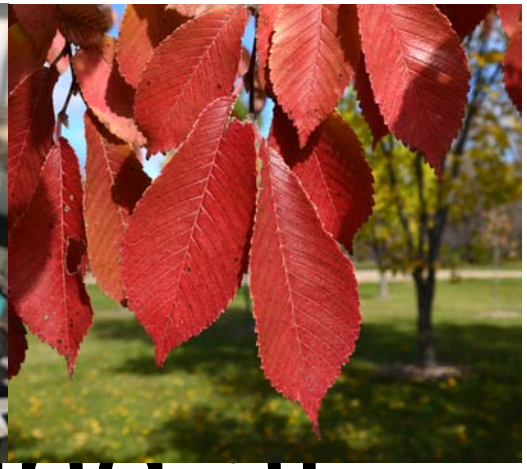




Plant Breeding at North Dakota State University

Todd P. West, Ph.D.

NDSU Woody Plant Improvement Program Director

NDSU North Dakota State University

NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION


Green
Eggs

NDSU Woody Plant Improvement Program (WPIP)

- 1954 - Woody plant evaluations began.
- 1971 - Improvement program initiated by Dr. Dale E. Herman (Professor Emeritus, 1971 – 2010).
- 1986 – First plant introductions.
- Under the direction of Dr. Dale Herman, 51 woody plant selections have been introduced.
- 2011 - Dr. Todd West selected as WPIP Project Leader.
- 2016 - Total of 56 introductions have been made.

http://ndsuresearchfoundation.org/horticulture

HORTICULTURE

ALDER
- Prairie Horizon® Manchurian Alder - Alnus hirsuta 'Harbin' RFM-33

ASH
- Dakota Centennial™ Green Ash - Fraxinus pennsylvanica 'Wahpeton' RFM-06
- Prairie Dome® Ash - Fraxinus pennsylvanica 'Leeds' RFM-11
- Prairie Spire® Green Ash - Fraxinus pennsylvanica 'Rugby' RFM-14

BIRCH
- Dakota Pinnacle® Asian White Birch - Betula platyphylla 'Fargo' RFM-19
- Prairie Dream® Paper Birch – Betula papyrifera 'Varen' RFM-32
- Prairie Vision™ Asian White Birch - Betula platyphylla 'Verdale' RFM-34
- Northern Tribute® River Birch – Betula nigra 'Dickinson' RFM-43
- Cinnamon Curls® Dwarf Korean Birch - Betula costata 'CinnDak' RRM-73

BUCKEYE
- Prairie Torch® Hybrid Buckeye - Aesculus x 'Bergeson' RFM-35
- Lavaburst® Ohio Buckeye - Aesculus glabra 'LavaDak' RFM-76

CHERRY
- Emerald Charm™ Cherry - Prunus x 'Morgenson' RFM-57

DOUGLAS FIR
- Green Canyon™ Rocky Mountain Douglas Fir - Pseudotsuga menziesii var. glauca 'Winterscape' RFM-67

ELM
- Prairie Expedition® American Elm - Ulmus americana 'Lewis & Clark' RFM-37
- Northern Empress® Japanese Elm - Ulmus davidiana var. japonica 'Burgundy Glow' RFM-74

Three Primary Goals

1. Evaluate unreleased or released cultivars from the nursery trade to determine usability in the United States Northern Great Plains.

2. Select and/or breed new cultivars suitable for the Northern Great Plains.
   - Fortunately, many of the selections are suitable for much wider use.

3. Increase plant diversity

Diversity

- Need for adapted, winter hardy, pest resistant woody plants suitable for use in the northern US and prairie Canada.

- Many of the current commercially available nursery cultivars are not suitable for USDA cold climatic zones 3 and 4, lower annual moisture availability, and higher soil pH levels.

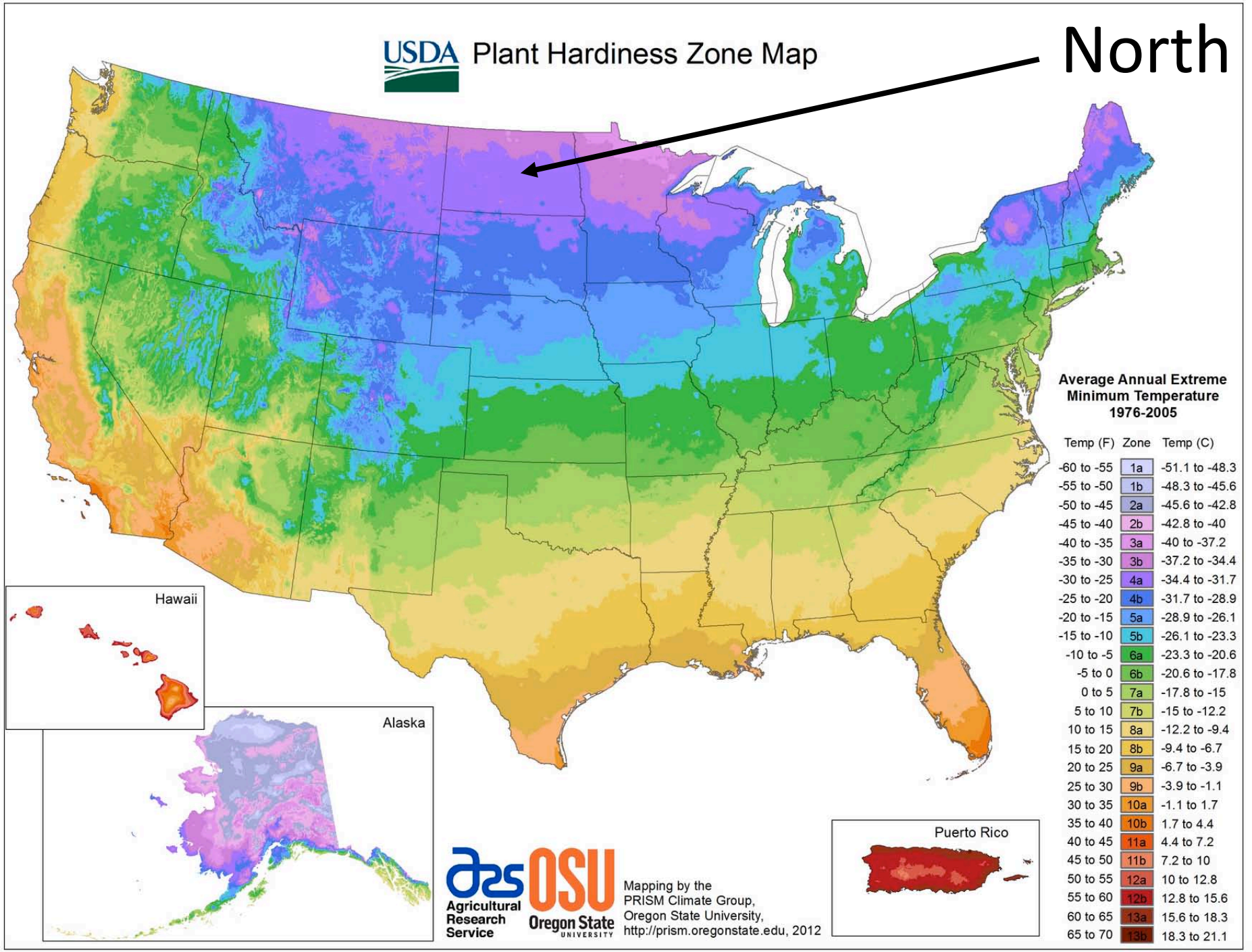
- Need to increase plant diversity in response to disease and insect pest issues and loss of adapted genera and species- Ash, Elm, Spruce, Pine.

Where am I?

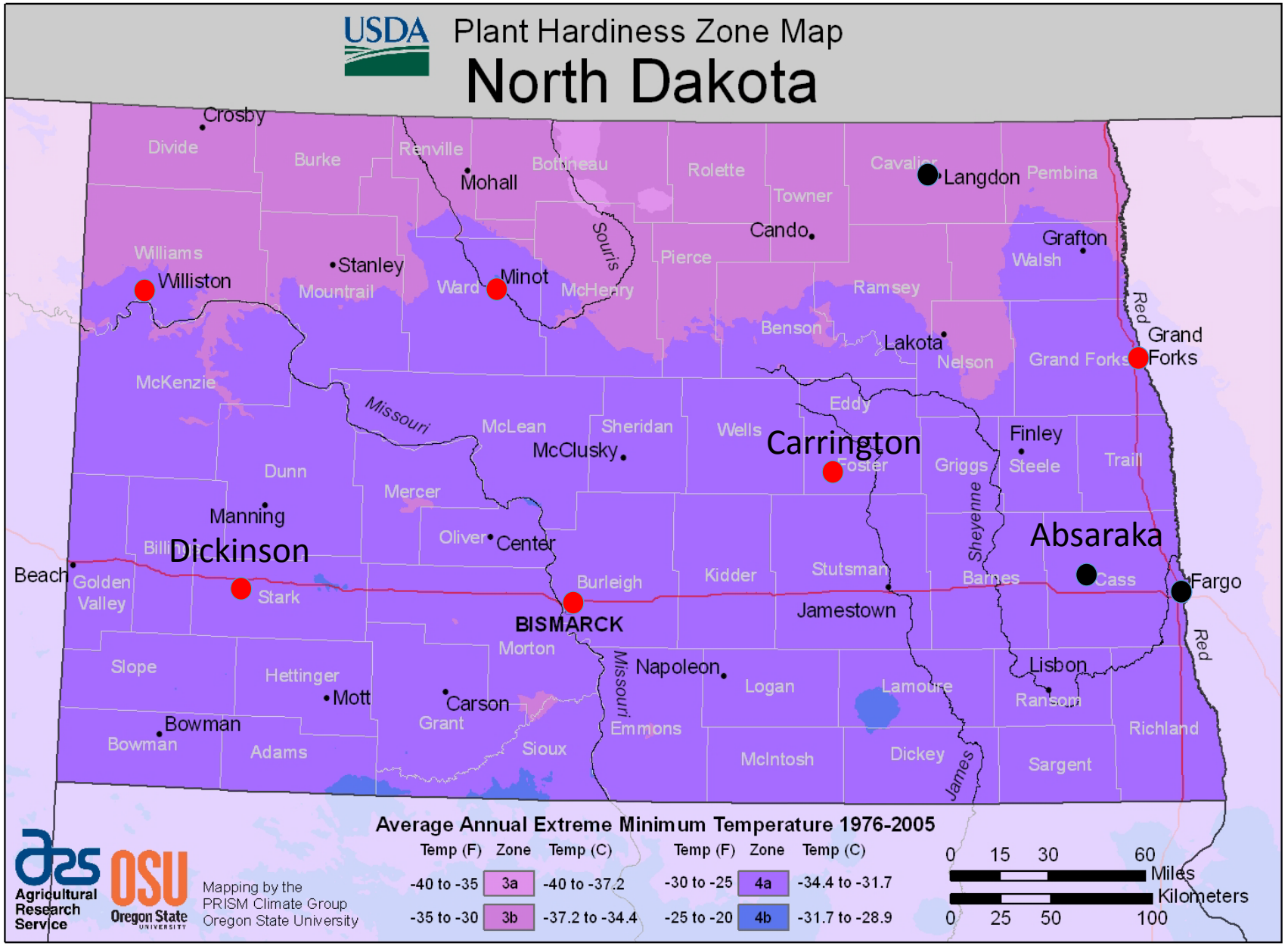
Photo by http://commons.wikimedia.org


90 MINUTE PARKING
NO PARKING
STREET CLEANING
MON WED FRI
1 AM - 7 AM


fargo park DISTRICT
Welcome to Fargo
"City of Parks"


USDA Plant Hardiness Zone Map
North Dakota
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-60 to -55 1a -51.1 to -48.3
-55 to -50 1b -48.3 to -45.6
-50 to -45 2a -45.6 to -42.8
-45 to -40 2b -42.8 to -40
-40 to -35 3a -40 to -37.2
-35 to -30 3b -37.2 to -34.4
-30 to -25 4a -34.4 to -31.7
-25 to -20 4b -31.7 to -28.9
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
-5 to 0 6b -20.6 to -17.8
0 to 5 7a -17.8 to -15
5 to 10 7b -15 to -12.2
10 to 15 8a -12.2 to -9.4
15 to 20 8b -9.4 to -6.7
20 to 25 9a -6.7 to -3.9
25 to 30 9b -3.9 to -1.1
30 to 35 10a -1.1 to 1.7
35 to 40 10b 1.7 to 4.4
40 to 45 11a 4.4 to 7.2
45 to 50 11b 7.2 to 10
50 to 55 12a 10 to 12.8
55 to 60 12b 12.8 to 15.6
60 to 65 13a 15.6 to 18.3
65 to 70 13b 18.3 to 21.1
Hawaii
Alaska
Puerto Rico
Agricultural Research Service
Oregon State University
Mapping by the PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, 2012

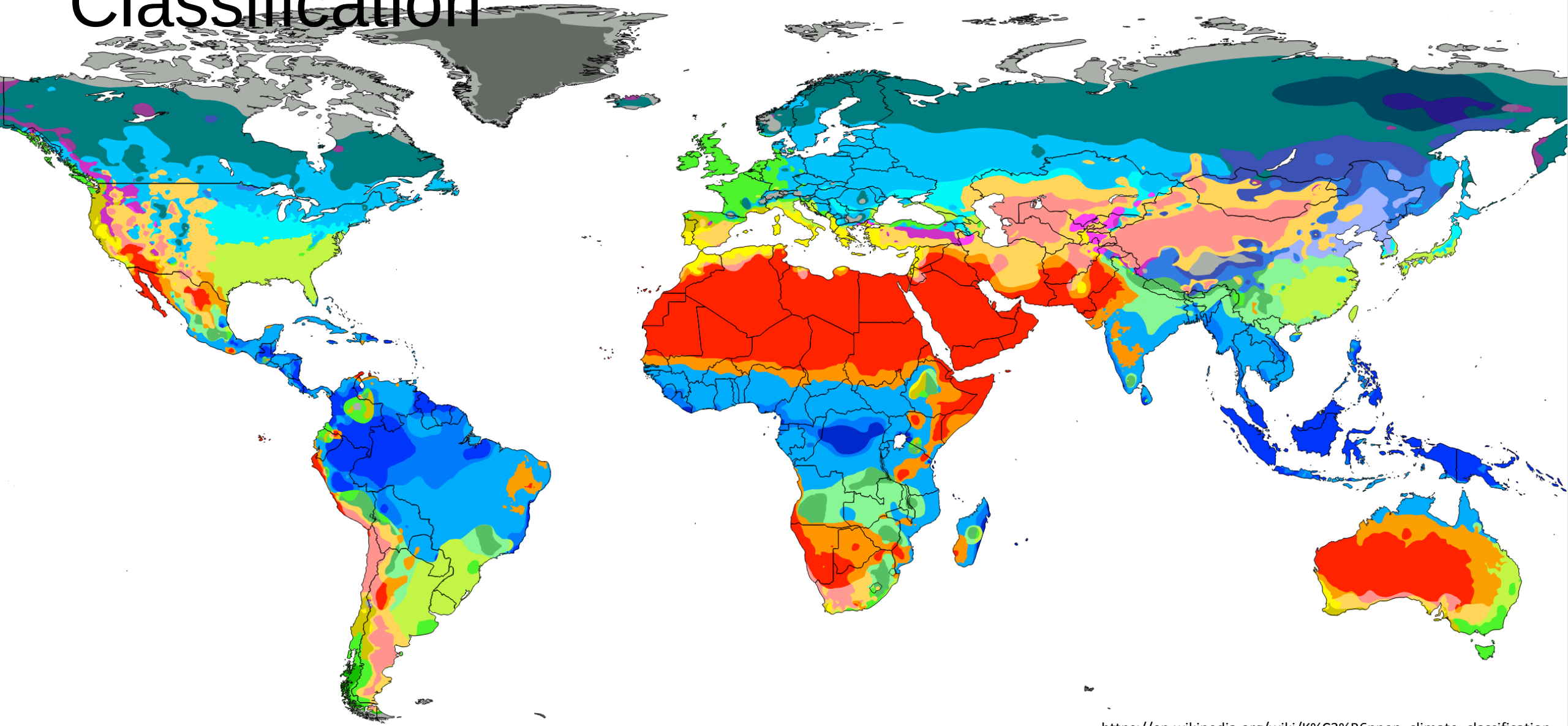
North Dakota Evaluation Sites



● - Primary Research Evaluation Sites

● - Secondary Research Evaluation Sites

World Map – Köppen-Geiger Climate Classification



https://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification

Climate data for Fargo, North Dakota (Hector Int'l), 1981–2010 normals, extremes 1881–present[a] [hide]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °F (°C)	54 (12)	66 (19)	80 (27)	100 (38)	104 (40)	104 (40)	114 (46)	106 (41)	102 (39)	93 (34)	74 (23)	65 (18)	114 (46)
Average high °F (°C)	18.4 (−7.6)	23.7 (−4.6)	36.3 (2.4)	55.8 (13.2)	69.3 (20.7)	77.4 (25.2)	82.5 (28.1)	81.2 (27.3)	70.8 (21.6)	56.0 (13.3)	37.3 (2.9)	22.3 (−5.4)	52.58 (11.43)
Average low °F (°C)	0.1 (−17.7)	5.6 (−14.7)	19.4 (−7)	32.7 (0.4)	44.9 (7.2)	55.0 (12.8)	59.5 (15.3)	57.3 (14.1)	47.4 (8.6)	35.1 (1.7)	20.3 (−6.5)	5.9 (−14.5)	31.93 (−0.03)
Record low °F (°C)	−48 (−44)	−47 (−44)	−34 (−37)	−13 (−25)	14 (−10)	28 (−2)	36 (2)	32 (0)	17 (−8)	−4 (−20)	−27 (−33)	−36 (−38)	−48 (−44)
Average precipitation inches (mm)	0.70 (17.8)	0.61 (15.5)	1.30 (33)	1.36 (34.5)	2.81 (71.4)	3.90 (99.1)	2.79 (70.9)	2.56 (65)	2.57 (65.3)	2.15 (54.6)	1.00 (25.4)	0.83 (21.1)	22.58 (573.5)
Average snowfall inches (cm)	11.2 (28.4)	7.0 (17.8)	9.1 (23.1)	3.0 (7.6)	trace	0 (0)	0 (0)	0 (0)	0 (0)	0.7 (1.8)	7.9 (20.1)	11.2 (28.4)	50.1 (127.3)
Average precipitation days (≥ 0.01 in)	8.3	7.2	8.3	7.4	11.0	11.7	9.5	9.1	8.7	8.3	7.1	9.2	105.8
Average snowy days (≥ 0.1 in)	8.9	6.7	5.3	1.8	0	0	0	0	0	0.8	5.4	9.5	38.4
Average relative humidity (%)	73.1	74.7	76.0	65.6	60.0	66.1	66.9	66.5	69.2	68.8	75.7	76.1	69.9
Mean monthly sunshine hours	140.9	153.9	212.3	241.6	283.2	303.2	350.2	313.2	231.2	178.9	113.1	107.4	2,629.1
Percent possible sunshine	51	53	58	59	61	64	73	71	61	53	40	40	59

Last Frost Date: May 10

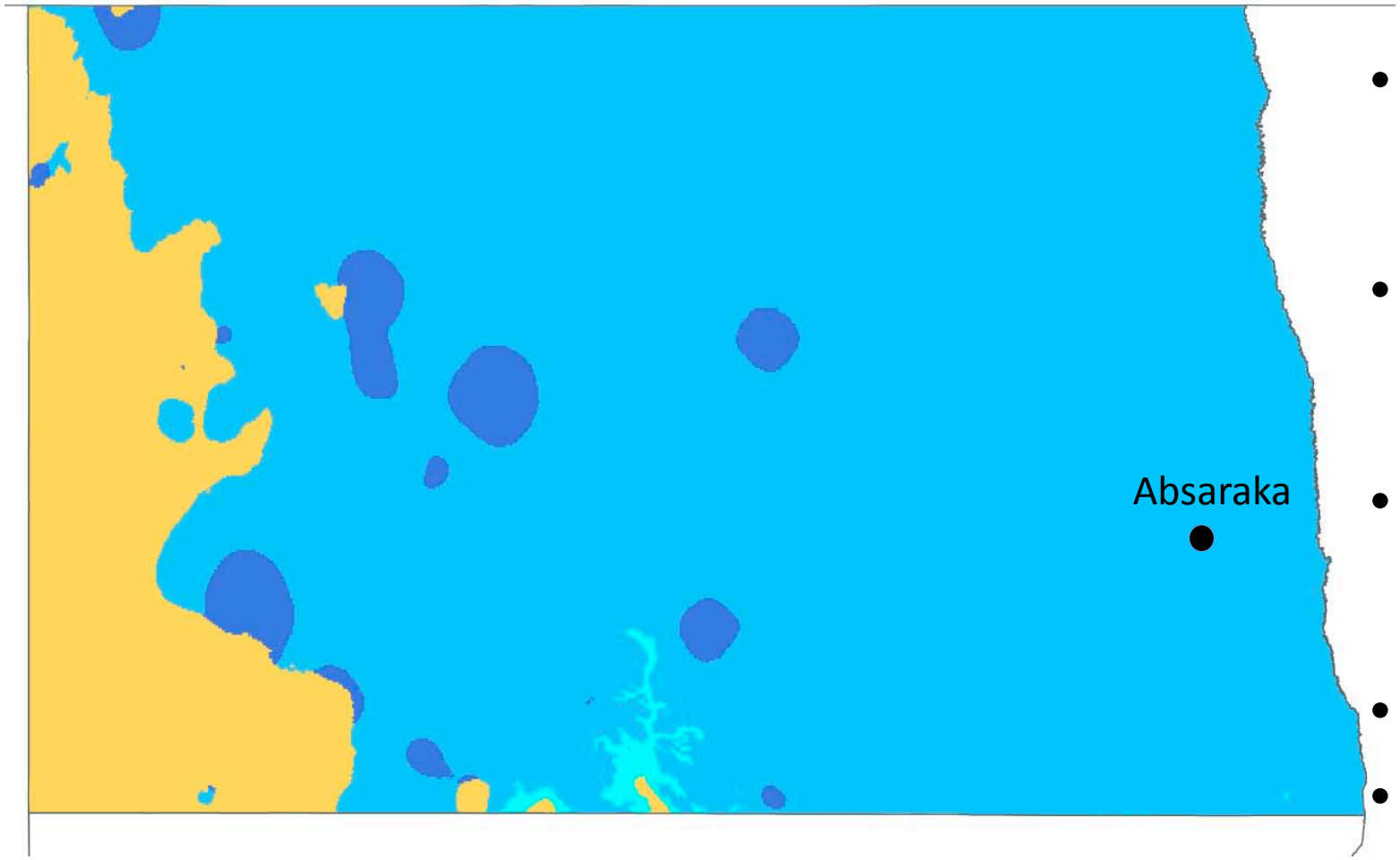
First Frost Date: September 25

ND Average Growing Days: 130

January Average Low: -17.7 °C

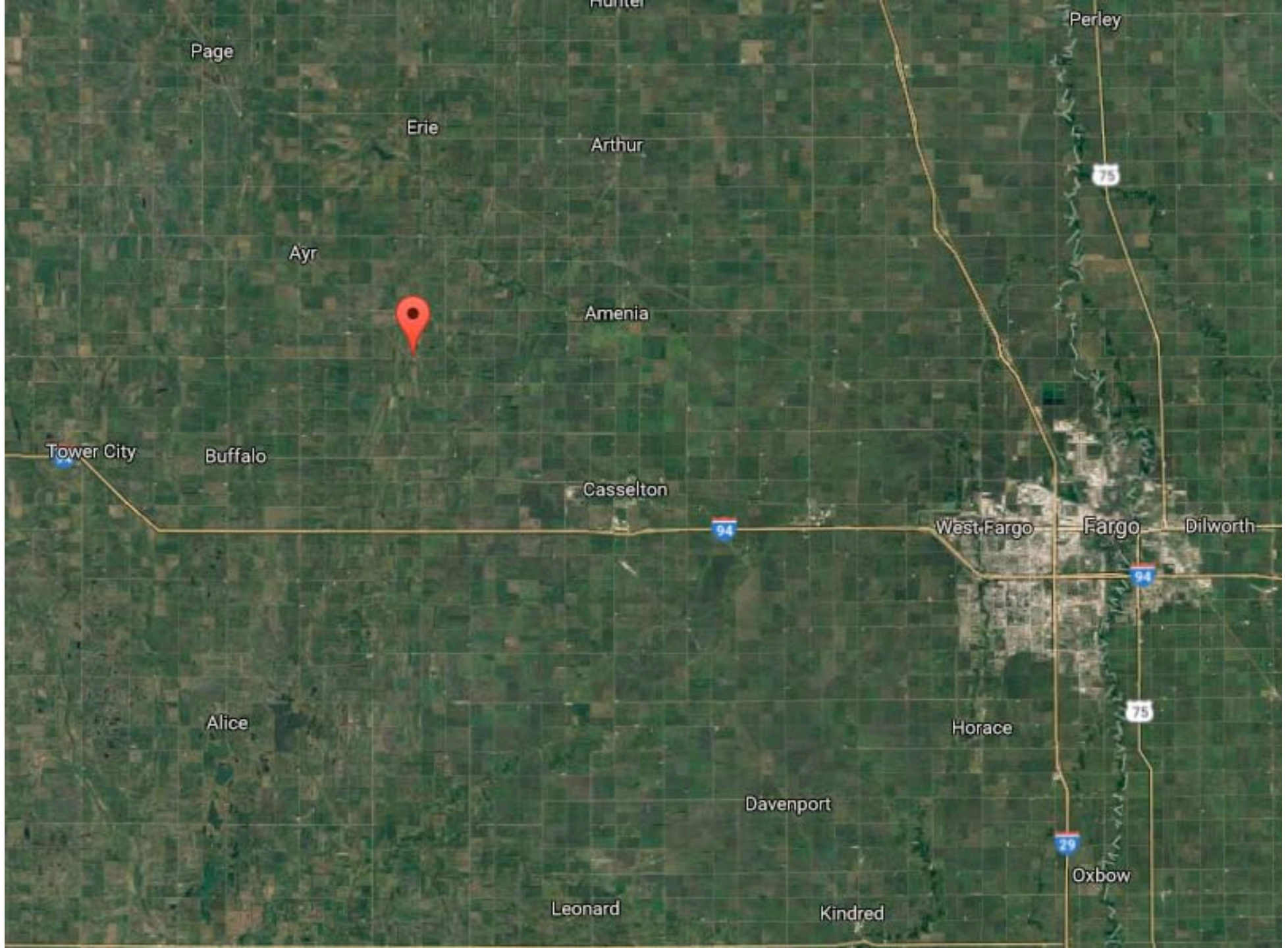
January 2016 Low: -31 °C (-24 °F)

NDSU Dale E. Herman Research Arboretum



- The program has evaluated **200+** genera and **3,000+** species and cultivars of trees and shrubs.
- Over **9500+** accessions obtained, evaluated and developed since planting began in 1974.
- Largest woody ornamental plant collection in North Dakota and the Northern Great Plains.
- Located near Absaraka, ND
- Total of 80 acres (~32 hectares)

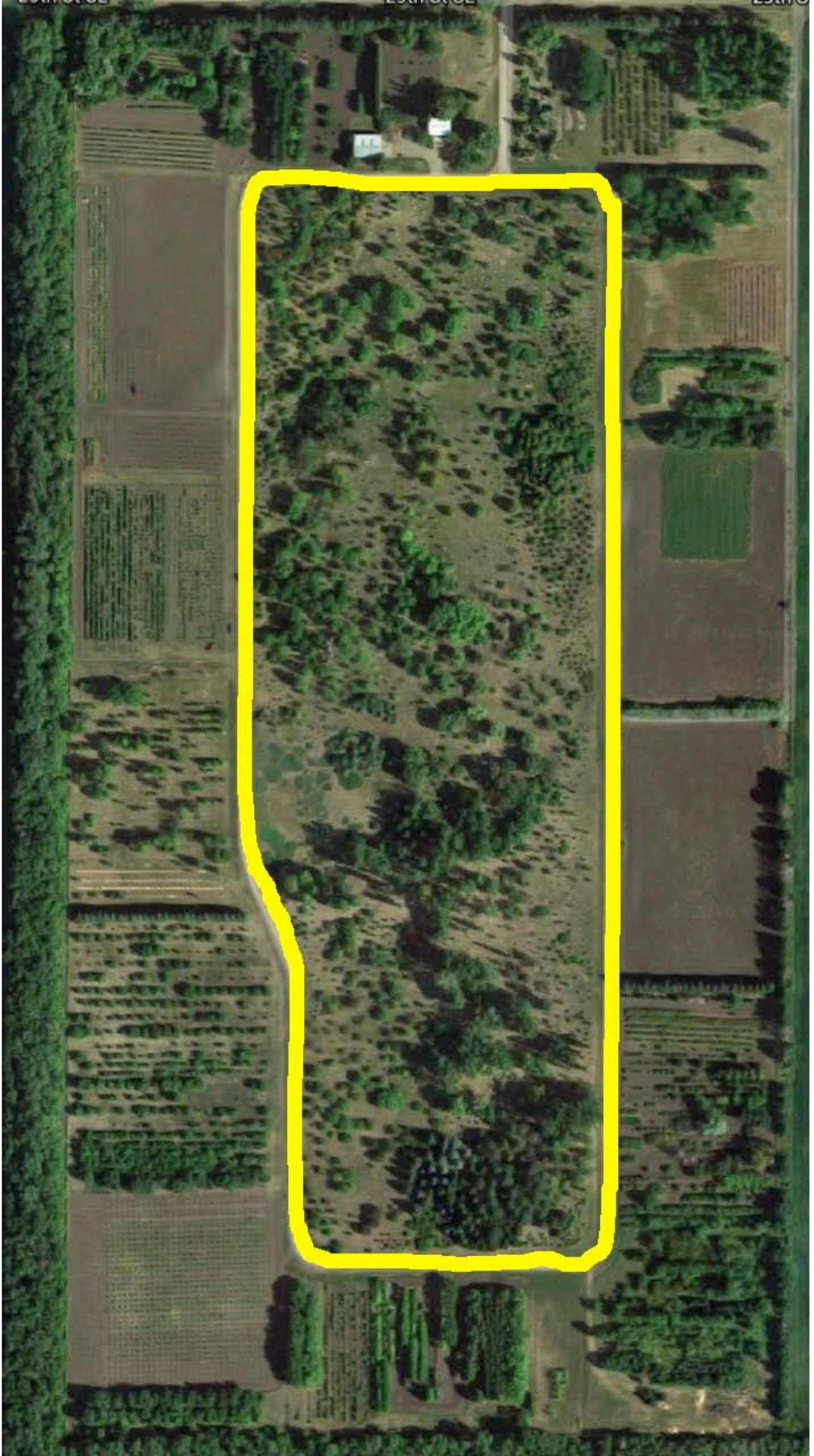
https://en.wikipedia.org/wiki/Climate_of_North_Dakota

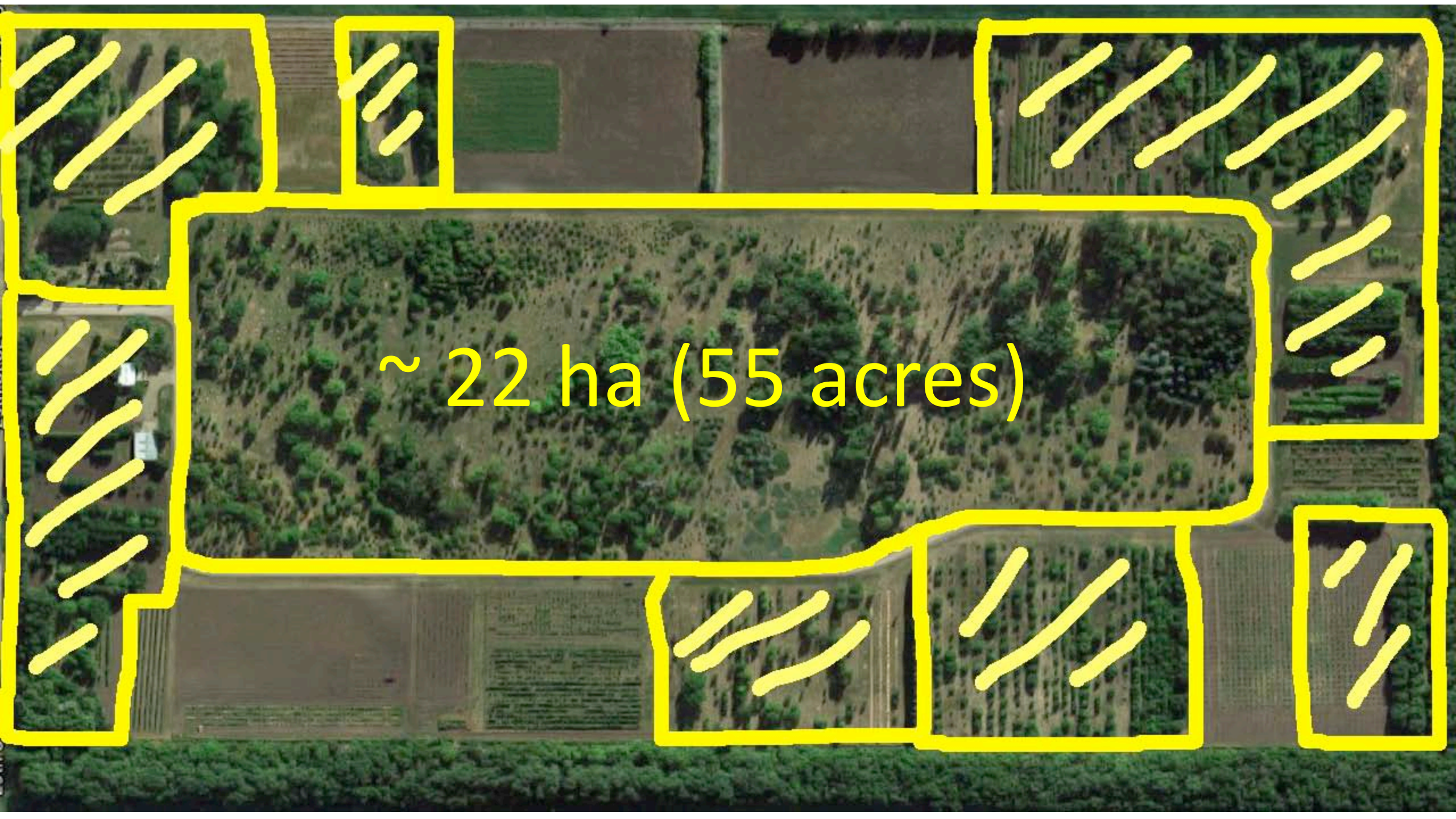

Hunter
Perley
Page
Erie
Arthur
75
Ayr
Amenia
Tower City
Buffalo
Casselton
West Fargo
Fargo
Dilworth
94
94
75
Alice
Horace
Davenport
29
Oxbow
Leonard
Kindred


5
32
5

Photos by NDSU WPIP


N




~ 22 ha (55 acres)

Urban Climate Conditions

- NDSU WPIP program is ideal for Northern US climate conditions.
- Urban Soils are typically:
  - Compacted
  - Dry
  - High pH (>8.0)
- ND is one of the driest states in the United States
- ND soils are typically >8.0 pH

Evaluations

Northern site for American Rose Trials for Sustainability (A.R.T.S)

American Rose Trials for Sustainability

AMERICAN ROSE TRIALS for SUSTAINABILITY
MISSION STATEMENT

Goals

To identify, through regional evaluation and testing under low input conditions, the most disease and pest resistant, hardiest and best garden-worthy rose cultivars and to provide objective, accurate and reliable information about the cultivars tested for each region to industry and the public.

Basis / Methodology

Establish and maintain an environmentally responsible testing model that incorporates current research-proven landscape management techniques for the evaluation of rose cultivars for regional suitability in the United States for landscape use under minimal input conditions. The testing model shall be expanded as scientific advancements in the area of environmentally responsible landscape management becomes relevant.

Guiding Principals

Horticultural decisions must be based on environmental responsibility and will be guided by the latest scientifically-sound research-based information.

Employ a 98% reduction in the application of pesticides (including fungicides, miticides and other pesticide products). Only in extreme and unusual circumstances will pesticides be allowed, and in that limited extreme instance the most environmentally responsible product will be applied.

Provide objective, accurate and reliable performance assessments of rose cultivars under evaluation to those submitting the cultivars for testing.

Maintain and protect the integrity and credibility of the program – at all costs, avoiding all conflicts and potential conflicts of interest.

Maintain complete transparency in the objectives, testing methodology, implementation and performance determinations.

Ensure that those selected to perform cultivar evaluations have a high level of practical relevance and expertise and ensure that those individuals perform evaluations based on the American Rose Trial protocols and Judging Guidelines without regard or consideration given to any outside influence.

American Rose Trials for Sustainability will launch January, 2013

Photos by NDSU WPIP

Cultivar Comparison Blocks with Industry Cooperators

Photos by NDSU WPIP

Northern site for Hybrid maple (*Acer palmatum* x *A. pseudosieboldianum*) Trial

Photo by NDSU WPIP

Cornus mas, Cornelian Cherry

Cultivars Grafted – 47

- Albanos (Eppler's Black)
- Aurea
- Black Plum
- Bukouvinski
- Butilochni
- Chicago
- Dripping Cherries
- Dublany
- Early Bird
- Early Purple
- Elegant
- Flava
- Florianka
- Gelbe Selection
- Golden Glory
- Julico
- Juliusz
- Kotula
- Kuklen
- Lagodekhi #1
- Lagodekhi #2
- Lagodekhi Yellow
- Lukanovski
- Lutea
- Macrocarpa
- Neczhnyi
- Palzoski
- Priorski
- Pyramidalis
- Raciborski
- Red Dawn
- Red Star
- Schonbrunner Gourmet
- Shan
- Shumen
- Slowianin
- Spring Glow
- Surprise
- Tcarigradski
- TS804 (UW-Arboretum)
- Typ 3
- Vavilov
- Violacea
- Vladimirski
- Vraca
- Yantarny
- Yellow September

Cornus mas – Micropropagation Evaluation

Germplasm Sources

- Foreign and domestic seed sources
  - Growing out seedling populations and selecting individuals with superior attributes.
- Plant breeding
  - Traditional breeding including F_2 populations to observe segregation of traits.
  - Hybridizing
    - Both intra- and interspecific hybridization
- In Vitro Tissue Culture
  - Somaclonal variation
  - Embryo rescue
  - Mutagenesis
  - Genetic engineering

Plant Improvement Methods

- Selections by landscape observations
- Seed source and seed lot variation (mass selection)
- Breeding
  - Traditional
  - Mutagenic

Selection by Landscape Observation

- Established mature seedling origin trees growing in landscapes throughout the central and northern plains.
- Select for species, form, plant quality, non or minimal fruiting, fall color, adaptability to soil pH, droughty conditions, etc.

Photos by Greg Morgenson, NDSU

Seed Source and Seed Lot Variation

- *Quercus bicolor* (Swamp White Oak) seed lot variation in seedlings.

Photos by NDSU WPIP

Long term Observation of Selected Seedlings
September Flare® Sugar Maple

Selected as 2-yr seedling in 2002 for very early red fall color initiation (day length dependent not temperature dependent), grown for additional 10 years to observe fall color, 2015 release from NDSU Woody Plant Program.

Photos by Greg Morgenson, NDSU

Breeding (Traditional)

Magnolia Breeding

Magnolia Breeding

- Historically the NDSU WPIP selections were a result of selections by landscape observations and mass selection (seed lot variation).
- No breeding work was conducted prior to 2011.
- Started breeding of *Magnolia* in 2012.

How did I get involved in the crazy world of Magnolias?

- Spring Welcome® Magnolia (*Magnolia* x*loebneri* 'Ruth')
  - Blooms reliably even after early spring frosts.
  - Flowers are pale pink in bud, gradually opening to white with 11 – 13+ tepals.
  - Outperformed other Loebner Magnolia hybrids tested in USDA hardiness zone 4.
- Dennis Ledvina
  - Sent email to me asking if my seed source for Spring Welcome® was from the MSI seed counter program.
  - Mentor

Photos by NDSU WPIP

Dennis Ledvina

- Met Dennis in 2012
- Made ~150 crosses in 2012
- Made ~200 crosses in 2013
- After seed collection in 2014, decision was made to focus breeding efforts.

Photo by NDSU WPIP

NDSU Breeding Goals

- Hardiness
  - To increase availability of hardy selections of magnolia for USDA cold hardiness zones 3b – 4b.
- Focusing on:
  - Form - Narrow form, smaller size (dwarf)
  - Bloom
    - Flower color, shape and size - Anything to increase flower color diversity from white
  - Increased bloom time
  - Increased fragrance

Breeding Objectives – Hardiness

- Developing magnolias hardy in a USDA hardiness zone 3b/4a environment
- Late blooming to avoid spring frosts
- Utilizing
  - Spring Welcome® magnolia (*M.* x *loebneri* 'Ruth') and Lynn magnolia (*M. stellata* 'Lynn')
  - *M. acuminata* hybrids from Dennis Ledvina and others.
- Field trials to determine hardiness potential of species, cultivars and unreleased materials.

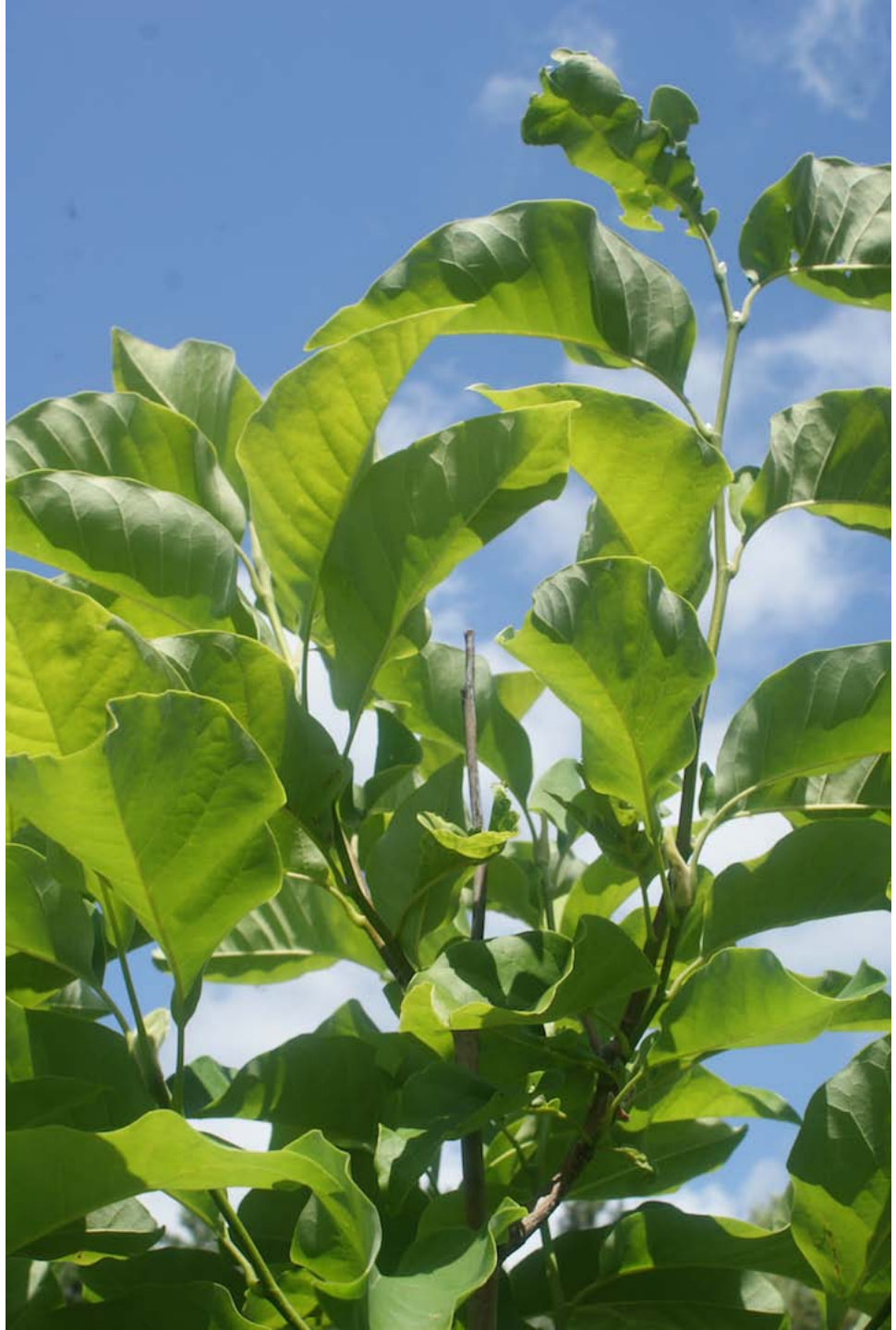
Spring Welcome® Magnolia

Photo by NDSU WPIP

Magnolia x ‘Yellow Lantern’

(*M. acuminata* var. *subcordata* x *M.* x*soulangeana* ‘Alexandrina’)

Photos by NDSU WPIP and http://www.missouribotanicalgarden.org/PlantFinder/FullImageDisplay.aspx?documentid=30045



Photos by Todd West, NDSU

Breeding Objectives – Bloo

- Color
  - Yellow, Pink, Magenta
- Bloom time (late and extended)

Photos by NDSU WPIP

Breeding Objectives - Form

- Developing dwarf-sized selections.
  - ‘Genie’
  - ‘Sunsprite’
- Developing narrow fastigiate (upright) selections.
  - ‘Candle Stick’ – unreleased Ledvina hybrid
  - ‘Sunspire’

’Sunsprite’

M. x ‘Genie’

Photo by NDSU WPIP

Breeding – Pollen Collection

Photo by NDSU WPIP

Breeding Limitations - Fie

- Timing
- Limited field planted germplasm in ND.
- Cold temps, especially at night can cause poor pollen tube development resulting in poor seed set.

Photo by NDSU WPIP

Photo by NDSU WPIP

Photos by NDSU WPIP

Wednesday
26 April 2017

Night temps: -4.5 °C (~24 °F)

Photo by Todd West

Magnolia x*loebneri* ‘Leonard Messel’ - 2017

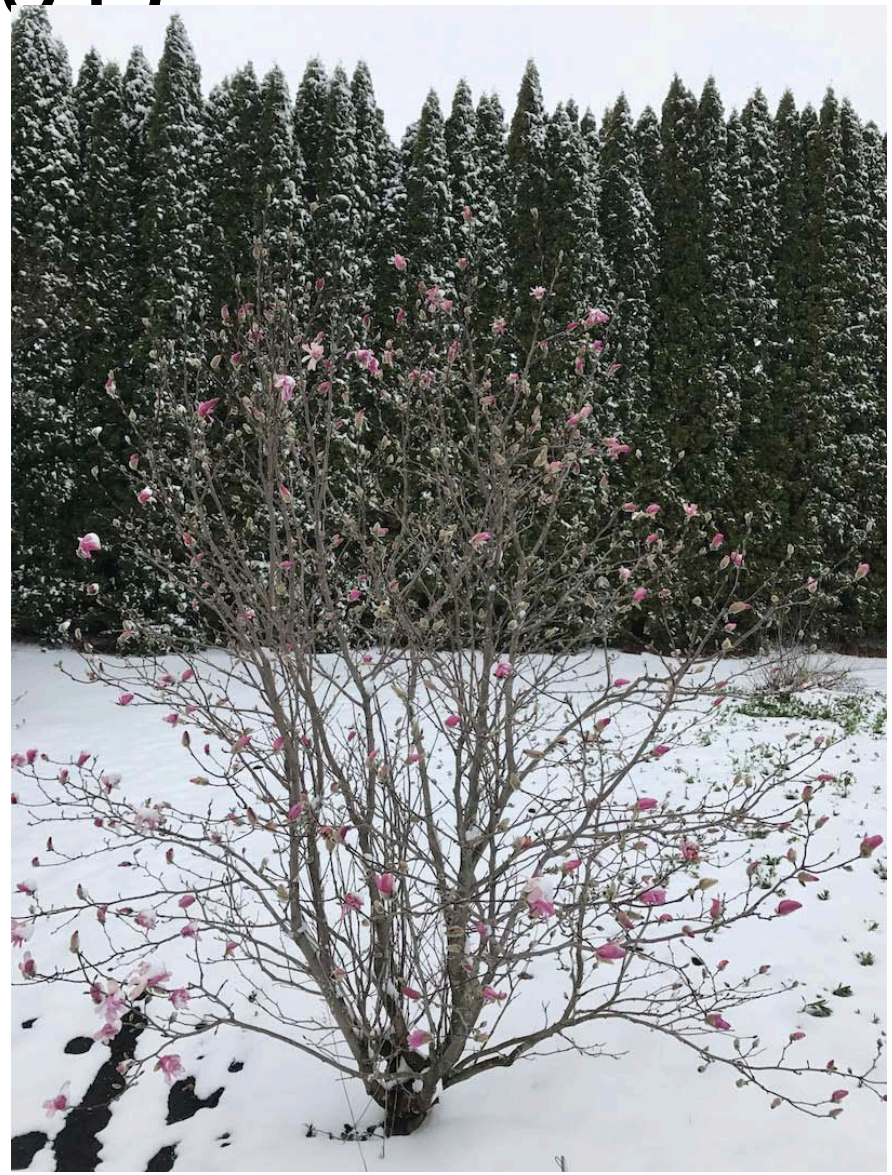


Photo by NDSU WPIP

Breeding – Forced Flowers

- Greenhouse forced flowers
- Limitation
  - Space
- Crosses
  - ‘Lynn’ x ‘Candle Stick’
  - ‘Lynn’ x ‘Burgundy Spire’
  - ‘Lynn’ x ‘Vulcan’
  - ‘Lynn’ x ‘Golden Gift’
  - ‘Lynn’ x ‘Black Beauty’
  - ‘Lynn’ x ‘Rose Marie’
  - ‘Lynn’ x ‘Peppermint Pop’ (‘Cosmic Gem’)

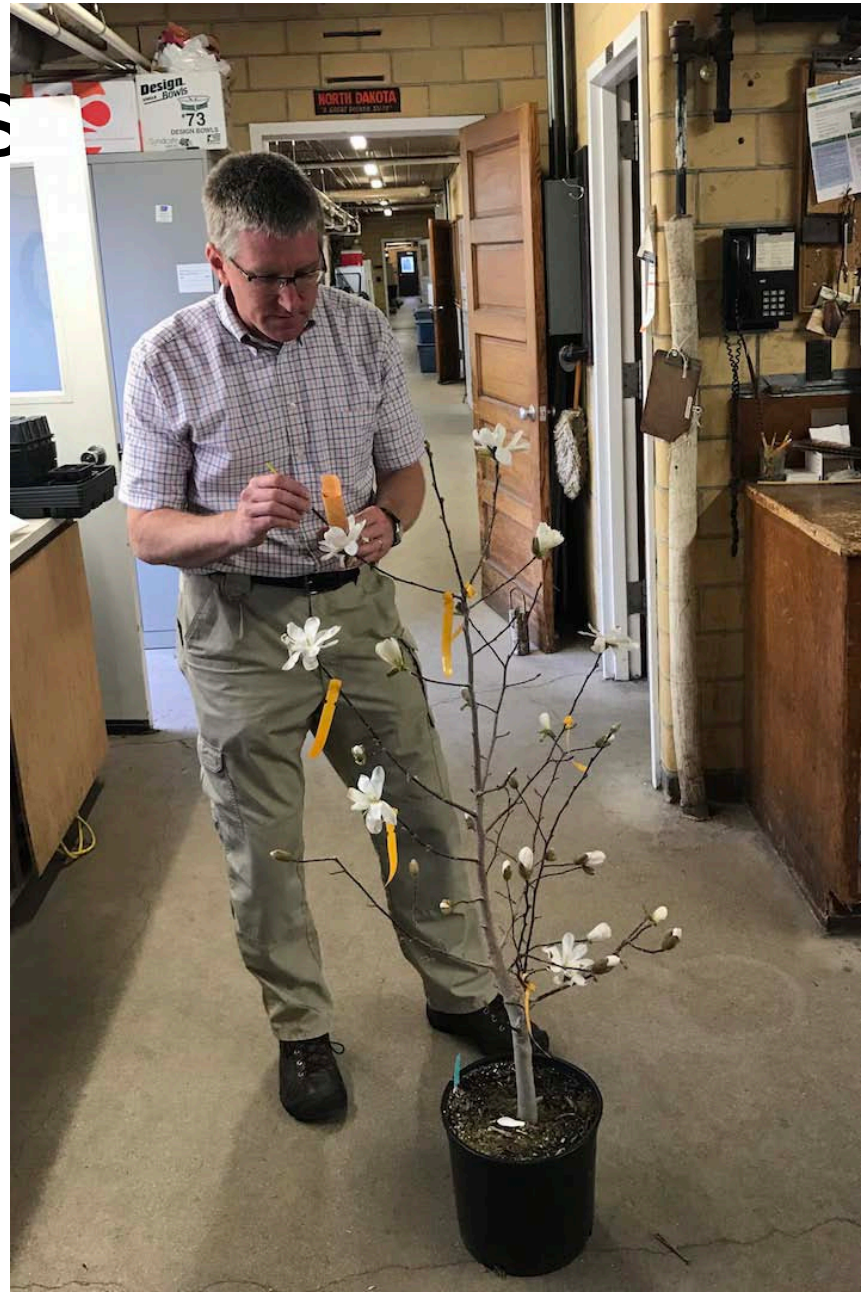


Photo by NDSU WPIP

Seed Collection

- Hybrid crosses

Seed Collection

- *M. acuminata* seed for growing own rootstocks.

Photo by NDSU WPIP

Photo by NDSU WPIP

Grow out of hybrid seed crosses for future outplanting at research arboretum.

Photos by NDSU WPIP

Cuttings and Grafting

Photo by NDSU WPIP

Magnolias may not be the most profitable, so….

Northern Spotlight® Korean Maple *Acer pseudosieboldianum* 'KorDak'

- NDSU release.
- Very winter hardy Korean Maple selection.
- 7-9 palmately lobed simple leaf
- Potential to fill void of winter hardy Japanese Maples.
- Retention of leaves throughout winter months – may assist in winter sun protection.

Photo by Greg Morgenson, NDSU

Summer

Fall

Photos by Greg Morgenson, NDSU

Acer x (*A. pseudosieboldianum* x *A. palmatum*)

X

Acer pseudosieboldianum 'KorDak'
Northern Spotlight® Korean Maple

Acer palmatum, Japanese Maple

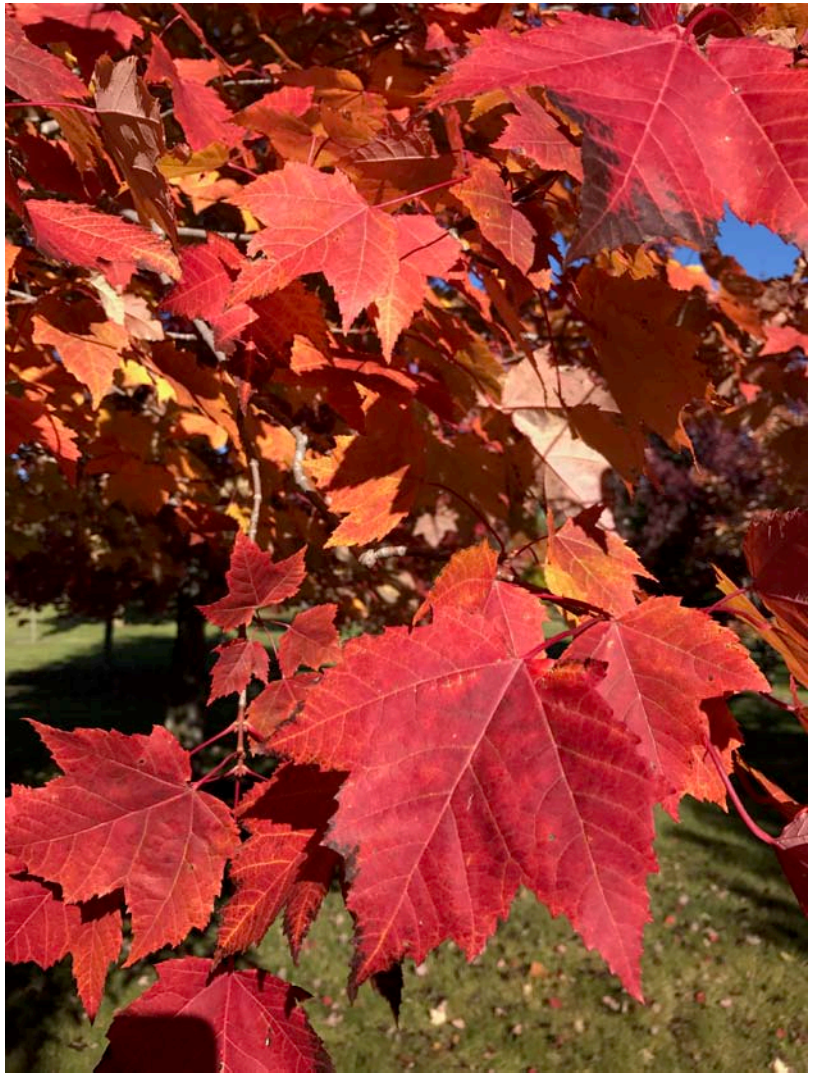
Photo by Greg Morgenson, NDSU

Photo by UBC Botanic Garden

Photos by NDSU WPIP

Acer x*freemanii* (*A. saccharinum* x *A. rubrum*)

X



Acer saccharinum ‘Skinner’, Skinner’s Cutleaf Silver Maple

Acer rubrum ‘Minnkota’, Fall Grandeur™ Red Maple

Photos by NDSU WPIP

F1 Hybrid

Autumn Blaze® Freeman maple with maple gall mites (top)
F1 Hybrid with no maple gall mites (bottom)

Photos by NDSU WPIP

Elms

- *Ulmus parvifolia* 'Hallelujah', Hallelujah lacebark elm
- *Ulmus davidiana* var. *japonica* 'Burgundy Glow', Northern Empress® Japanese elm

Photos by NDSU WPIP

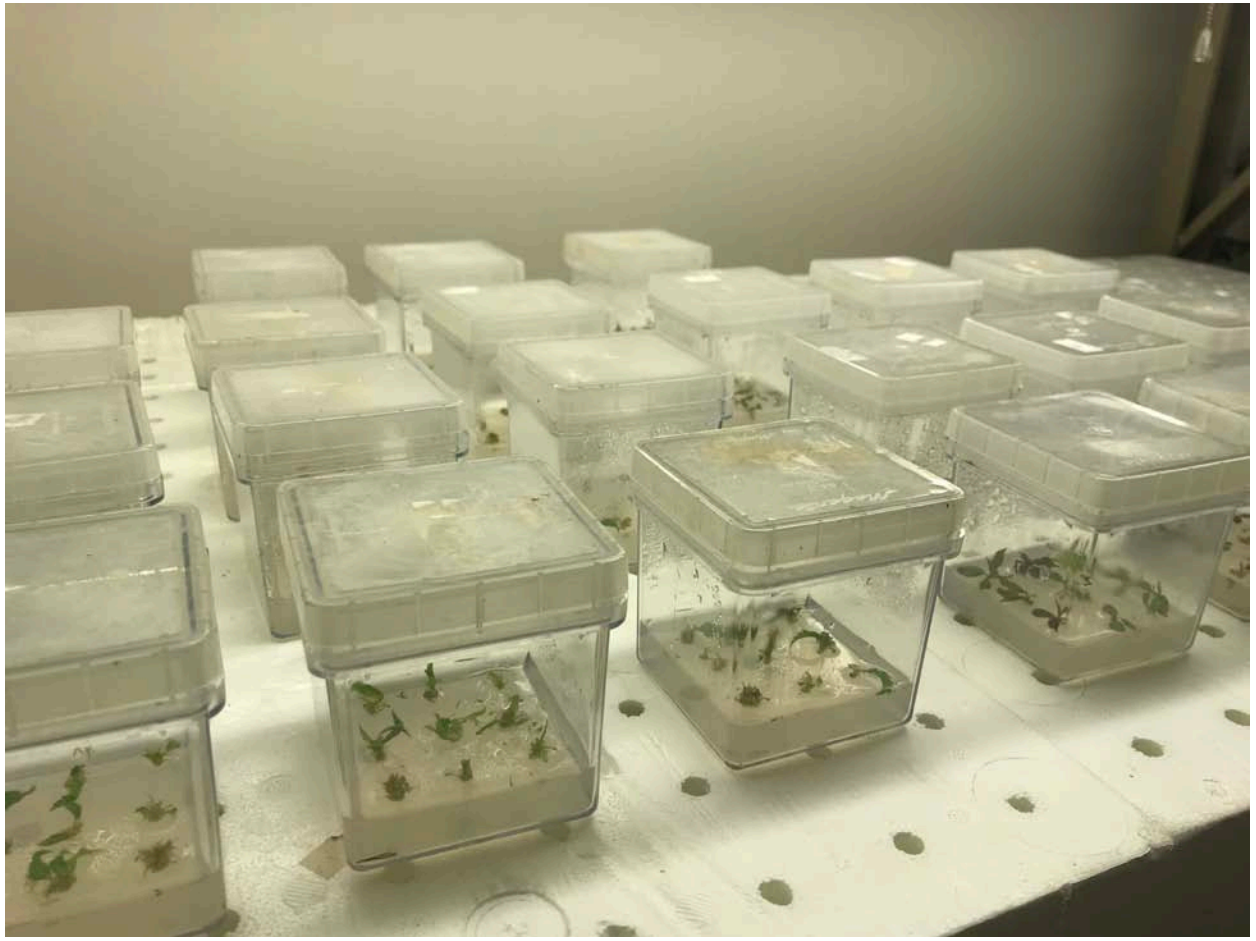
X

Photos by NDSU WPIP

Sambucus nigra ‘TS14019’ – Prostrate Form

Breeding Mutagenic

- Using gamma radiation and chemical mutagens
  - Trifluralin
  - Oryzalin
  - Colchicine
  - EMS
- Limited genetic diversity
- Development of induced polyploids and point mutations



Breeding Research

Procedures

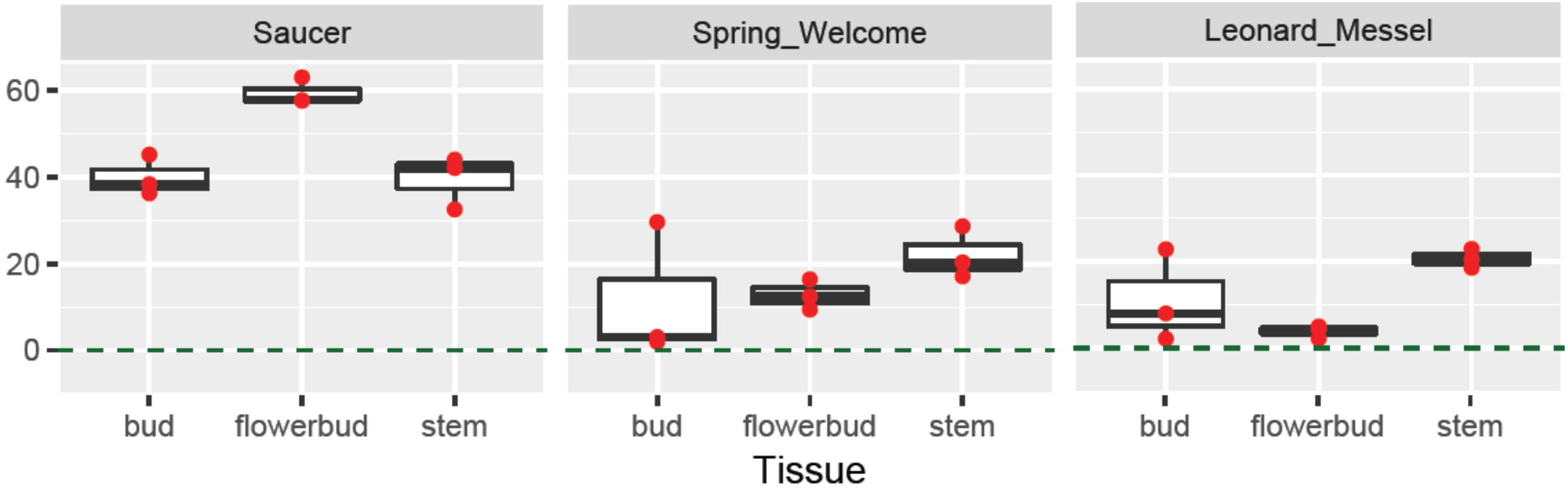
- Developing freeze test procedures in for earlier hardiness screening
- Breeding - making interspecific crosses with cold hardy species and hybrids
- Developing molecular markers for breeding selection
- Utilizing genetic modification technology for earlier trait screening

Freeze Tests – Measuring Electrical Conductivity (EC)

Photo by Todd West, NDSU WPIP

Freeze Tests – Measuring Electrical Conductivitv (EC)

Cold Injury -36C



Research (Other)

Propagation – Tissue Culture

For propagation and mutagenic breeding such as chromosome doubling.

Photos by NDSU WPIP

Propagation – Shoot Forcing (Latent/Epicormic Buds)

Photos by NDSU WPIP

Photos by NDSU WPIP

Photo by NDSU WPIP

Propagation – Grafting

- Oak rootstock compatibility trials and tolerance to higher pH soils.
- Prairie Pioneer® dwarf chinkapin oak on *Q. bicolor* (left) and on *Q. macrocarpa* (right) .

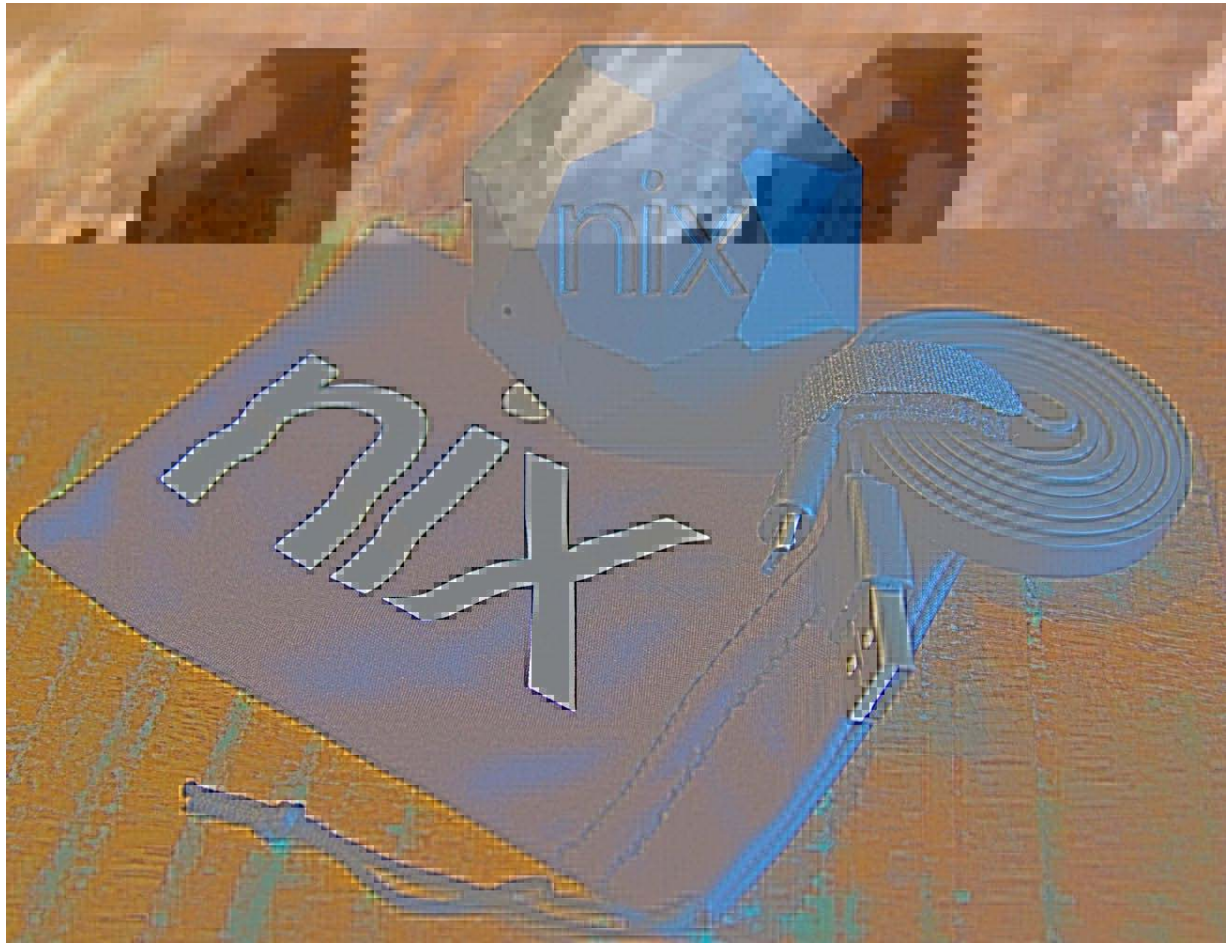
Photo by NDSU WPIP

Evaluating Flower Colors

- Colorimeter expensive but not subjective.
  - CR-400 Konica Minolta
- Use RHS Colour Chart
  - 6th ed. - 2015
  - Light sensitive
  - Time consuming
  - Subjective
- Nix Pro Color Sensor

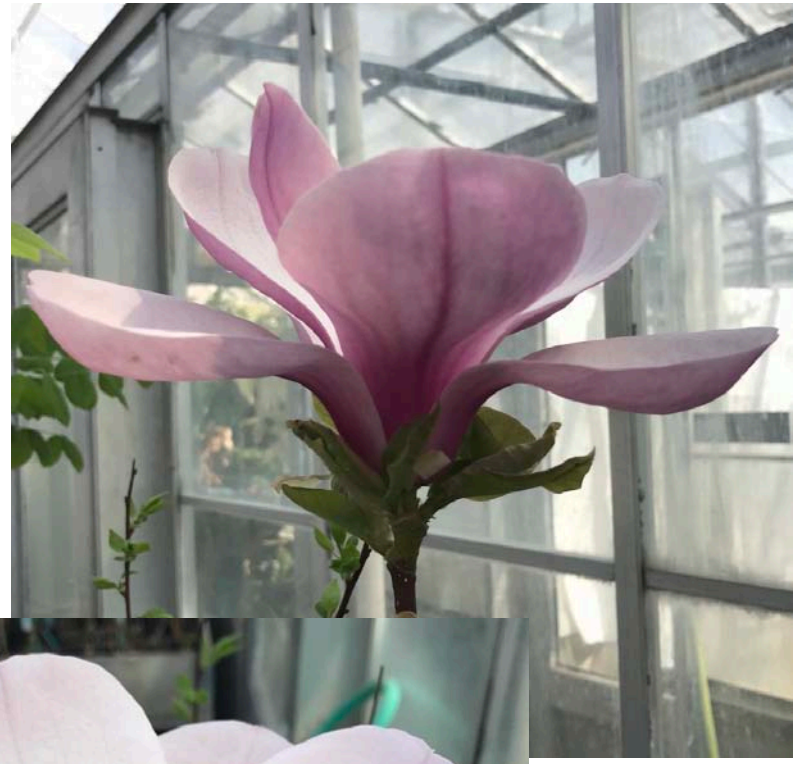
Nix Pro Color Sensor

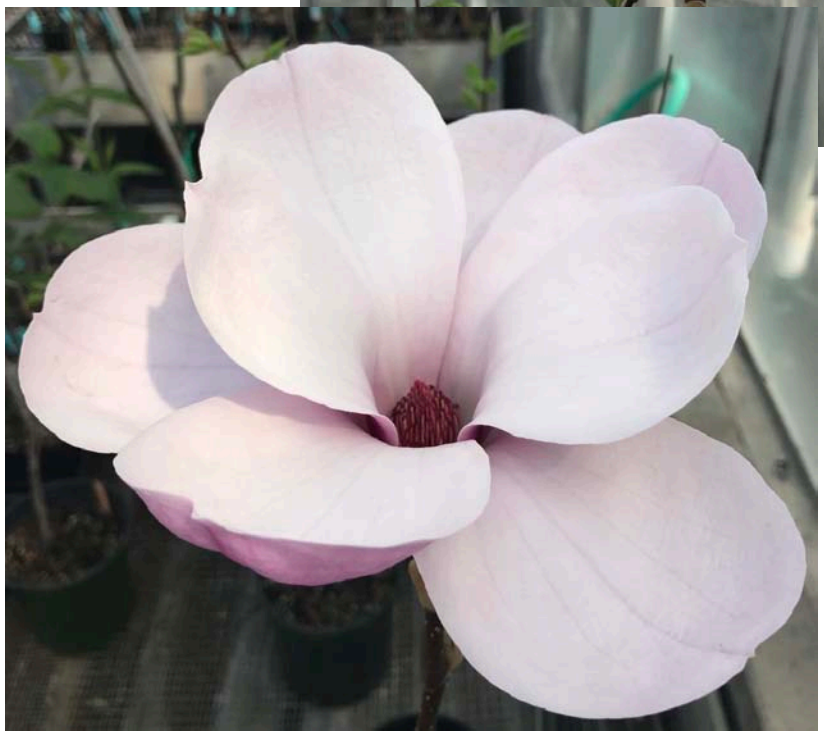
- Handheld device that can measure the color of any surface and provide accurate color information to smartphones or tablets.
- Patented design blocks out all ambient light and uses its own calibrated light source to provide an industry-leading level of accuracy.
- $350 U.S. dollars



Magnolia x ‘Roseanne’

- *M. lilliflora ‘*O’Neill’ x *M. kobus* ‘Noman Gould’
- Tetraploid cross
- Hybrid has six or seven tepals
- Rich lavender pink on the outside and a lighter pink on the inside.
- Denise Ledvina introduction

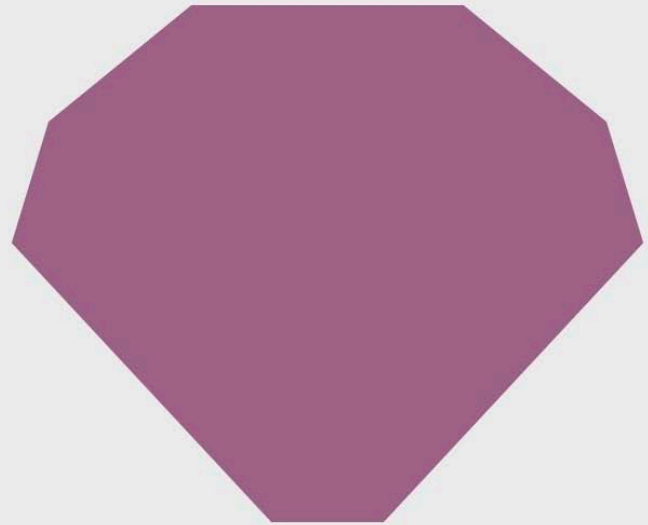





nix


nix

Scan Color



Illuminant: D50 Observer: 2°

RGB: R:159 G:98 B:136

CMYK: C:40% M:71% Y:25% K:2%

HEX: #9F6288

CIELAB: L:49.3 a:29.4 b:-10.3

Scan with Nix Pro

Compare to Library

Scanned Color:

CIELAB: L:49.3 a:29.4 b:-10.3

Select Color Library

Closest Matches:

Strong Purple - 77B
dE2000: 4.7 dE76: 9.7

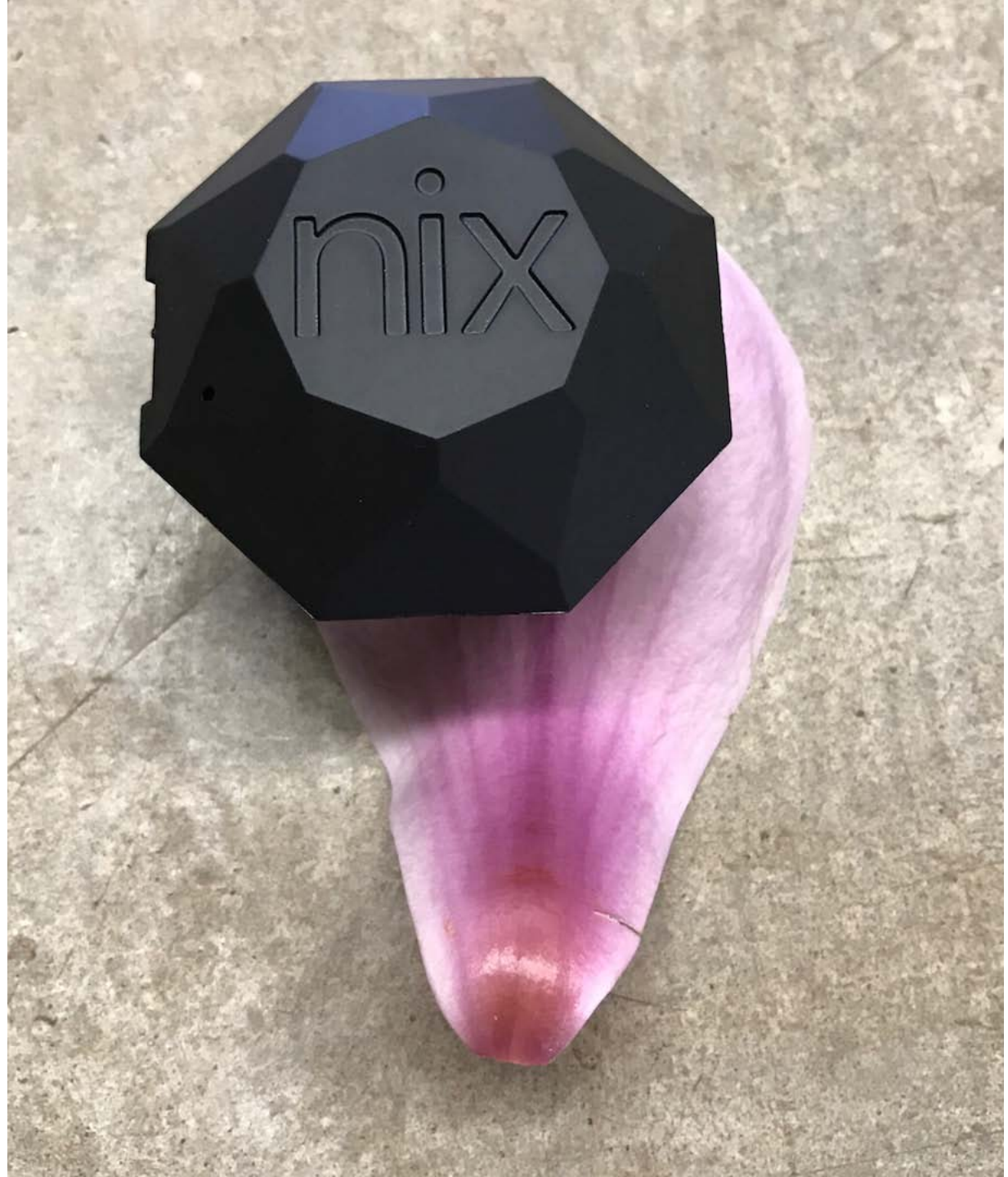
Greyish Purplish Red - N77D
dE2000: 4.9 dE76: 10.0

Strong Reddish Purple - 70B
dE2000: 6.1 dE76: 14.4

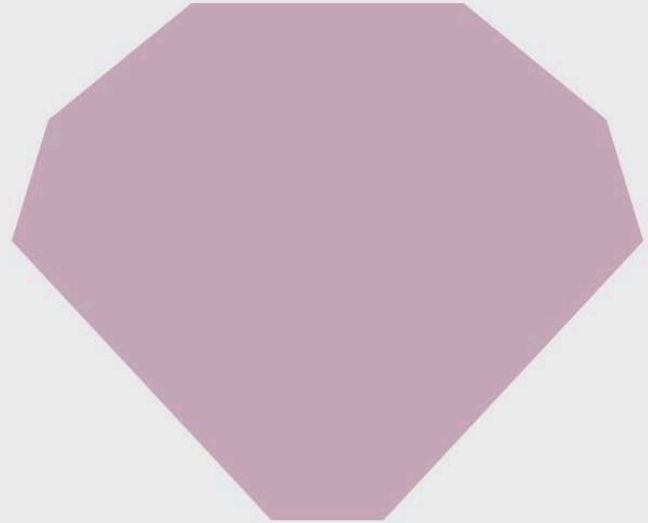
Strong Purple - N80B
dE2000: 6.4 dE76: 14.7

Strong Reddish Purple - N78B
dE2000: 6.9 dE76: 18.6


FAN 2
Red-Purple Group
Purple Group
Purple-Violet Group
Violet Group
Violet-Blue Group
Blue Group
Royal Horticultural Society
Sixth Edition (2015)
PURPLE GROUP
N75
Light Reddish Purple
A
B
C
D
PURPLE GROUP
76
Light Purple
A
B
C
D
PURPLE GROUP
77
Deep reddish Purple
A
Strong Purple
B
C
D


nix

Scan Color



Illuminant: D50 Observer: 2°

RGB: R:200 G:168 B:184

CMYK: C:21% M:35% Y:16% K:0%

HEX: #C8A8B8

CIELAB: L:72.1 a:13.9 b:-3.4

Scan with Nix Pro

Compare to Library

Scanned Color:

CIELAB: L:72.1 a:13.9 b:-3.4

Select Color Library

Closest Matches:

Light Purple - 84C
dE2000: 4.4 dE76: 6.6

Moderate Purplish Pink - 186D
dE2000: 5.2 dE76: 7.7

Very Light Purple - 76B
dE2000: 5.6 dE76: 8.1

Light Purple - 77D
dE2000: 6.3 dE76: 10.6

Light Purple - 75B
dE2000: 7.0 dE76: 11.2


VIOLET
GROUP
84
Strong Purple
A
Light Purple
B
Light Purple
C
Pale Purple
D

Nix_CSV_Template.csv

Country	Province	Brand_Name	Color_Collection	Color_Number	Color_Name	X	Y	Z	Note1	N
US		RHS	Colour Chart	1A	Brilliant Greenish Yellow	67.23	74.2	12.03		
US		RHS	Colour Chart	1B	Brilliant Greenish Yellow	67.58	75.11	15.1		
US		RHS	Colour Chart	1C	Light Greenish Yellow	74.27	81.45	29.03		
US		RHS	Colour Chart	1D	Pale Greenish Yellow	78.05	84.06	36.15		
US		RHS	Colour Chart	2A	Vivid Greenish Yellow	70.68	76.1	11.17		
US		RHS	Colour Chart	2B	Brilliant Greenish Yellow	71.46	77.85	15.83		
US		RHS	Colour Chart	2C	Light Yellow Green	78.32	85.35	31.05		
US		RHS	Colour Chart	2D	Pale Greenish Yellow	79.79	84.84	40.34		
US		RHS	Colour Chart	3A	Brilliant Greenish Yellow	72.45	77.37	11.92		
US		RHS	Colour Chart	3B	Brilliant Greenish Yellow	72.88	78.66	15.2		
US		RHS	Colour Chart	3C	Light Greenish Yellow	76.39	82.36	24.55		
US		RHS	Colour Chart	3D	Pale Greenish Yellow	80.86	86.64	33.6		
US		RHS	Colour Chart	4A	Brilliant Greenish Yellow	72.47	77.39	15.72		
US		RHS	Colour Chart	4B	Light Greenish Yellow	77.68	83.88	23.85		
US		RHS	Colour Chart	4C	Light Greenish Yellow	78.44	83.69	32.2		
US		RHS	Colour Chart	4D	Pale Yellow Green	81.44	85.57	47.15		
US		RHS	Colour Chart	5A	Brilliant Greenish Yellow	69.58	73.32	11.84		
US		RHS	Colour Chart	5B	Brilliant Greenish Yellow	73.73	78.29	13.05		
US		RHS	Colour Chart	5C	Light Greenish Yellow	76.61	81.64	21.24		
US		RHS	Colour Chart	5D	Light Greenish Yellow	79.03	83.06	33.31		
US		RHS	Colour Chart	6A	Brilliant Greenish Yellow	72.2	74.89	10.52		
US		RHS	Colour Chart	6B	Brilliant Greenish Yellow	73.42	76.58	12.11		
US		RHS	Colour Chart	6C	Brilliant Greenish Yellow	75.29	78.43	16.55		
US		RHS	Colour Chart	6D	Light Greenish Yellow	78.09	81.68	30.33		
US		RHS	Colour Chart	7A	Brilliant Yellow	65.05	66.57	8.56		
US		RHS	Colour Chart	7B	Brilliant Yellow	72.07	74.2	13.38		
US		RHS	Colour Chart	7C	Brilliant Greenish Yellow	74.94	77.97	14.57		
US		RHS	Colour Chart	7D	Light Greenish Yellow	75.71	80.2	21.57		
US		RHS	Colour Chart	8A	Brilliant Yellow	73.56	76.08	15.22		

Need to create database by scanning all 812 colour references from the RHS Colour Chart, 6th ed.

Thank You!

Looking for a graduate student!!!

Photo by http://commons.wikimedia.org

More Information:

- http://ndsuresearchfoundation.org/horticulture
  - NDSU Research Foundation links to individual introductions
- https://www.ag.ndsu.edu/plantsciences/research/woody-plants
  - Overview page
- https://www.ag.ndsu.edu/plantsciences/research/introductions
  - Links to datasheets for individual introductions
- https://www.ag.ndsu.edu/plantsciences/research/woody-plants/research
  - Links to PDF lists of the NDSU introductions
- **Dr. Todd West – NDSU Woody Plant Improvement Program**
  Contact: todd.p.west@ndsu.edu
- **Greg Morgenson – NDSU Woody Plant Improvement Program**
  Contact: gregory.morgenson@ndsu.edu