Contrasting ecosystem services of hybrid poplar and white pine in the Lake States, USA

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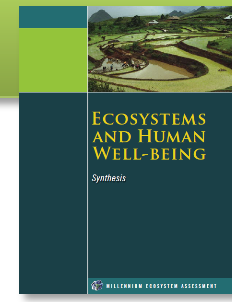
Ecosystem Services



Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington. 155pp.

"The benefits people obtain from ecosystems"

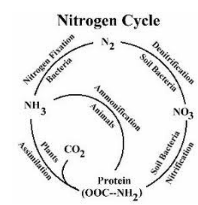
(Source: http://www.greenfacts.org/glossary/def/ecosystem-services.htm)

Cultural Services
The nonmaterial benefits obtained from ecosystems (e.g., values)

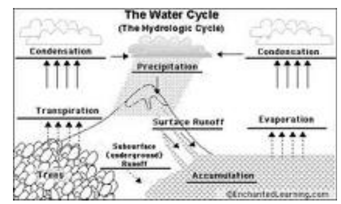
Spiritual

Educational

Supporting Services
The natural processes that maintain the other ecosystem services



Nitrogen



Water

Provisioning Services
The goods or products obtained from ecosystems

Freshwater

Biomass

Regulating Services
The benefits obtained from an ecosystem's control of natural processes

Erosion Control

Soil Quality

Ecosystem Services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Indicators for assessing socioeconomic sustainability of bioenergy systems: A short list of practical measures

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Provisioning Services
Aboveground Biomass

Regulating Services
Aboveground Carbon Sequestration

Hybrid Poplar & White Pine

***Populus* spp. & hybrids**

***Pinus strobus* L.**

Rationale

- Both genera exhibit ecological & economic importance for providing ecosystem services
- Few comparisons exist highlighting differences in their potential for providing ecosystem services, especially for biomass & carbon

Comparing Soil Carbon of Short Rotation Poplar Plantations with Agricultural Crops and Woodlots in North Central United States

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SOIL CARBON CHANGES ASSOCIATED WITH SHORT-ROTATION SYSTEMS

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Contrasting fine-root production, survival and soil CO_2 efflux in pine and poplar plantations

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Objectives

- Evaluate differences in aboveground biomass & carbon sequestration potential of hybrid poplars at rotation age (10 y) & stand decline (20 y) with mid-rotation white pine (48 y)
- Stated differently, at what ages are these potential ecosystem services for white pine comparable to that of hybrid poplar in the region?

10-yr-old 7300501

20-yr-old DN34

48-yr-old White Pine

Hybrid Poplar Clones

10-yr-olds (7 clones)

P. deltoides
C916000, C916400, C918001

P. nigra* × *P. suaveolens* subsp. *maximowiczii
NM2

(*P. trichocarpa* × *P. deltoides*) × *P. deltoides*
NC13624, NC13649, NC13563

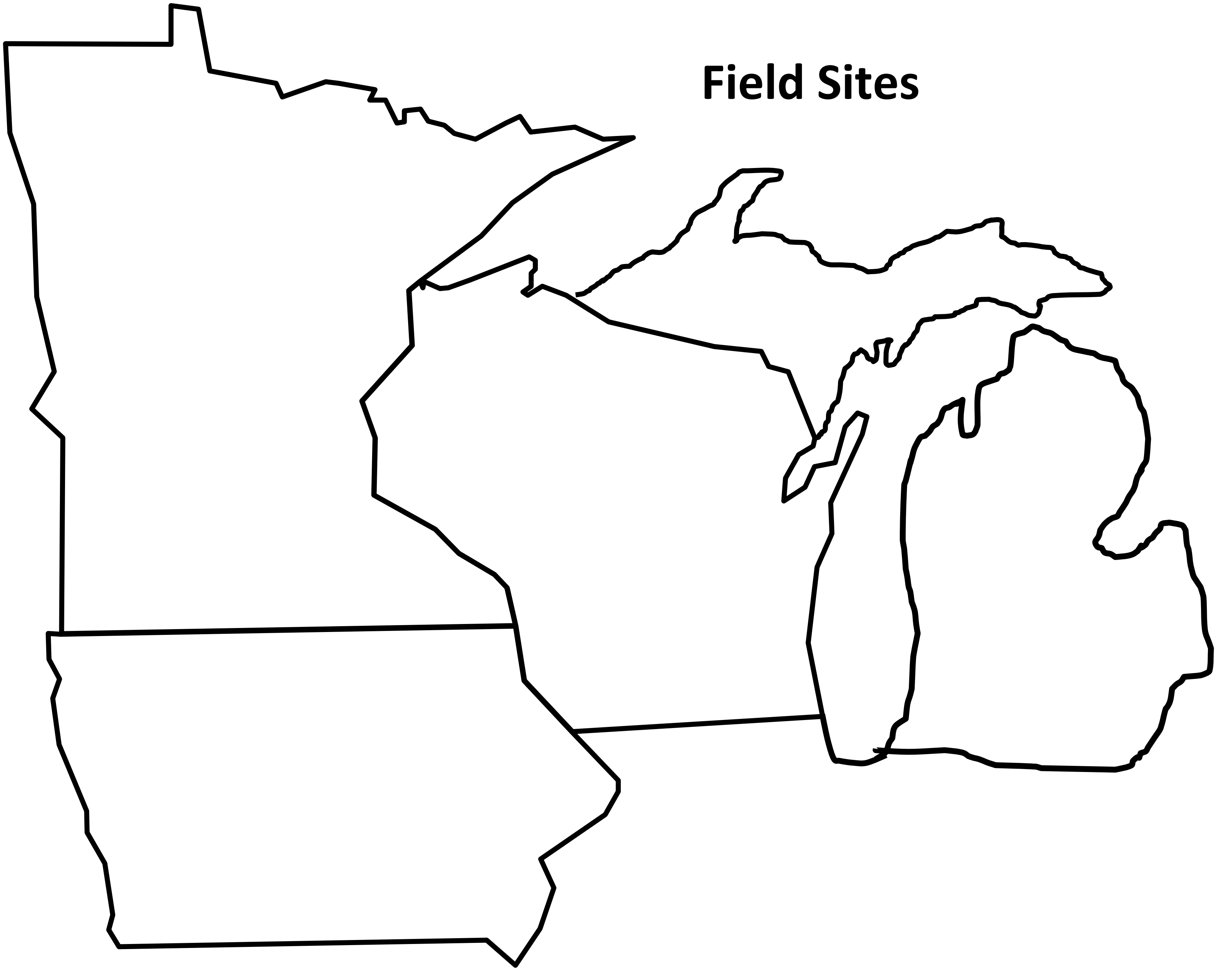
20-yr-olds (2 clones)

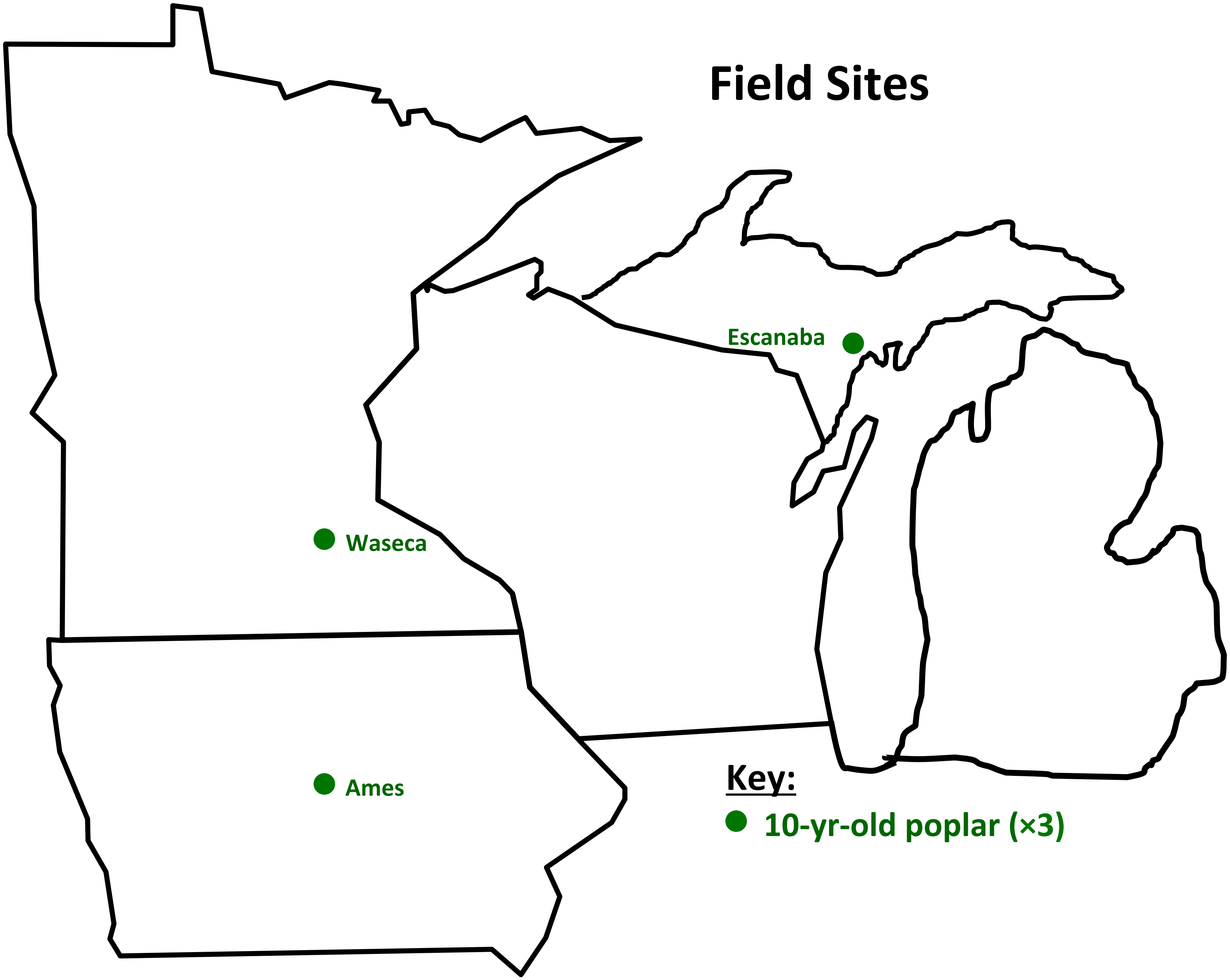
P. deltoides* × *P. nigra
DN34, DN182

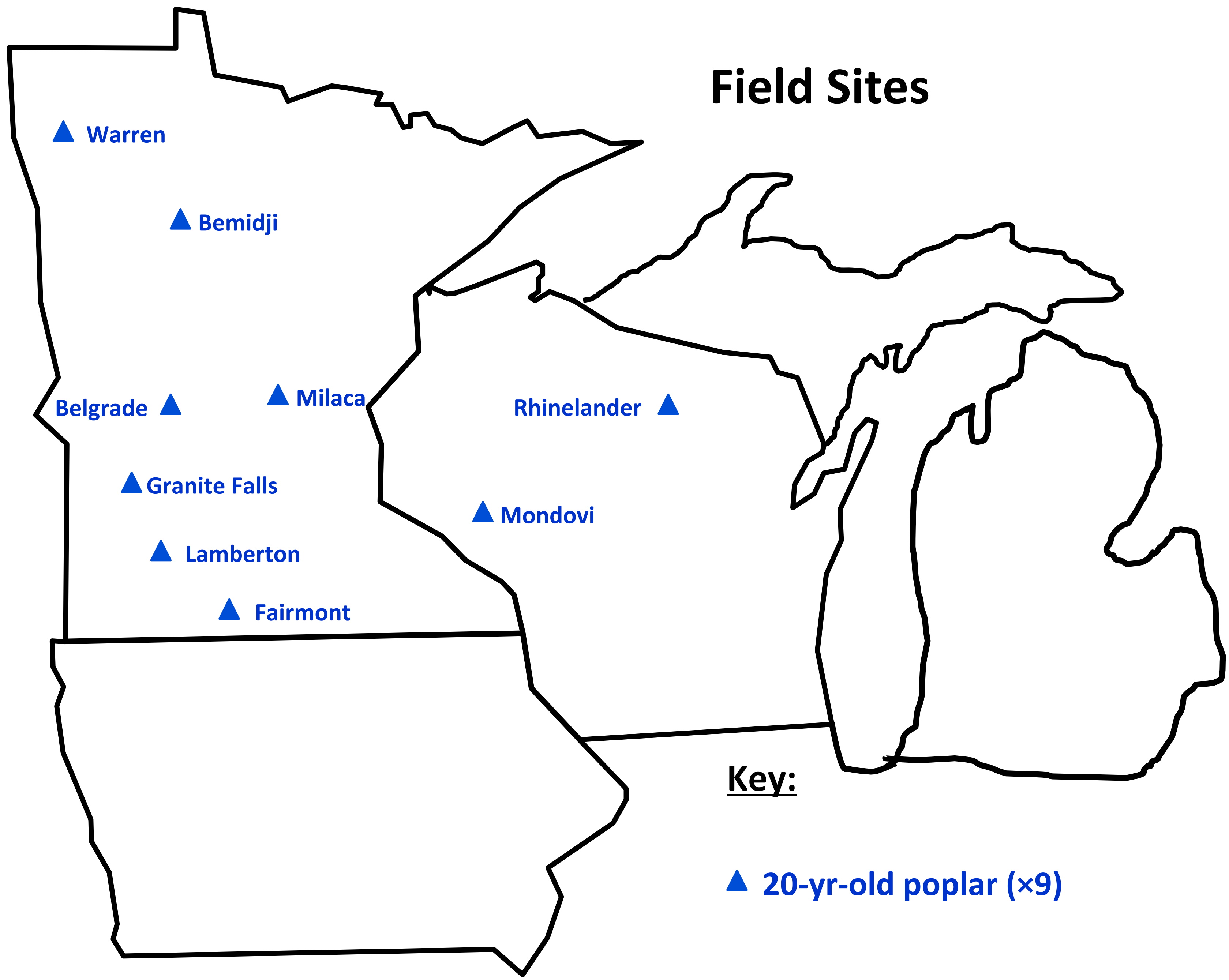
White Pine Provenances

Canada	United States	Location of Origin	Latitude	Longitude
1	1633	Union County, Georgia	34°5´	84°0´
2	1634	Greene County, Tennessee	36°0´	82°5´
3	1640	Monroe County, Pennsylvania	41°1´	75°3´
4	1639	Franklin County, New York	44°3´	74°2´
6	1632	Ashland County, Ohio	40°5´	82°2´
7	1624	Allamakee County, Iowa	43°2´	91°2´
8	1622	Cass County, Minnesota	47°2´	94°3´
9	1623	Forest County, Wisconsin	45°5´	88°5´
10	1637	Luneborg County, Nova Scotia	44°3´	64°4´
11	1635	Pontiac District, Quebec	47°3´	77°0´
12	1636	Algoma District, Ontario	46°1´	82°4´
13	1670	Newaygo County, Michigan	43°3´	85°4´

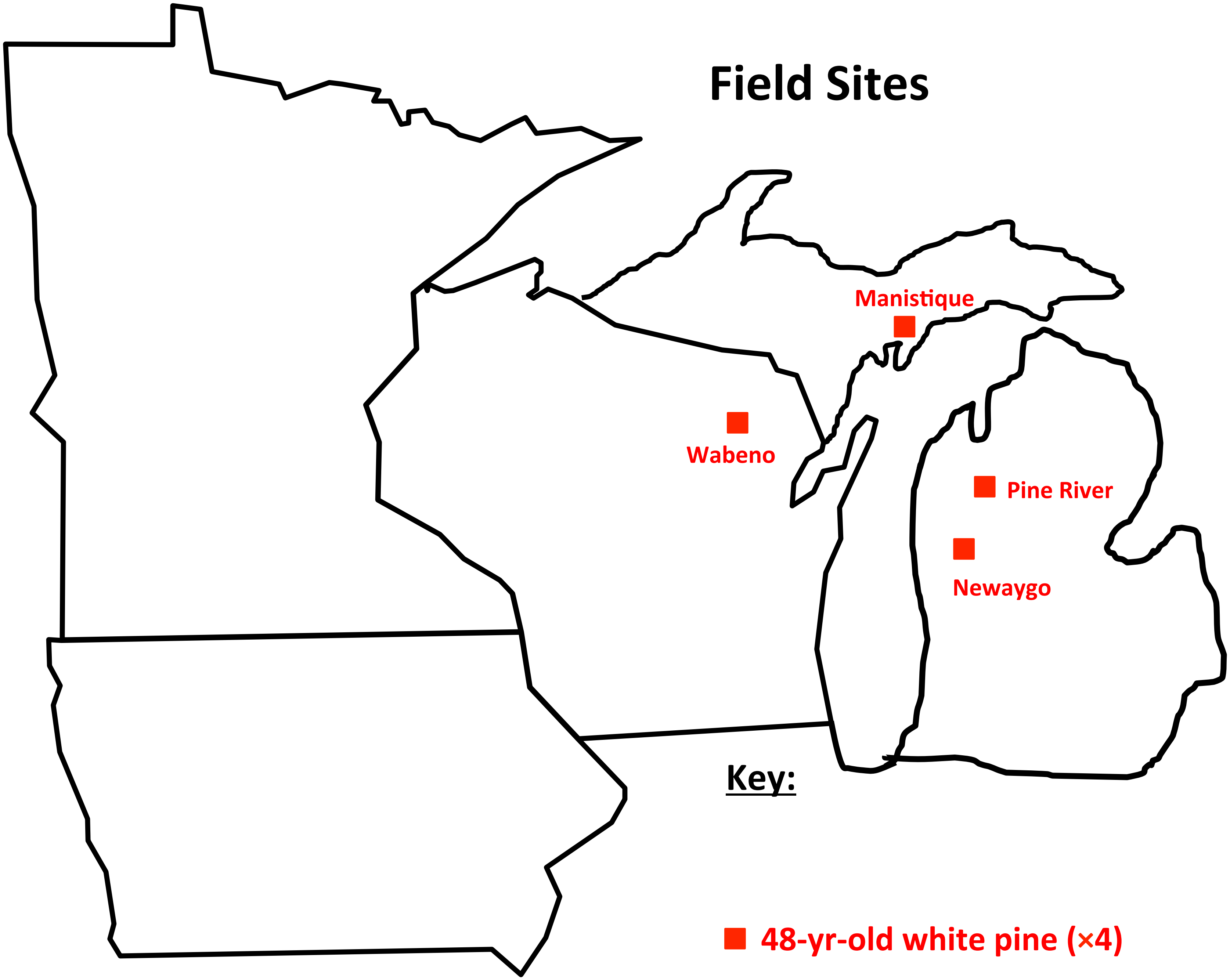
Field Sites

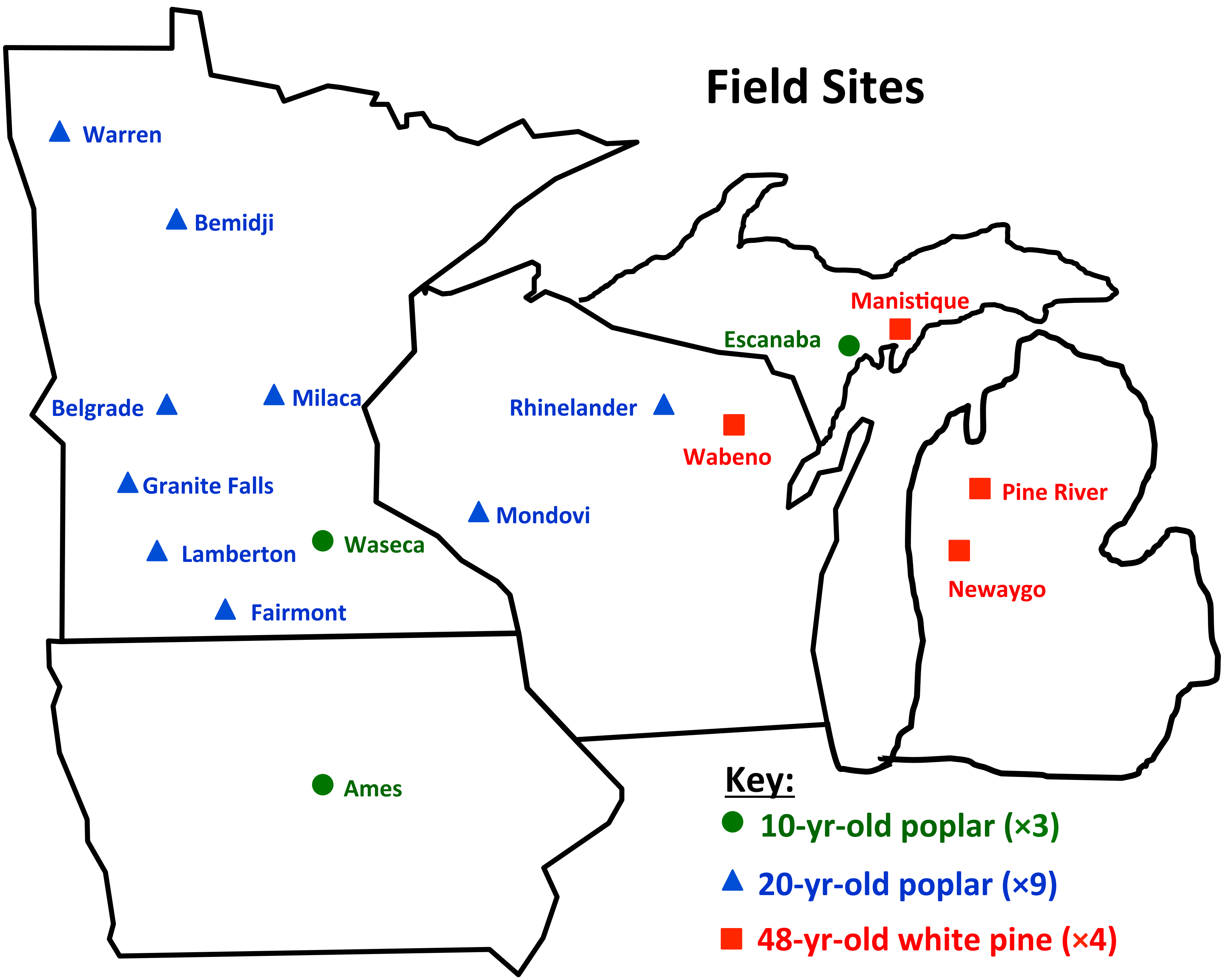



Field Sites
Escanaba
Waseca
Ames
Key:
10-yr-old poplar (×3)


Field Sites
Warren
Bemidji
Belgrade
Milaca
Rhinelander
Granite Falls
Mondovi
Lamberton
Fairmont
Key:
20-yr-old poplar (×9)

Field Sites


Manistique
Wabeno
Pine River
Newaygo
Key:
48-yr-old white pine (×4)



Field Sites
Warren
Bemidji
Belgrade
Milaca
Granite Falls
Lamberton
Waseca
Fairmont
Ames
Rhinelander
Mondovi
Wabeno
Escanaba
Manistique
Pine River
Newaygo
Key:
10-yr-old poplar (×3)
20-yr-old poplar (×9)
48-yr-old white pine (×4)

Group	State	Site	Height (m)	Lat (°N)	Long (°W)	Soil Texture
Poplar (10 y)	IA	Ames	15.1 ± 0.4	42.05	93.66	Fine Sandy Loam
	MI	Escanaba	[illegible]	45.77	87.20	Fine Sandy Loam
	MN	Waseca	16.3 ± 0.4	44.06	93.54	Clay Loam
Poplar (20 y)	MN	Belgrade	17.2 ± 0.4	45.67	95.11	Loam
	MN	Bemidji	17.9 ± 0.3	47.58	94.93	Loamy Sand
	MN	Fairmont	18.7 ± 0.2	43.69	94.35	Clay Loam
	MN	Granite Falls	[illegible]	44.80	95.52	Loam
	MN	Lamberton	[illegible]	44.25	95.29	Clay Loam
	MN	Milaca	19.4 ± 0.3	45.78	93.63	Silt Loam
	MN	Warren	20.8 ± 0.7	48.14	96.65	Fine Loamy Sand
	WI	Mondovi	19.3 ± 0.3	44.52	91.65	Silt Loam
	WI	Rhinelander	21.5 ± 0.6	45.63	89.46	Loamy Sand
White Pine	MI	Manistique	20.3 ± 0.2	46.00	86.41	Fine Sandy Loam
	MI	Newaygo	[illegible]	43.47	85.66	Sand
	MI	Pine River	19.4 ± 0.3	44.23	85.76	Sand
	WI	Wabeno	18.8 ± 0.2	45.43	88.51	Silt Loam

14.6

19.4

18.0

Hybrid Poplar Data

- Trees were harvested during the leafless period
- Cross-sectional disks were collected at dbh
- Disks were cut in half
- Wafers were processed along a plane extending through the pith
- Wood samples were extracted from each growth ring

  - Aboveground biomass
  - Carbon concentration
  - Stocking, age

- Biomass_{TOTAL} (Mg ha^{-1})
- Biomass_{MAI} ($\text{Mg ha}^{-1}\ \text{yr}^{-1}$)
- Carbon_{MAI} ($\text{Mg C ha}^{-1}\ \text{yr}^{-1}$)

White Pine Data

- Trees were cored at dbh during the 49th growing season
- Cores were processed & analyzed with WinDENDRO to determine annual growth ring measurements
- Annual diameters were calculated based on WinDENDRO data

  - Biomass = Exp[-2.5356 + 2.4349 ln(dbh)] *Jenkins et al. (2003)*
  - Carbon concentration = 49.74% *Lamlom & Savidge (2003)*
  - Stocking, age

- Biomass_{TOTAL} ($Mg\ ha^{-1}$)
- Biomass_{MAI} ($Mg\ ha^{-1}\ yr^{-1}$)
- Carbon_{MAI} ($Mg\ C\ ha^{-1}\ yr^{-1}$)

*Jenkins JC, Chojnacky DC, Heath LS, Birdsey RA. 2003. Forest Science 49:12-26
*Lamlom SH, Savidge RA. 2003. Biomass Bioenergy 25:381-388.

Hybrid Poplar Biomass

Source	*P*-value
Site	0.0007
Clone	<0.0001
Site × Clone	0.0134

10-yr MAI (Mg ha^{-1} yr^{-1})

Clone	Ames	Escanaba	Waseca	*All Clones*
C916000	**7.6 ± 0.5**	**7.9 ± 1.4**	**11.8 ± 3.6**	*9.0 ± 1.2*
C916400	**8.7 ± 2.1**	**5.7 ± 1.7**	**11.4 ± 1.7**	*8.9 ± 1.2*
C918001	**3.9 ± 0.8**	**3.3 ± 0.6**	**7.1 ± 1.4**	*4.8 ± 0.8*
NC13563	**5.8 ± 0.4**	**5.9 ± 0.2**	**10.4 ± 0.7**	*7.3 ± 0.7*
NC13624	**3.6 ± 0.4**	**5.6 ± 0.6**	**3.1 ± 1.1**	*4.4 ± 0.5*
NC13649	**4.3 ± 0.4**	**7.6 ± 0.6**	**4.6 ± 0.3**	*5.9 ± 0.6*
NM2	**6.5 ± 2.1**	**13.0 ± 1.1**	**14.0 ± 2.0**	*11.4 ± 1.4*
All Sites	*6.0 ± 0.6*	*7.1 ± 0.6*	*9.2 ± 0.9*	*7.4 ± 0.4*

+ 159%

+ 53%

Hybrid Poplar Biomass

Source	*P*-value
Site	<0.0001
Clone	0.0807
Site × Clone	<0.0001

20-yr MAI (Mg ha^{-1} yr^{-1})

Site	DN182	DN34	*All Clones*
Belgrade	6.9 ± 0.5	8.5 ± 0.7	*7.7 ± 0.5*
Bemidji	7.0 ± 0.6	5.8 ± 0.7	*6.4 ± 0.5*
Fairmont	18.0 ± 2.3	11.4 ± 0.3	*14.7 ± 1.7*
Granite Falls	18.3 ± 3.4	13.7 ± 1.2	*16.0 ± 1.9*
Lamberton	9.6 ± 2.0	17.3 ± 2.8	*13.4 ± 2.2*
Milaca	10.7 ± 1.4	12.6 ± 0.7	*11.7 ± 0.8*
Mondovi	6.8 ± 0.6	8.9 ± 1.1	*7.8 ± 0.7*
Rhinelander	21.7 ± 1.3	14.0 ± 1.6	*17.8 ± 1.7*
Warren	14.2 ± 2.3	8.9 ± 0.5	*11.5 ± 1.5*
All Sites	*12.6 ± 1.1*	*11.2 ± 0.7*	*11.9 ± 0.6*

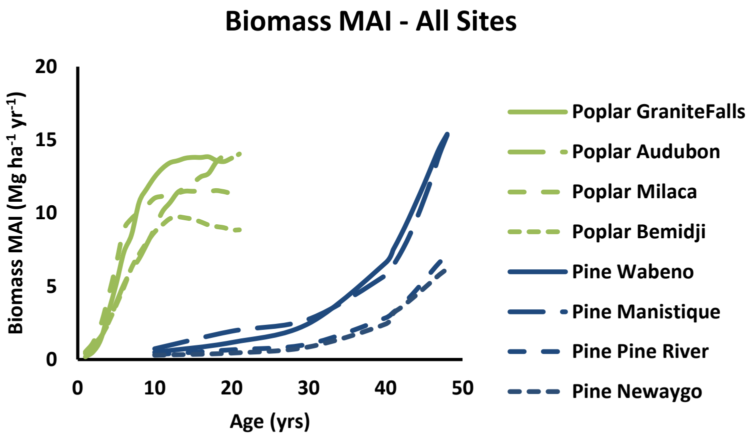
White Pine Biomass

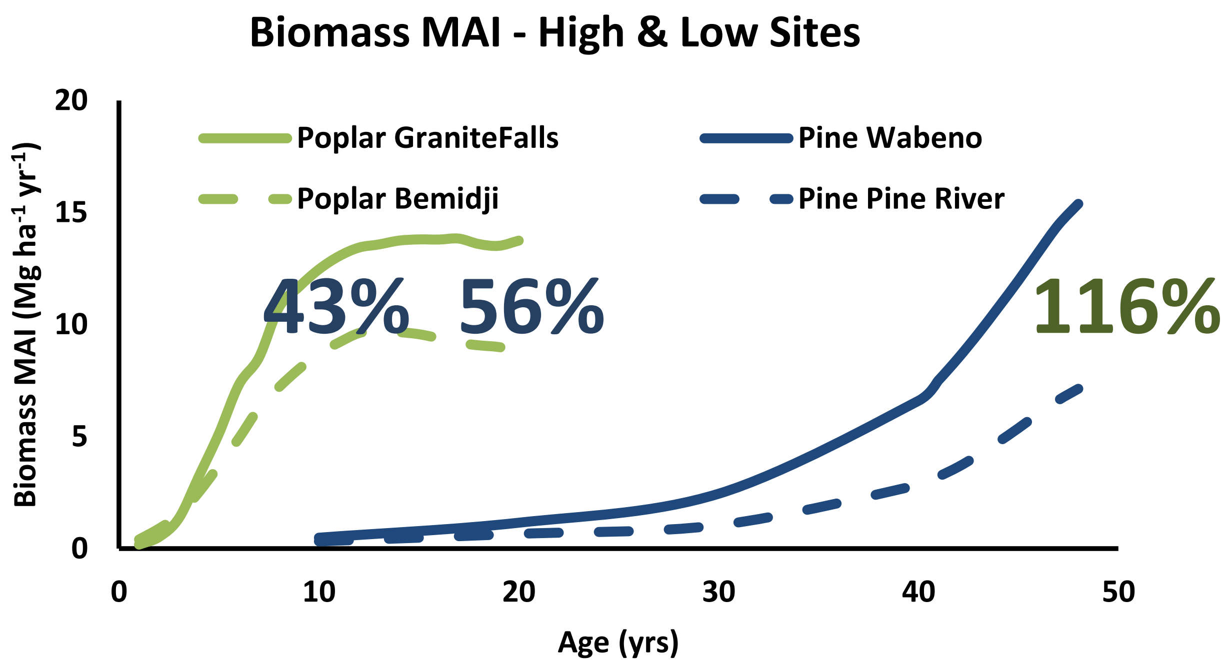
Provenance	Manistique	Newaygo	Pine River	Wabeno	*All Sites*
1622	**16.1 ± 2.9**	**5.2 ± 0.3**	**9.2 ± 2.8**	**6.5 ± 4.4**	*7.5 ± 0.9*
1623	**16.0 ± 1.6**	**4.7 ± 0.2**	**5.9 ± 1.1**	**18.5 ± 2.1**	*8.8 ± 0.9*
1624	**11.0 ± 1.8**	**5.4 ± 0.5**	**4.8 ± 1.7**	**14.5 ± 5.5**	*7.8 ± 0.9*
1632	**15.0 ± 2.4**	**4.5 ± 0.2**	**7.6 ± 1.1**	**19.5 ± 1.5**	*9.5 ± 0.9*
1633	**9.9 ± 1.6**	**7.3 ± 0.7**	**5.5 ± 0.7**	**4.5 ± 0.3**	*7.0 ± 0.5*
1634	**7.9 ± 1.2**	**7.4 ± 0.4**	**8.2 ± 1.7**	**3.8 ± 1.4**	*7.3 ± 0.4*
1635	**12.8 ± 1.9**	**4.0 ± 0.3**	**3.1 ± 0.7**	**6.3 ± 4.5**	*5.9 ± 0.7*
1636	**17.7 ± 3.1**	**8.3 ± 1.2**	**5.4 ± 1.3**	**11.5 ± 2.3**	*9.7 ± 1.0*
1637	**15.8 ± 2.2**	**6.9 ± 0.6**	**6.0 ± 1.3**	**11.1 ± 2.8**	*9.1 ± 0.8*
1639	**13.5 ± 2.1**	**6.2 ± 0.4**	**3.7 ± 0.5**	**15.0 ± 1.9**	*8.2 ± 0.7*
1640	**23.4 ± 3.6**	**8.8 ± 0.6**	**11.2 ± 2.1**	**32.7 ± 7.5**	*13.0 ± 1.3*
1670	**20.8 ± 2.9**	**5.6 ± 0.2**	**10.5 ± 2.3**	**20.1 ± 8.0**	*11.6 ± 1.4*
All Provenances	*15.3 ± 0.8*	*6.2 ± 0.2*	*7.1 ± 0.5*	*15.5 ± 1.4*	*8.9 ± 0.3*

48-yr MAI
(Mg ha^{-1} yr^{-1})

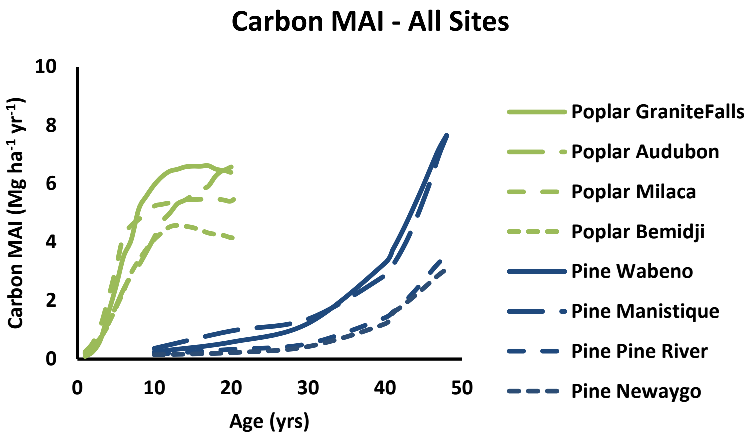
Source	*P*-value
Site	<0.0001
Provenance	<0.0001
Site × Provenance	<0.0001

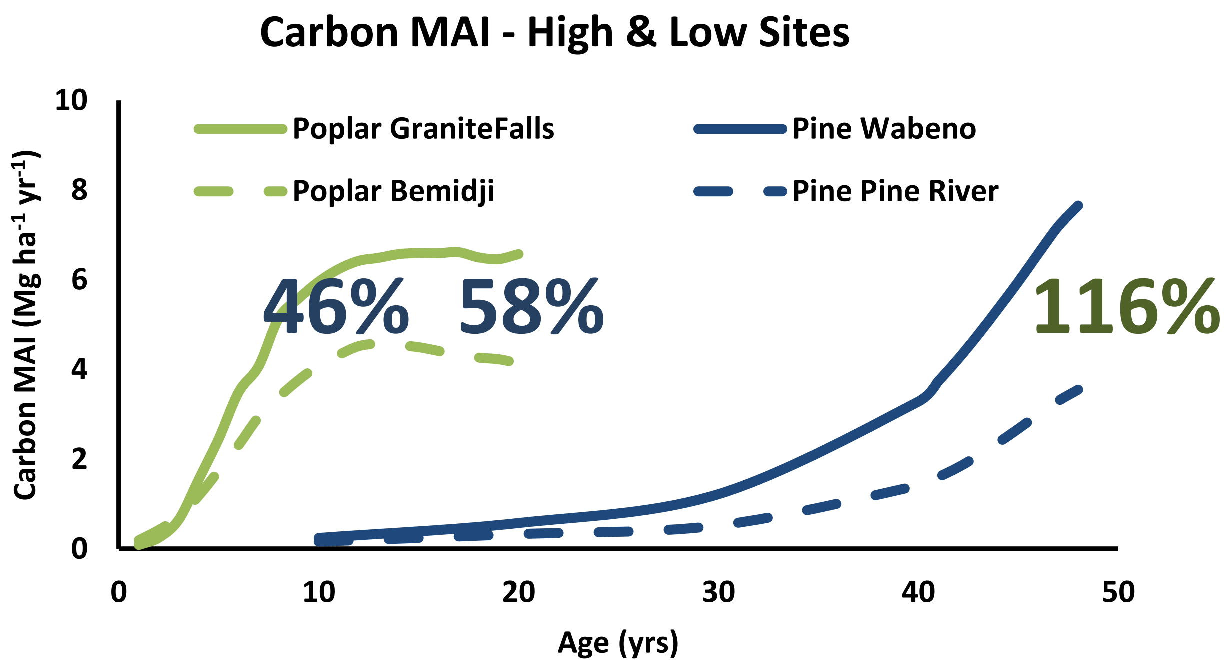
Site Effects – Biomass MAI



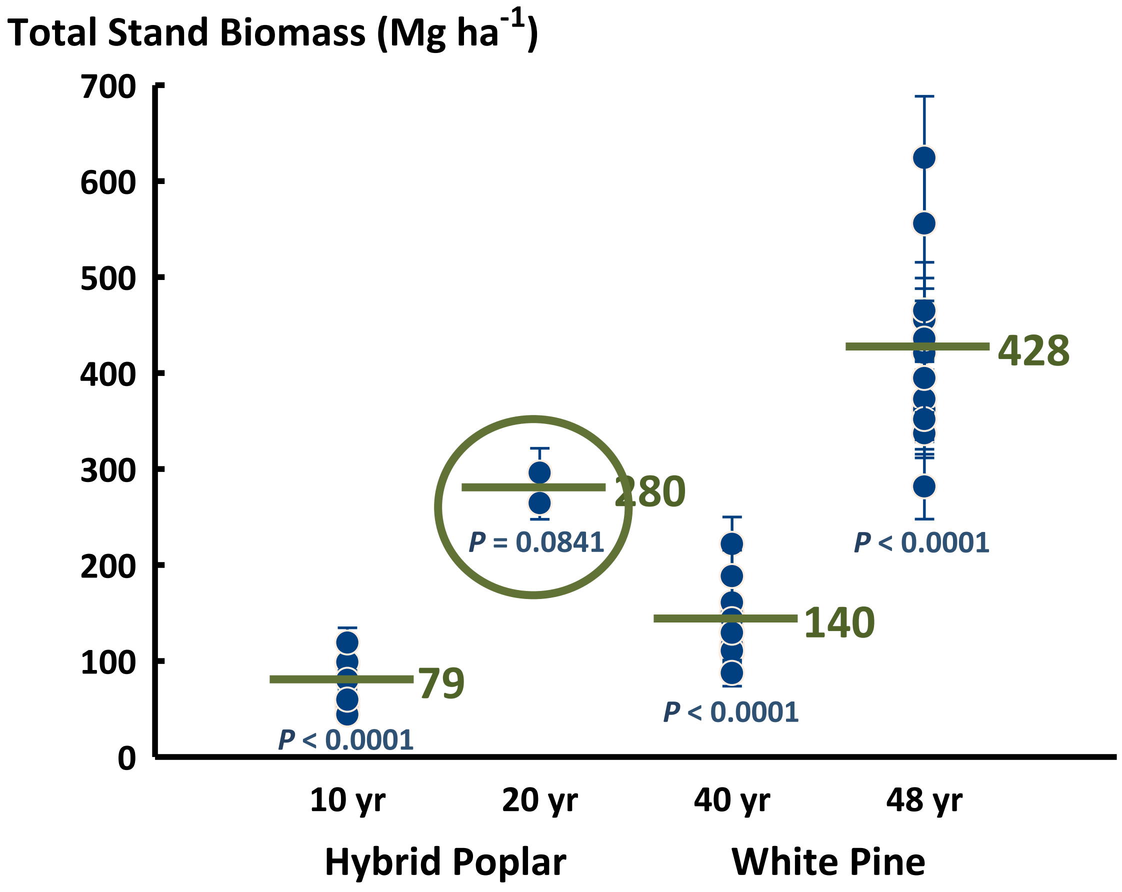


Site Effects – Carbon MAI

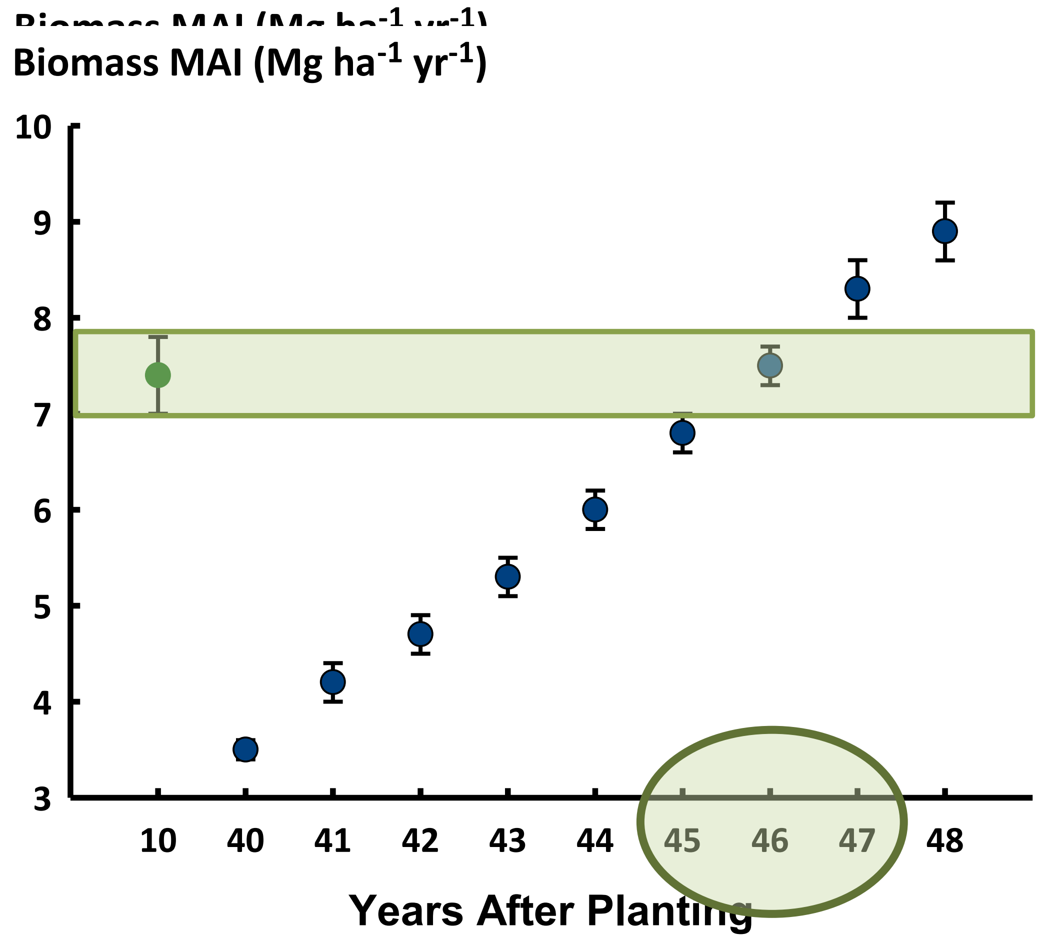




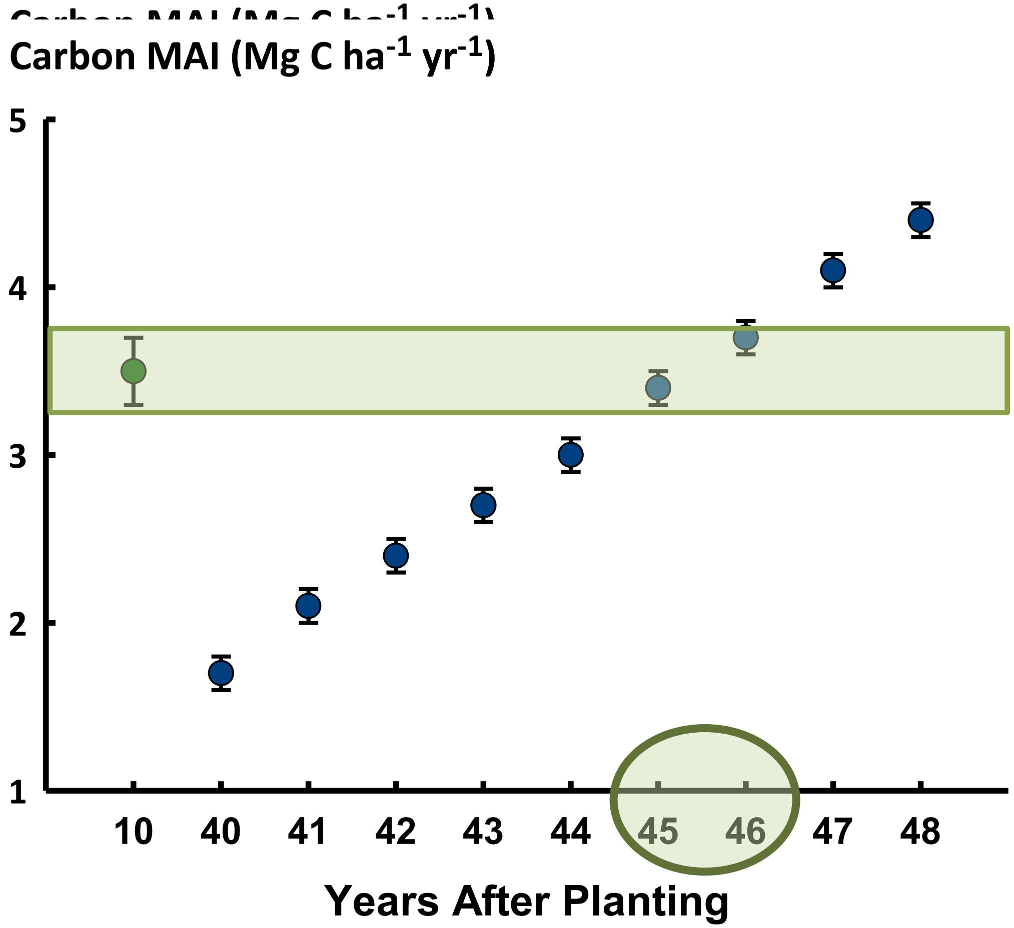
Genotype Effects



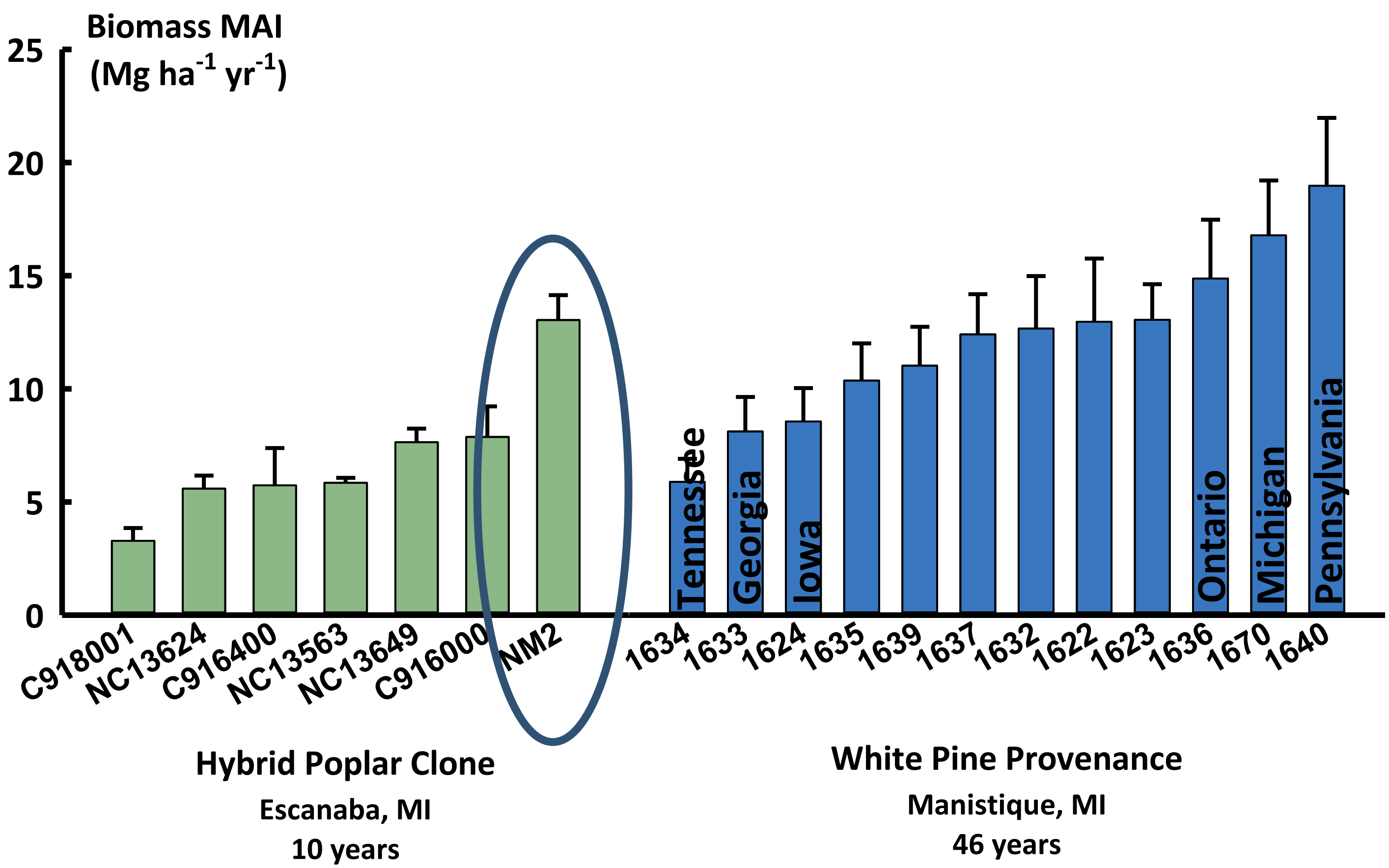
Comparable Ages



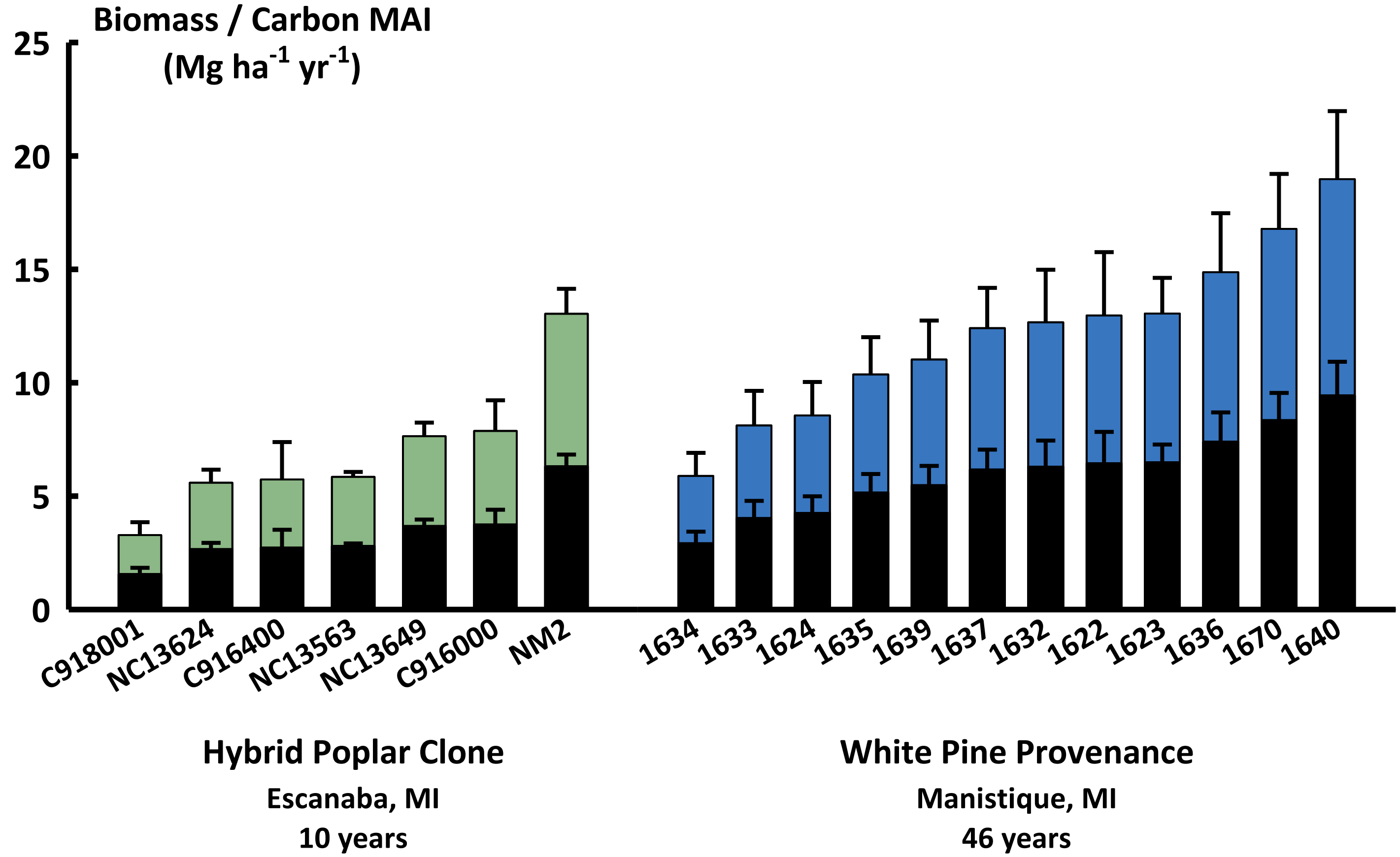
Comparable Ages



Site × Genotype Effects



Site × Genotype Effects



Conclusions

- In general, comparable 10-yr hybrid poplar stand biomass & carbon sequestration FOR WHITE PINE were not achieved until 45 yrs

  Biomass @ 45 to 47 yrs   Carbon @ 45 to 46 yrs

- Specific genotype × environment interactions resulted in white pine exceeding 10-yr-old hybrid poplar at ages younger than 45 yrs
- White pine was not comparable to 20-yr-old hybrid poplar at 48 yrs
- While the timing & magnitude of biomass/carbon differ between the genera, producing both provides greater ecosystems services across the landscape

Hybrid poplar

2 to 4 rotations with the potential for reduced establishment costs with coppice systems

Quicker return on investment

White pine

Fewer entries with the potential for greater soil carbon sequestration over time

Wildlife habitat for longer time periods

Thank you!

Contact Information

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