Ecosystem services of rotation-age hybrid poplars used for phytoremediation

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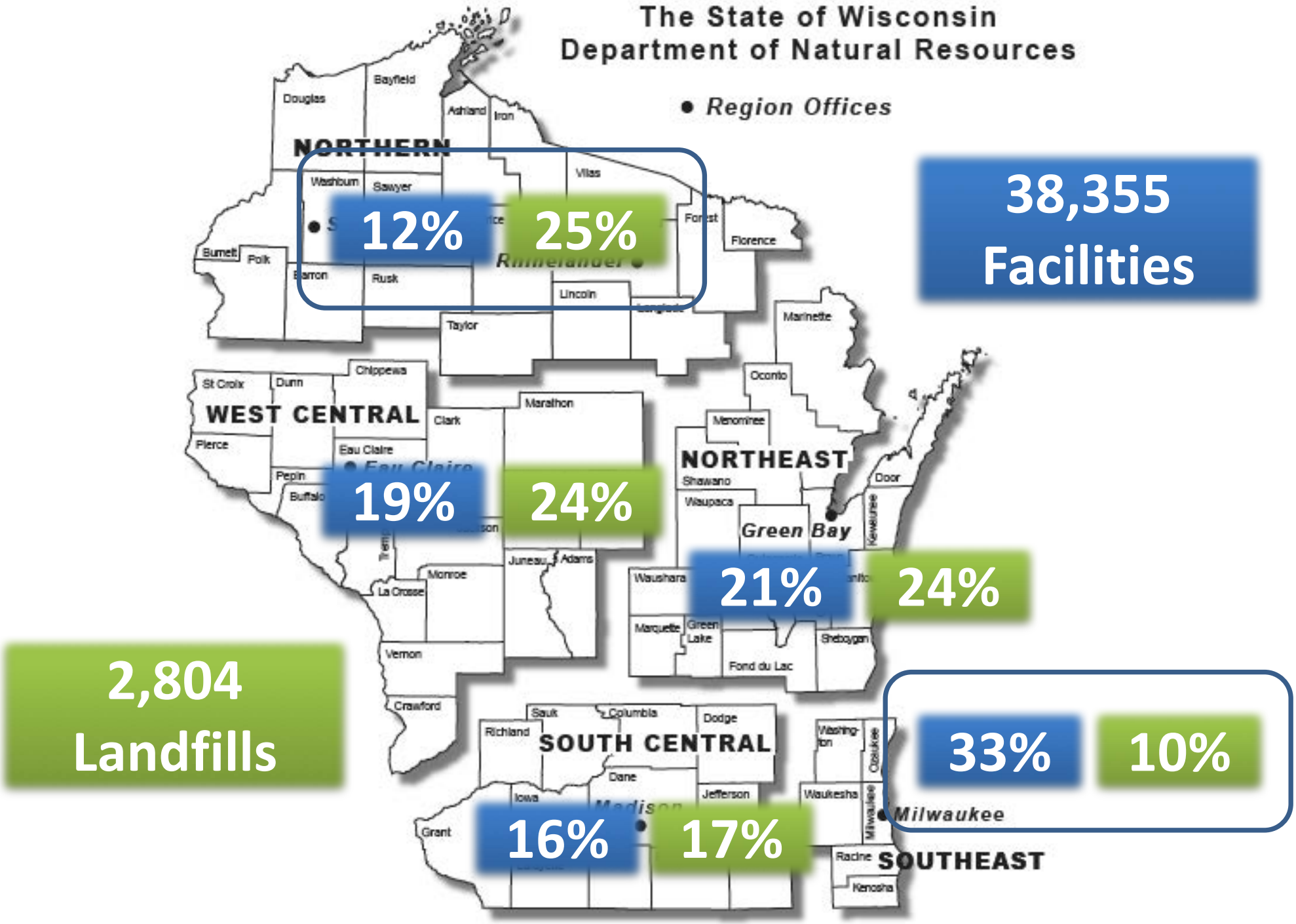
SRWCOWG
10/12/16

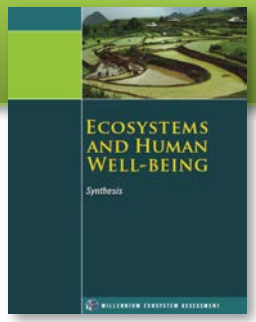


http://dnr.wi.gov/sotw; WDNR Solid & Hazardous Waste Information System; Accessed 10/11/16

Ecosystem Services

"The benefits people obtain from ecosystems"

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



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

Cultural Services

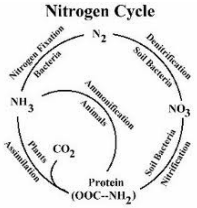
The nonmaterial benefits obtained from ecosystems (e.g., values)

Spiritual

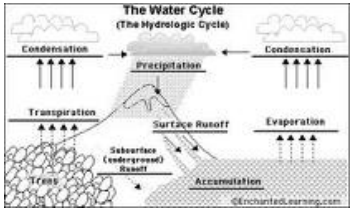
Educational

Supporting Services

The natural processes that maintain the other ecosystem services



Nitrogen



Water

Provisioning Services

The goods or products obtained from ecosystems

Freshwater

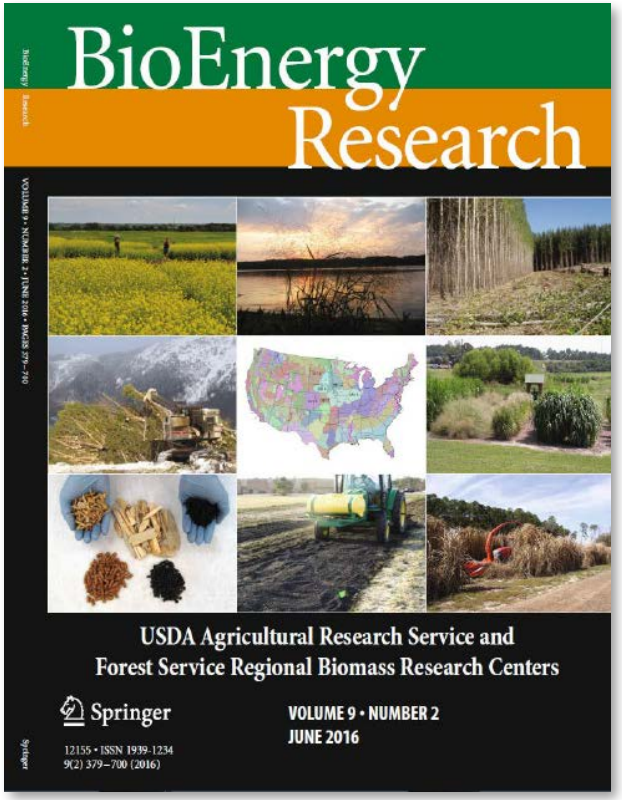
Biomass

Regulating Services

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

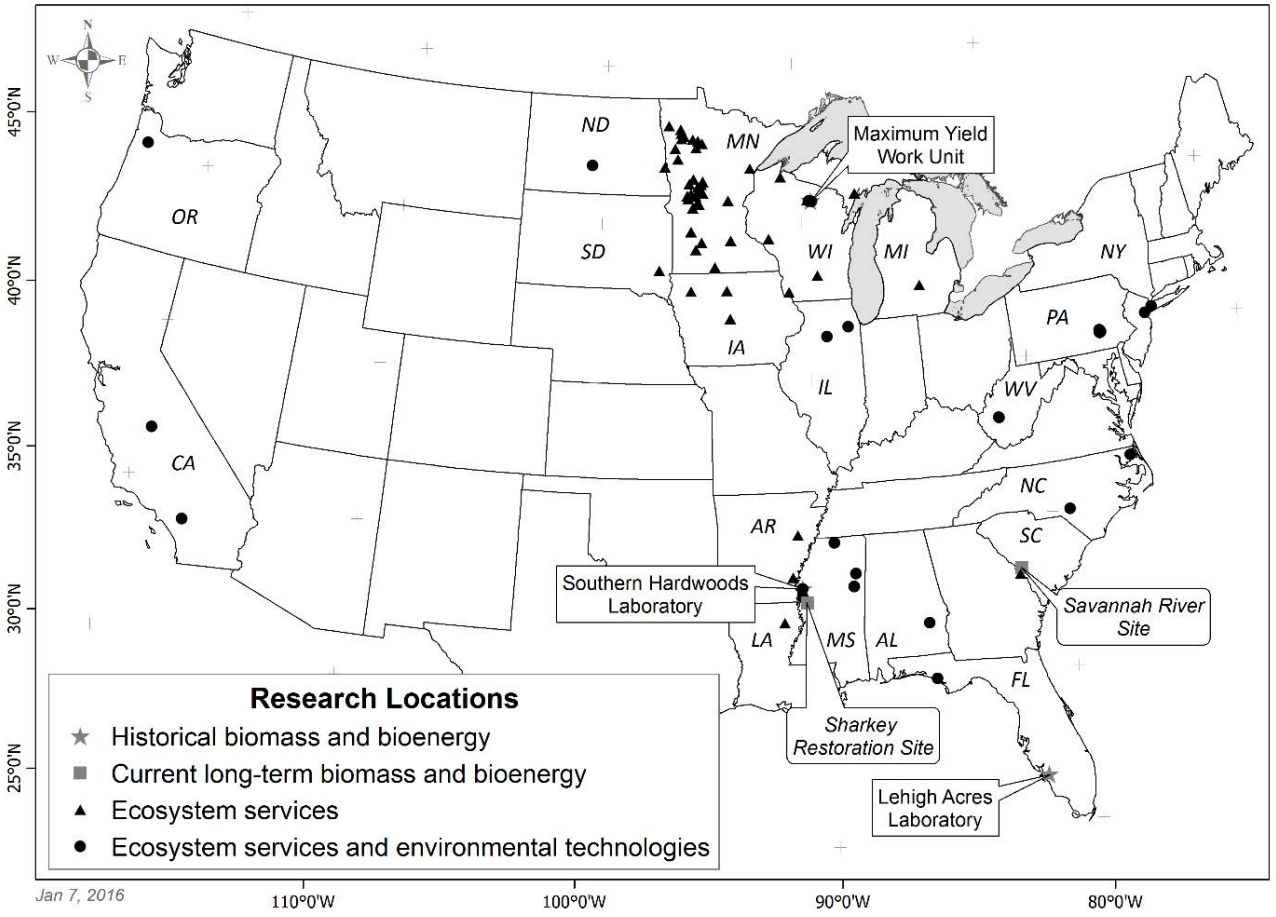
Erosion Control

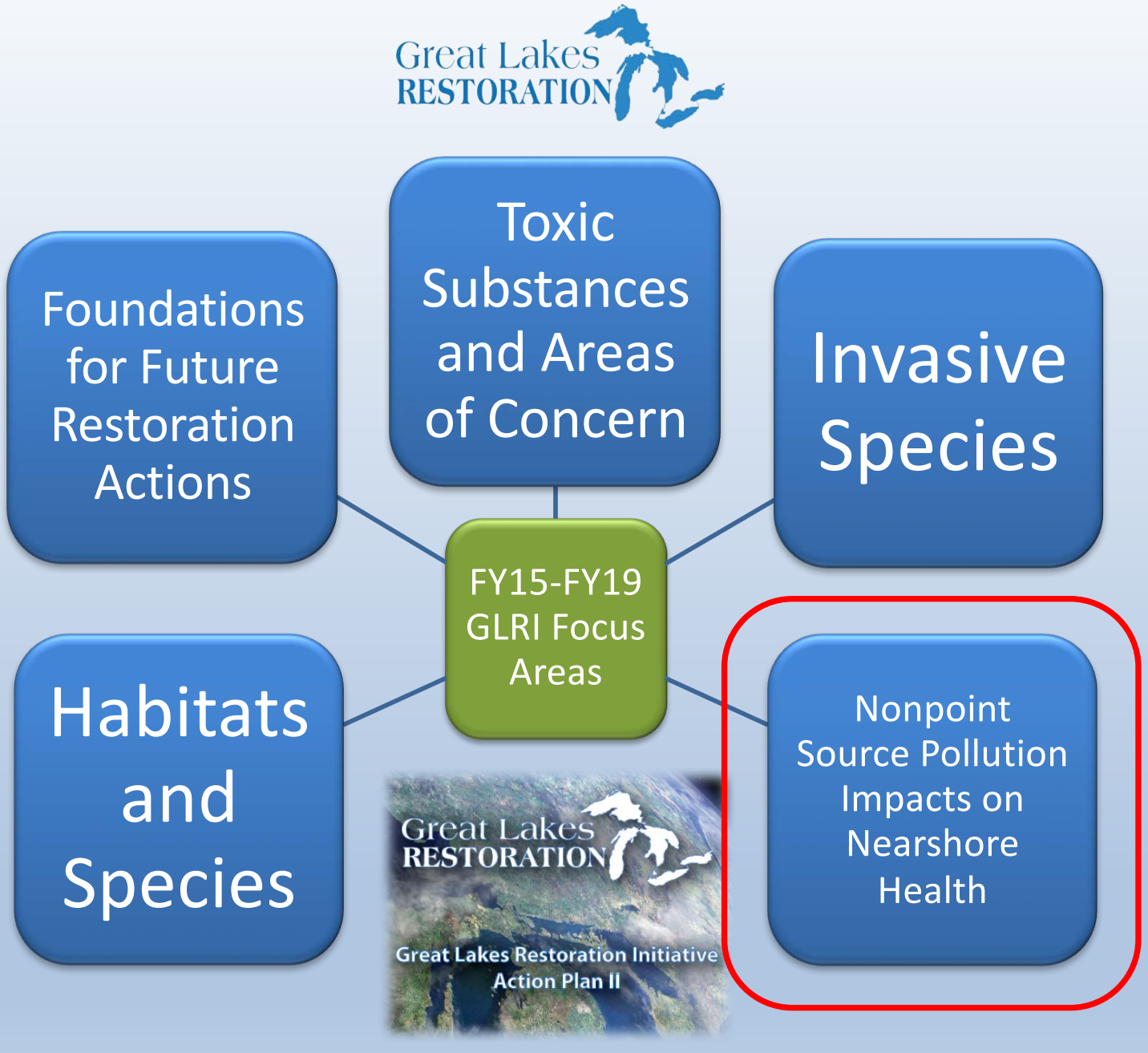
Soil Quality



Zalesny, R.S. Jr., Stanturf, J.A., Gardiner, E.S., Perdue, J.H., Young, T.M., Coyle, D.R., Headlee, W.L., Bañuelos, G.S., and Hass, A. 2016. Ecosystem services of woody crop production systems. BioEnergy Research 9:465-491.

Zalesny, R.S. Jr., Stanturf, J.A., Gardiner, E.S., Bañuelos, G.S., Hallett, R.A., Hass, A., Stange, C.M., Perdue, J.H., Young, T.M., Coyle, D.R., and Headlee, W.L. 2016. Environmental technologies of woody crop production systems. BioEnergy Research 9:492-506.





Zalesny, R.S. Jr., Burken, J.G., Hallett, R.A., and Wiese, A.H. 2016. Mitigating nonpoint source pollution impacts on nearshore health in the Great Lakes Basin, USA. In: 25th Session of the International Poplar Commission, Food and Agriculture Organization of the United Nations: Poplars and Other Fast-Growing Trees – Renewable Resources for Future Green Economies; September 13-16, 2016; Berlin, Germany.

Ecosystem services of poplar at long-term phytoremediation sites in the Midwest and Southeast, United States

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[7] University of Florida; Gainesville, FL, USA

Zalesny, R.S. Jr., Headlee, W.L., Gopalakrishnan, G., Hall, R.B., Hazel, D.W., Isebrands, J.G., Negri, M.C., Guthrie-Nichols, E., and Rockwood, D.L. 2014. Ecosystem services of poplar at long-term phytoremediation sites in the Midwest and Southeast, United States. In: International Poplar Symposium VI; July 20-23, 2014; Vancouver, British Columbia, Canada.

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Sapflow of hybrid poplar (*Populus nigra* L. × *P. maximowiczii* A. Henry 'NM6') during phytoremediation of landfill leachate

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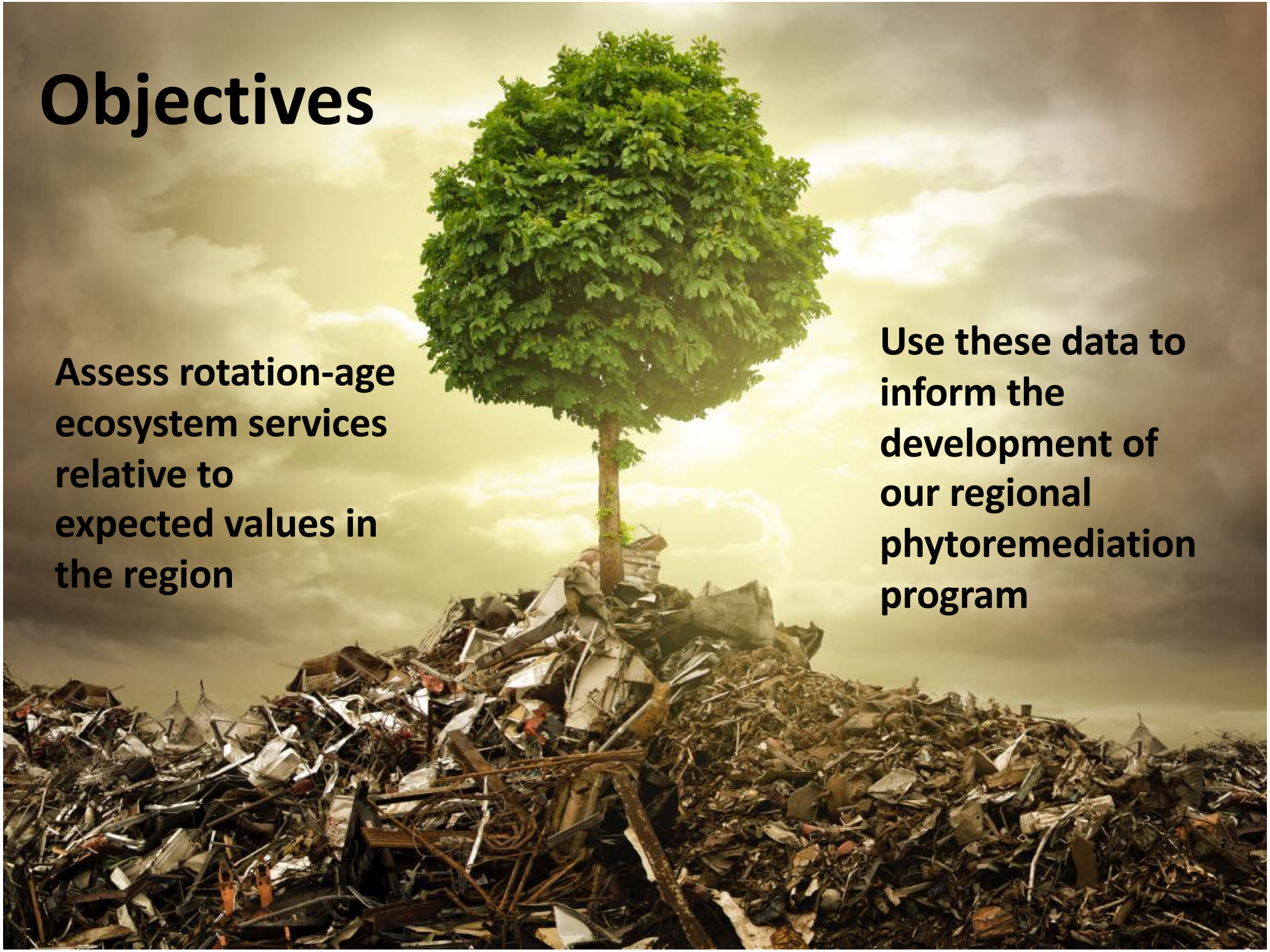
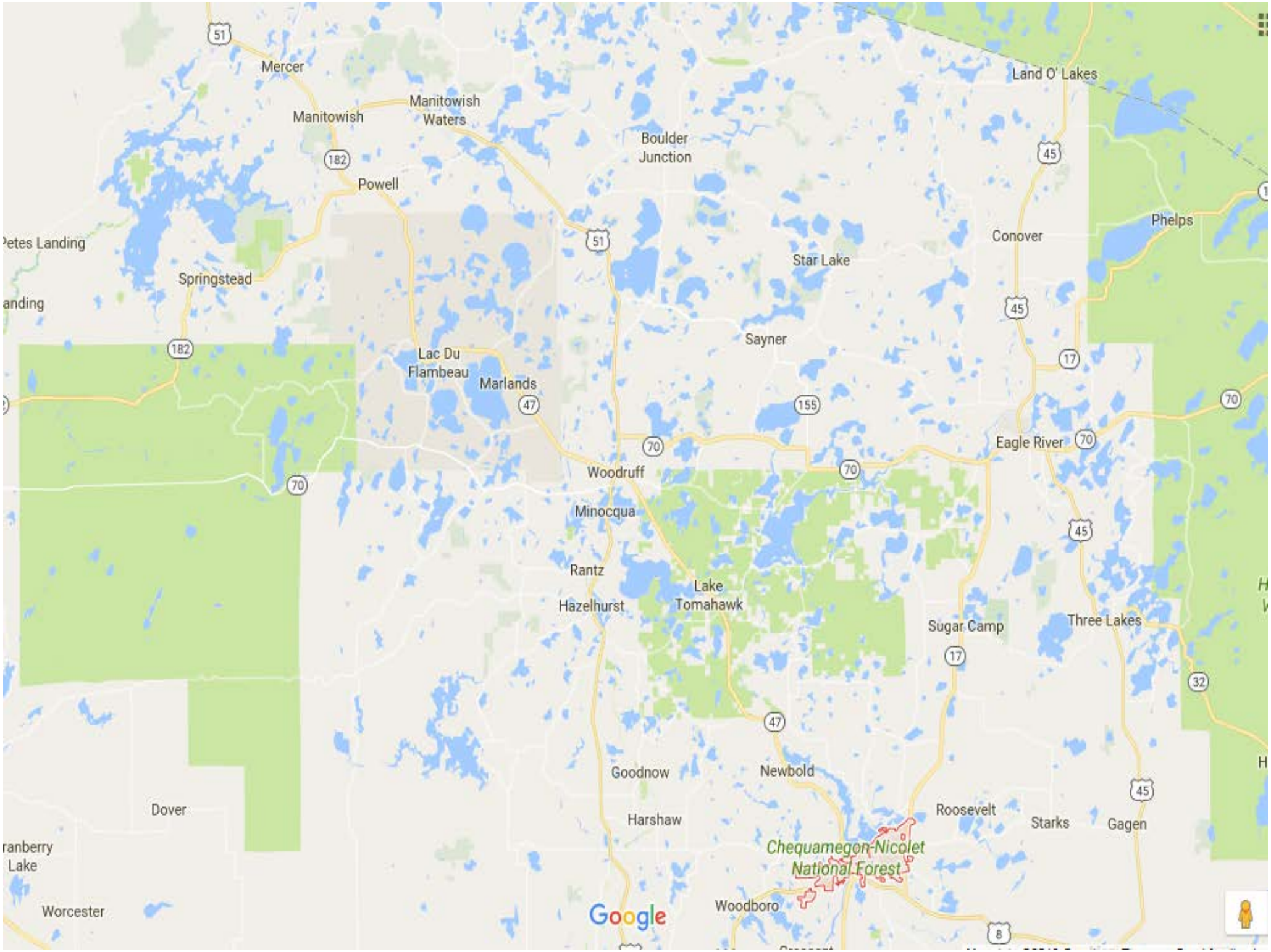
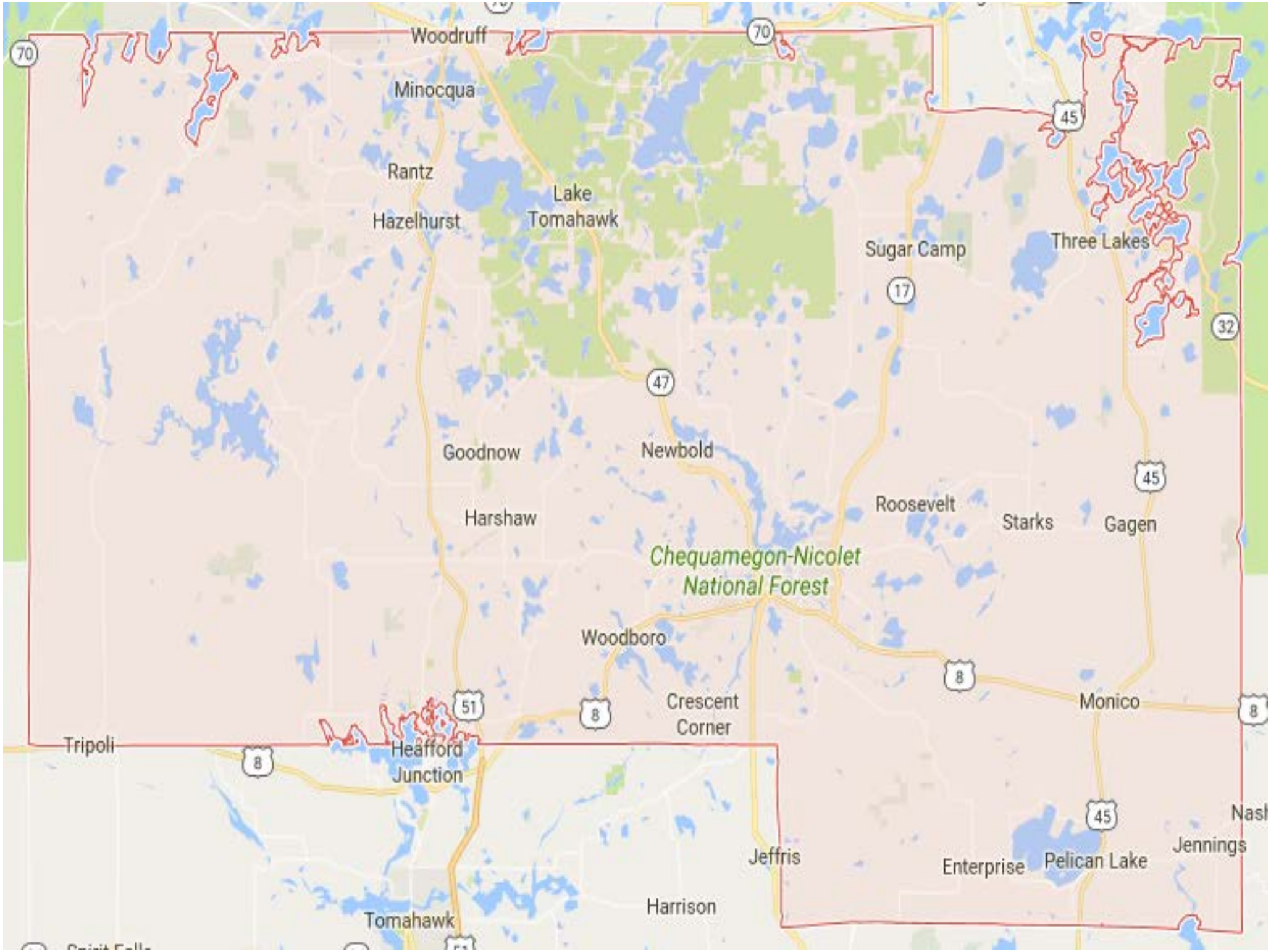
Objectives

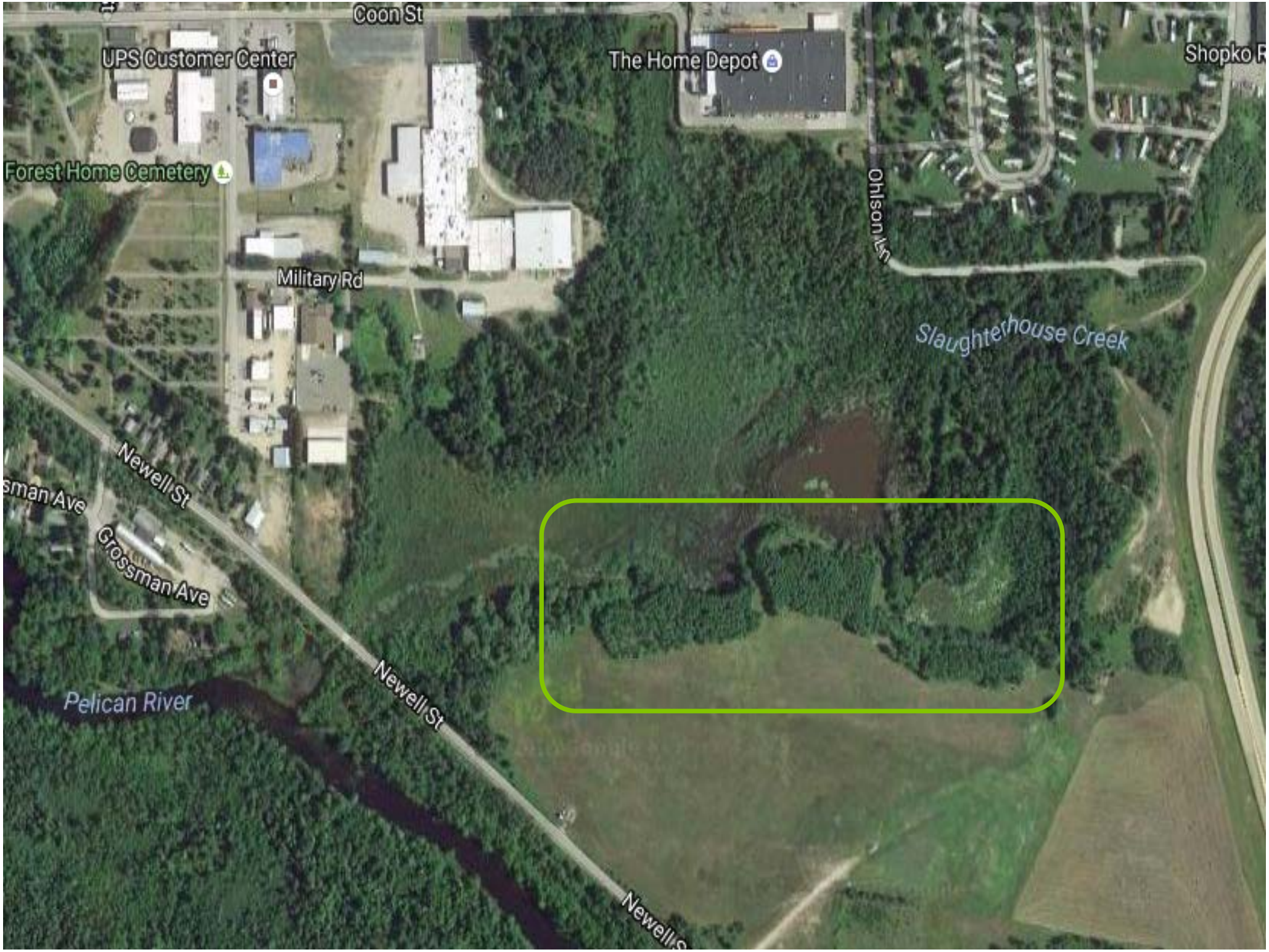


Assess rotation-age ecosystem services relative to expected values in the region

Use these data to inform the development of our regional phytoremediation program


Mercer
Manitowish
Manitowish Waters
Boulder Junction
Land O' Lakes
Powell
Phelps
Conover
Star Lake
Springstead
Sayner
Lac Du Flambeau
Marlands
Eagle River
Woodruff
Minocqua
Rantz
Lake Tomahawk
Hazelhurst
Sugar Camp
Three Lakes
Goodnow
Newbold
Dover
Harshaw
Roosevelt
Starks
Gagen
Chequamegon-Nicolet National Forest
Woodboro
Worcester
Google


Woodruff
Minocqua
Rantz
Hazelhurst
Lake
Tomahawk
Sugar Camp
Three Lakes
Goodnow
Newbold
Harshaw
Roosevelt
Starks
Gagen
Chequamegon-Nicolet
National Forest
Woodboro
Crescent
Corner
Monico
Tripoli
Heafford
Junction
Jeffris
Enterprise
Pelican Lake
Jennings
Harrison
Tomahawk
70
45
17
32
47
51
8


Coon St
UPS Customer Center
The Home Depot
Shopko R
Forest Home Cemetery
Ohlson Ln
Military Rd
Slaughterhouse Creek
Newell St
sman Ave
Grossman Ave
Pelican River
Newell St
Newell S

Former City of Rhinelander Landfill

- A gravelly, mixed-soil cover, 30–60 cm deep, was placed on the landfill in the late 1980s to function as a cap
- Poplars & willows were planted over portions of the cover in 1999 for phytoremediation of landfill leachate (834 trees ha^{-1})
- 7.8 °C mean winter daytime temperature
- 25.6 °C mean summer daytime temperature
- 144.8 cm mean snowfall
- 61.0 cm mean rainfall
- 1863 mean annual number of growing degrees days (GDD, 10 °C), with 544 occurring in July and 480 in August

Soils

Depth	Texture
0-10 cm	Sandy Loam
10-13 cm	Sandy Loam / Loamy Sand

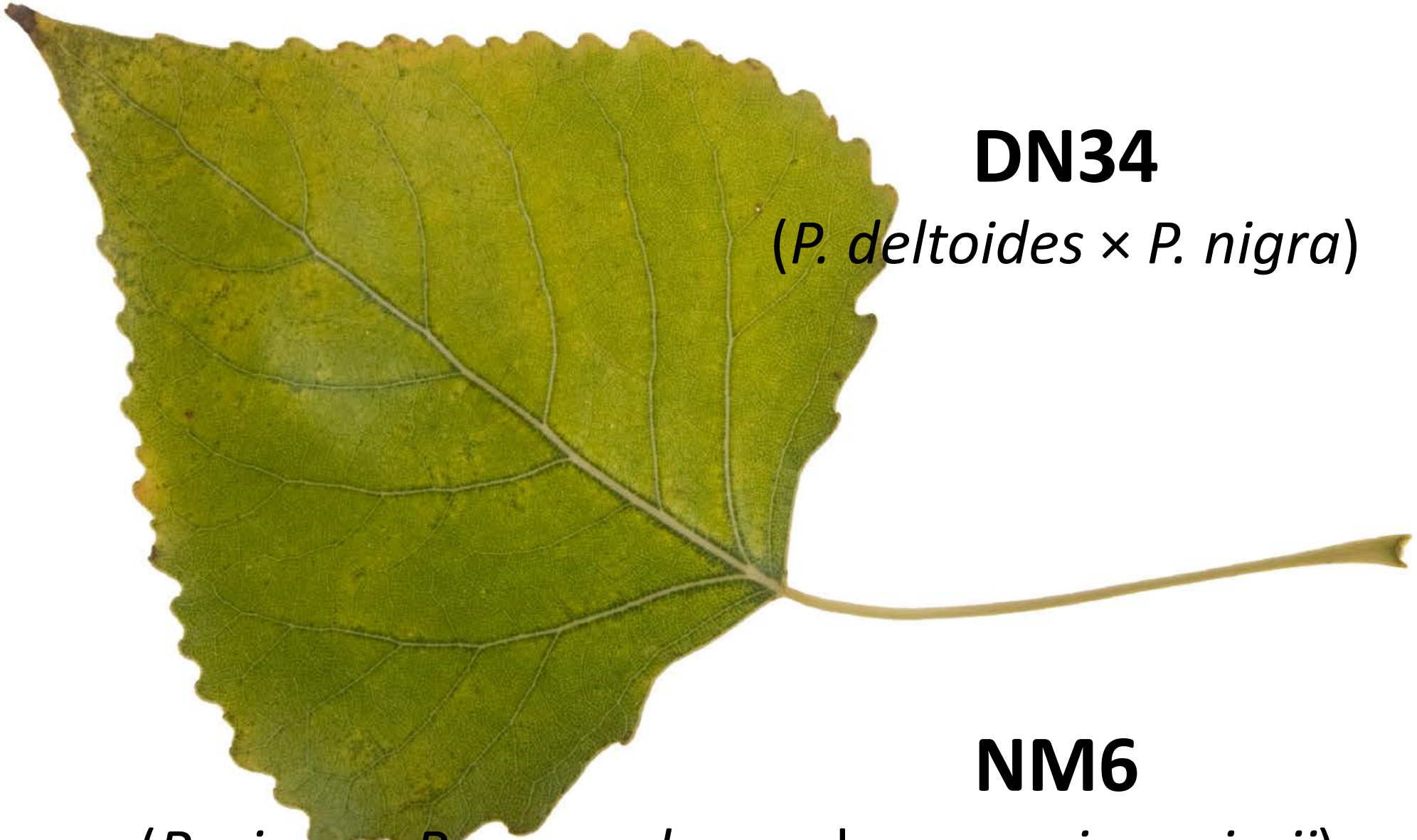
Depth	pH	N (%)	C (%)	P	K
0-10 cm	4.79	0.18	2.41	31.2	106.6
10-13 cm	4.51	0.12	1.31	25.4	59.7

Depth	Cl	Na	Mg	Ca	Al
0-10 cm	0.7	7.5	150.2	667.2	821.5
10-13 cm	0.9	15.0	96.1	336.0	1137.9

Depth	Mn	Cr	Cu	Fe	Co
0-10 cm	129.7	0.5	2.9	463.3	0.7
10-13 cm	96.9	0.6	5.0	489.7	0.9

Depth	Ni	Cd	Pb	Zn
0-10 cm	0.4	0.0	2.1	3.3
10-13 cm	0.8	0.0	1.1	3.4

*Except for pH, N, & C, all data are in mg kg^{-1}

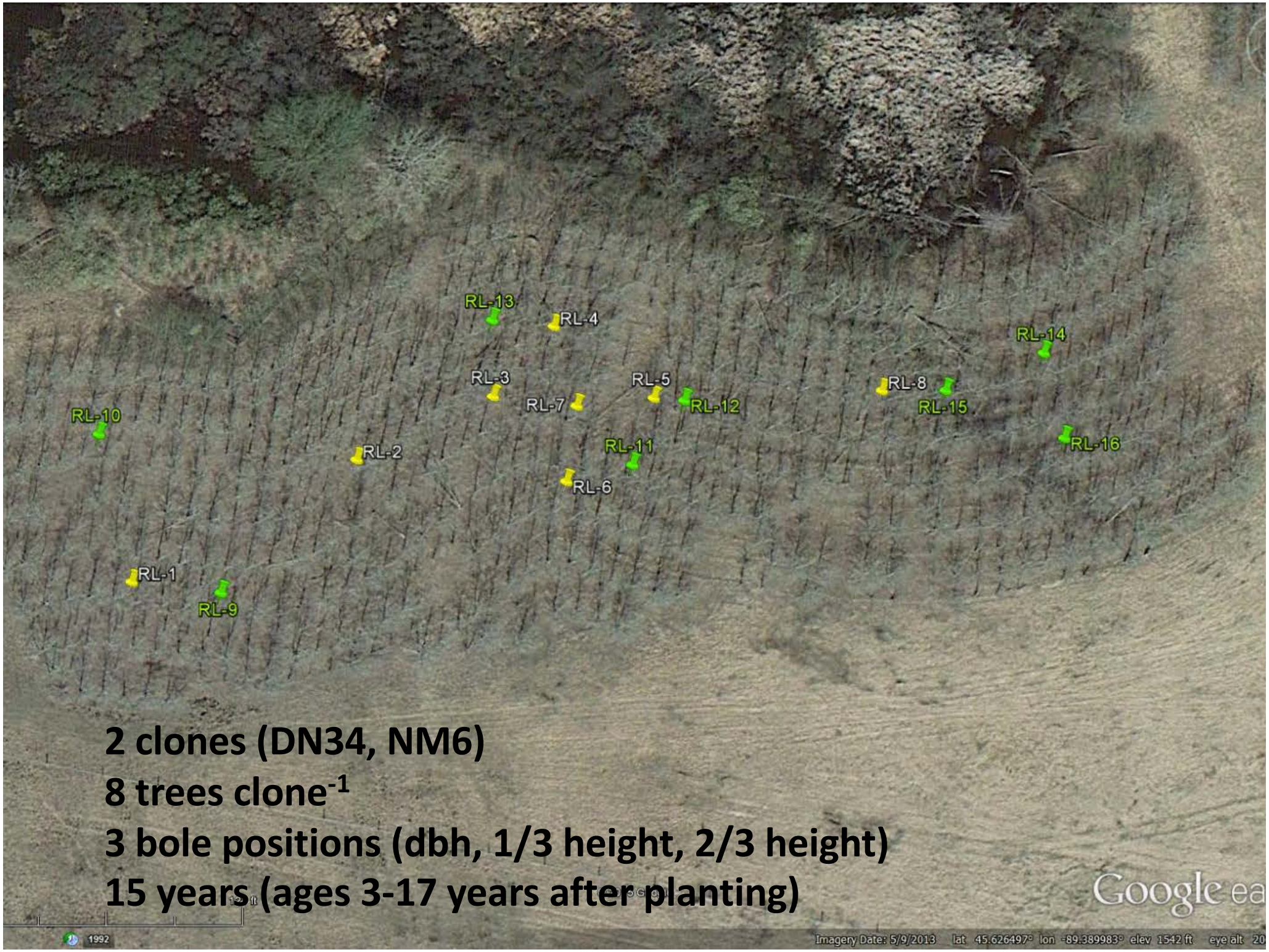


DN34

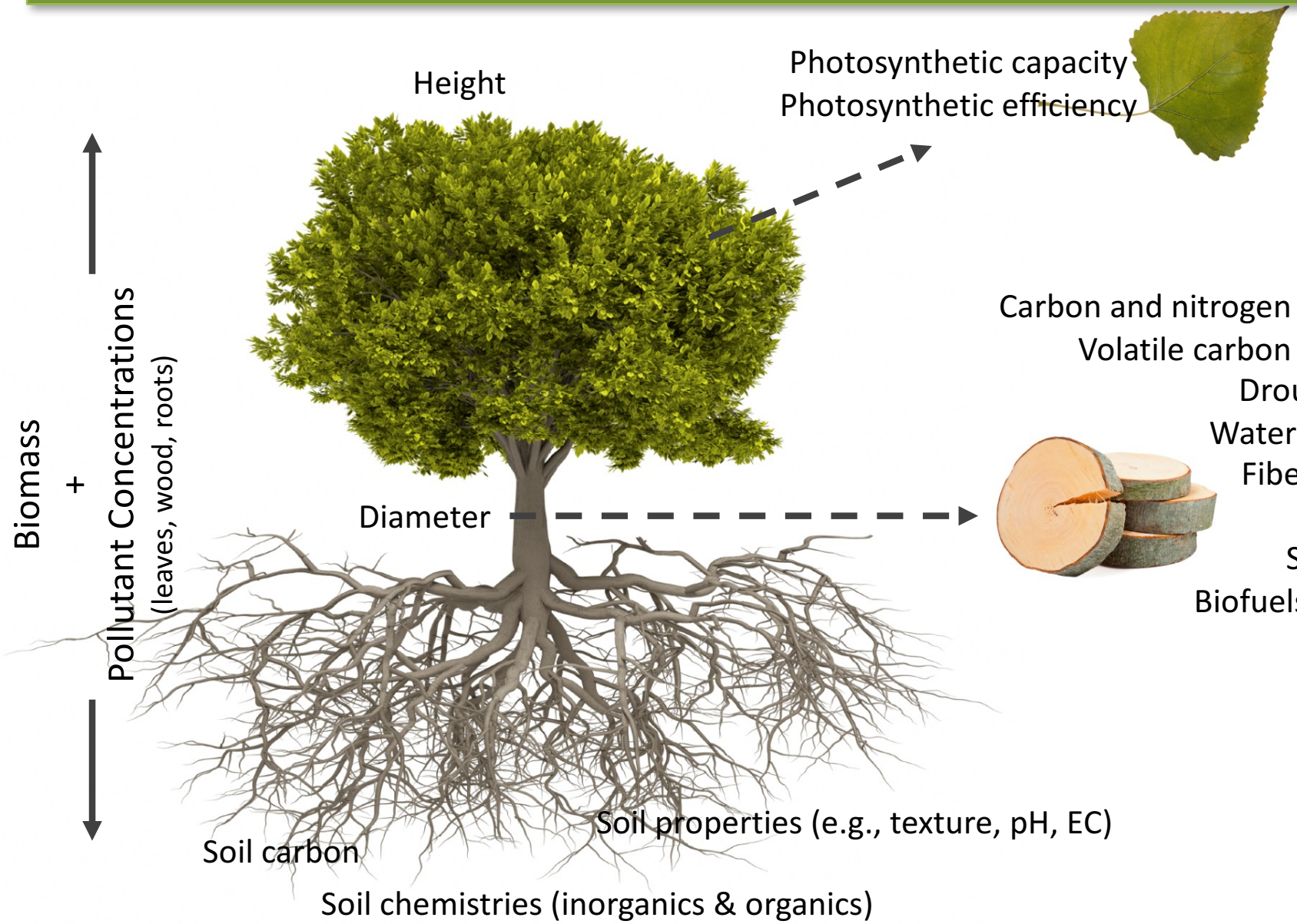
(*P. deltoides* × *P. nigra*)

NM6

(*P. nigra* × *P. suaveolens* subsp. *maximowiczii*)


RL-13
RL-4
RL-14
RL-3
RL-5
RL-8
RL-7
RL-12
RL-15
RL-10
RL-2
RL-11
RL-16
RL-6
RL-1
RL-9
2 clones (DN34, NM6)
8 trees clone-1
3 bole positions (dbh, 1/3 height, 2/3 height)
15 years (ages 3-17 years after planting)
Google ea
1992
Imagery Date: 5/9/2013 lat 45.626497° lon -89.389983° elev 1542 ft eye alt 20

Data


Height
Photosynthetic capacity
Photosynthetic efficiency
Biomass
+
Pollutant Concentrations
(leaves, wood, roots)
Diameter
Carbon and nitrogen concentration
Volatile carbon concentration
Drought tolerance
Water use efficiency
Fiber composition
Ash content
Specific gravity
Biofuels recalcitrance
Soil properties (e.g., texture, pH, EC)
Soil carbon
Soil chemistries (inorganics & organics)

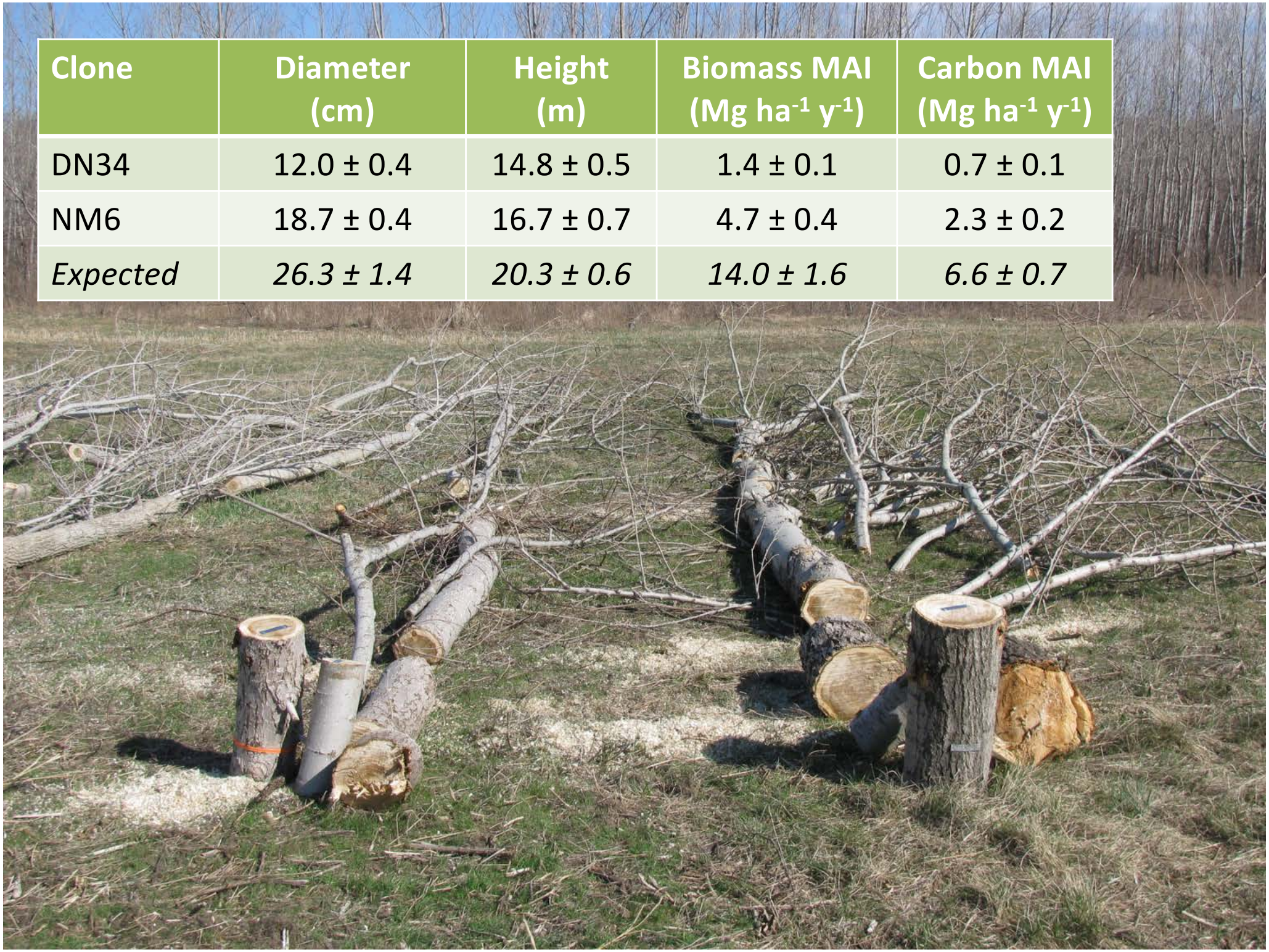
Clone / Tissue	N (%)	C (%)	P	K	Cl	Na	Mg	Ca	Al
DN34									
Branch	0.7	50.1	861.2	4994.8	na	7.0	1397.9	3392.3	94.7
Leaf	2.6	47.4	2074.9	13211.5	341.6	9.1	4148.1	10047.2	205.1
Wood	0.3	48.3	167.8	5386.4	na	14.6	1131.0	2411.8	245.4
NM6									
Branch	0.6	49.8	700.9	4293.3	na	4.1	1107.2	4545.8	348.0
Leaf	2.3	47.2	2045.0	10795.9	262.6	6.5	4252.7	18591.3	314.1
Wood	0.3	48.1	141.7	7770.4	na	5.7	915.2	1844.6	325.2

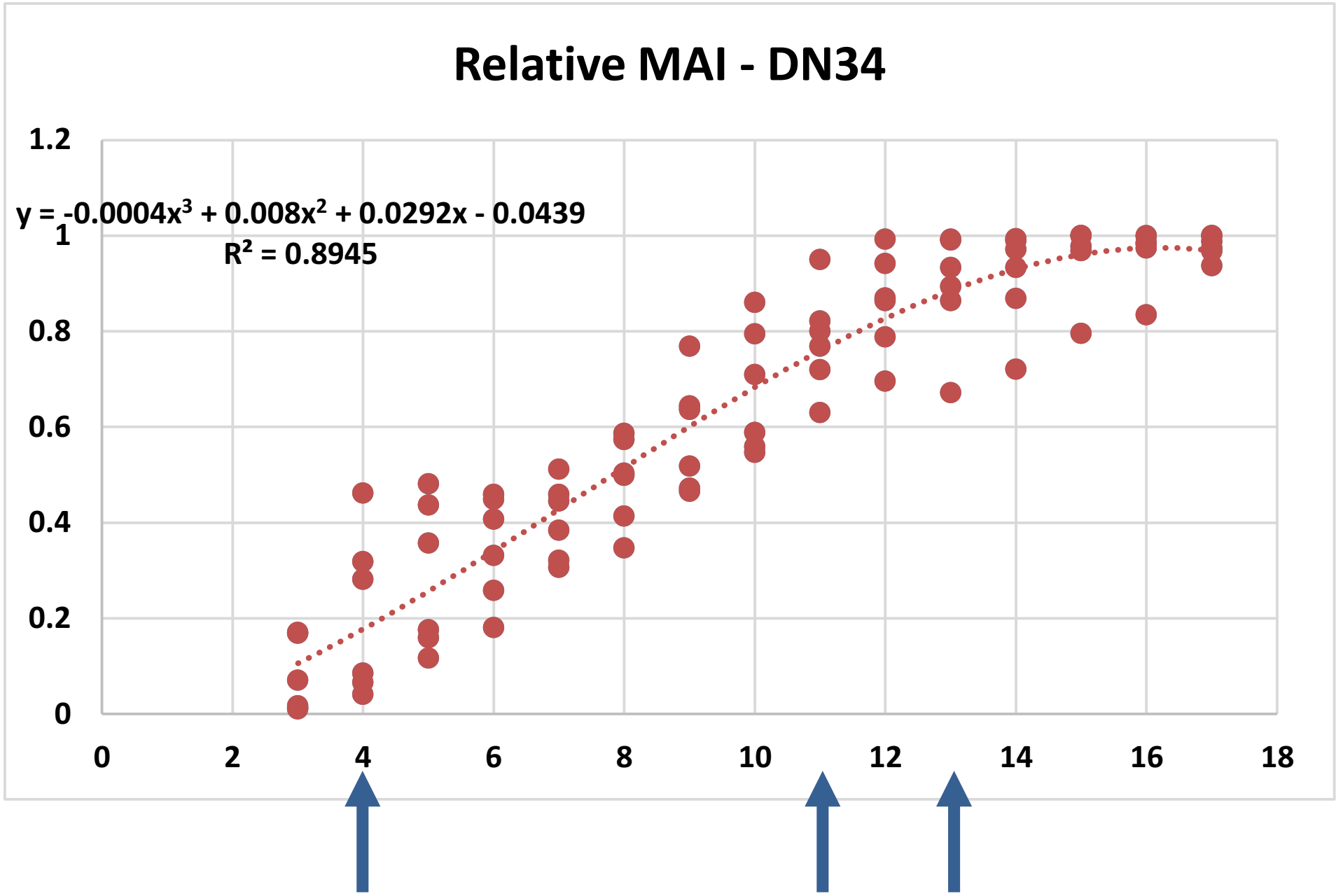
Clone / Tissue	Mn	Cr	Cu	Fe	Co	Ni	Cd	Pb	Zn
DN34									
Branch	65.1	1.2	4.9	89.1	0.6	4.6	0.1	5.3	41.1
Leaf	376.2	5.5	5.4	504.4	6.4	4.3	0.1	7.0	139.9
Wood	65.1	1.0	2.8	5.6	14.0	3.0	0.2	6.0	25.6
NM6									
Branch	33.6	5.1	2.0	43.4	3.6	1.0	0.4	5.8	43.5
Leaf	231.5	3.2	8.4	232.0	5.4	9.3	0.2	10.1	169.4
Wood	15.9	0.0	8.1	1.8	12.2	4.3	0.0	9.7	19.5

Clone	Hemicellulose	Cellulose	Lignin	Carbon
DN34	19.1 ± 0.4	59.3 ± 0.7	14.9 ± 0.3	48.3 ± 0.2
NM6	18.6 ± 0.3	59.6 ± 0.5	14.1 ± 0.2	48.1 ± 0.2
Expected	*16.4 ± 0.4*	*57.6 ± 0.6*	*16.4 ± 0.4*	*47.3 ± 0.0*

Clone	Specific Gravity
DN34	0.363 ± 0.003
NM6	0.320 ± 0.007
Expected	*0.340 ± 0.007*

Clone	Diameter (cm)	Height (m)	Biomass MAI (Mg ha^{-1} y^{-1})	Carbon MAI (Mg ha^{-1} y^{-1})
DN34	12.0 ± 0.4	14.8 ± 0.5	1.4 ± 0.1	0.7 ± 0.1
NM6	18.7 ± 0.4	16.7 ± 0.7	4.7 ± 0.4	2.3 ± 0.2
Expected	*26.3 ± 1.4*	*20.3 ± 0.6*	*14.0 ± 1.6*	*6.6 ± 0.7*




Relative MAI - DN34
y = -0.0004x³ + 0.008x² + 0.0292x - 0.0439
R² = 0.8945
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
18

Additional Analyses

- **Water Use Efficiency**
  - Evaluate stable isotope ratios within the growth rings of landfill- & production-grown DN34 & NM6 to identify the implications of phytoremediation on water use efficiency & future deployment on water-limited sites
- **Biofuels Conversion**
  - Evaluate dilute acid (DA) & sulfite pretreatment to overcome recalcitrance of lignocelluloses (SPORL) pretreatments applied to landfill- and production-grown DN34 & NM6 to evaluate their recalcitrance & subsequent sugar & ethanol yields

Conclusions

- **ROTATION-AGE ECOSYSTEM SERVICES**
  - In general, values were lower than those expected from traditional biomass/bioenergy sites
  - These data are important for establishing methodologies for other long-term phyto sites
- **REGIONAL PHYTO PROGRAM**
  - Lessons learned will inform the development of our new regional phyto program – especially with regard to resources & logistics needed to collect the data

Thank you!

Contact Information

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I am grateful to the conference organizers for the opportunity to speak today.