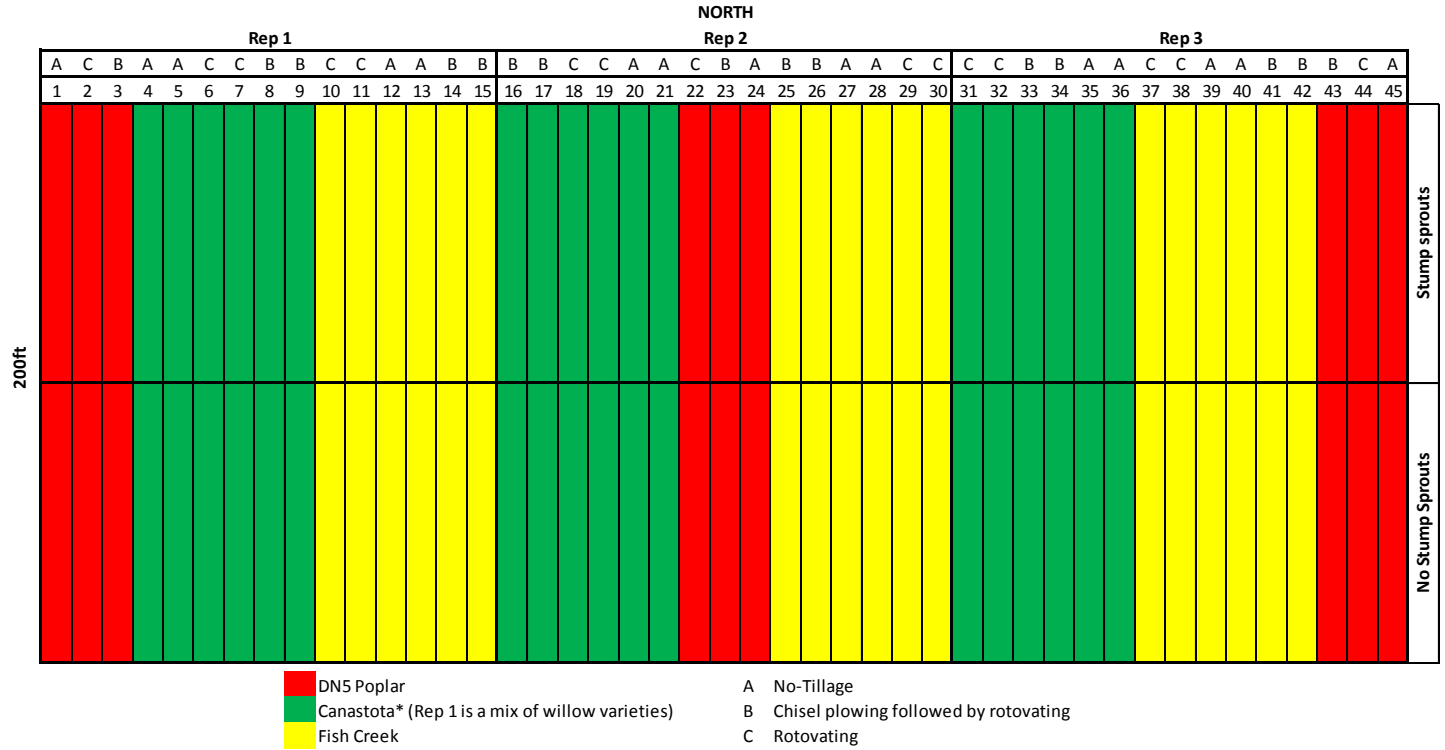


WEST



Tree Plantation Trials
Port Wing

Hybrid Poplar Re-Plant Trial—Ashland



Hybrid Poplar Re-Plant Trial—Spooner

