

# Importing the Forestry Reclamation Approach to Northern Minnesota



## *An ASRS Technology-Transfer Success Story*

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Butte, Montana

June 2025



## Agenda:

- Background
- Project 1
  - Methods
  - Assessment Results
- Project 2
  - Experimental Design
  - Methods
- What Comes Next?

## **Background**



Lake Superior Iron Ore Regions;  
2017 ASMR → 2022 ASRS;  
Paradigm Shifts

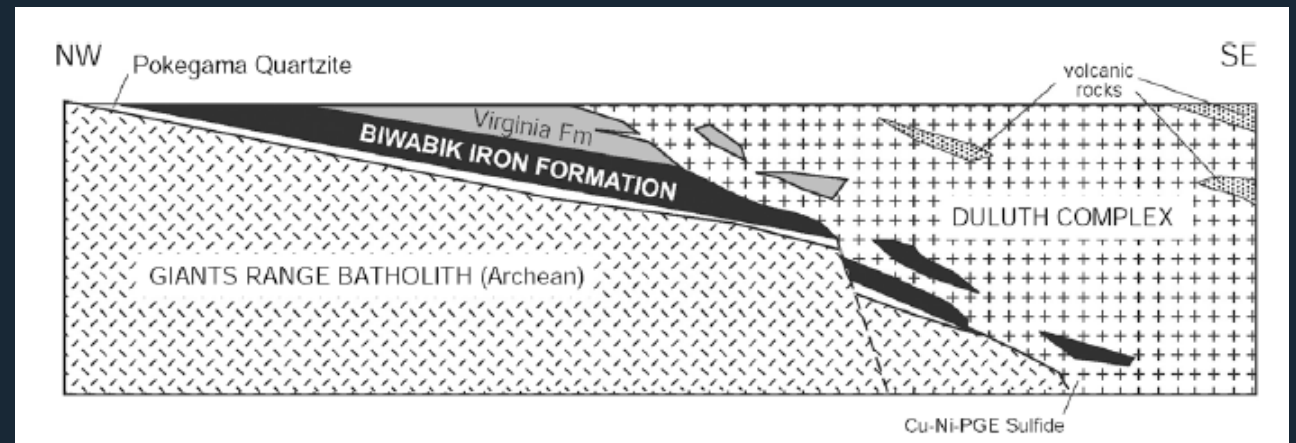
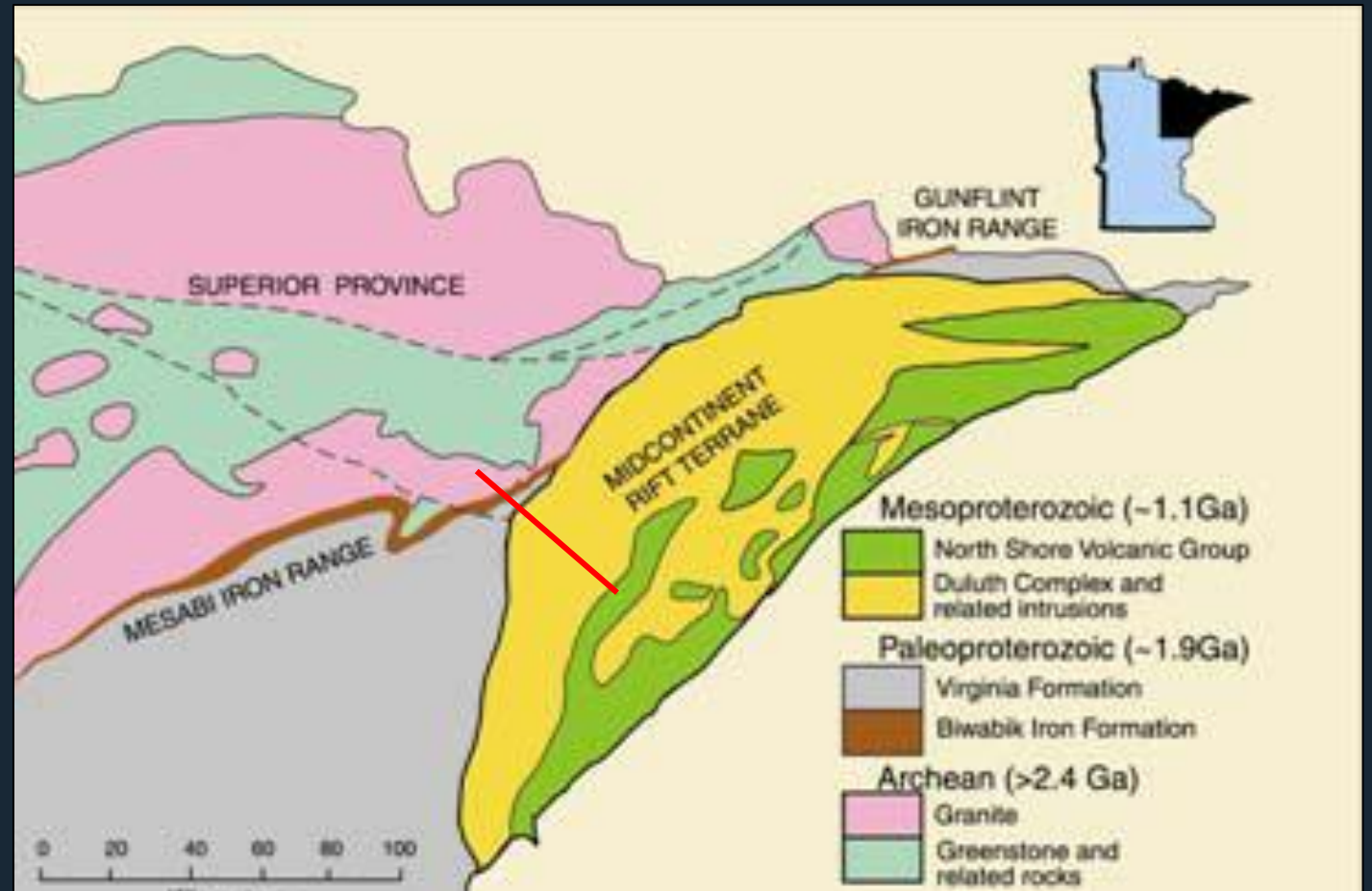
# NE MN Mining Region



Edge of Canadian Shield, abundant mineral potential

- Archean - Gold and VMS ore deposits
- Paleoproterozoic - Lake Superior-Type Iron Formation
- Mesoproterozoic – Duluth Complex Cu/Ni +/- PGE

130+ year history of mining



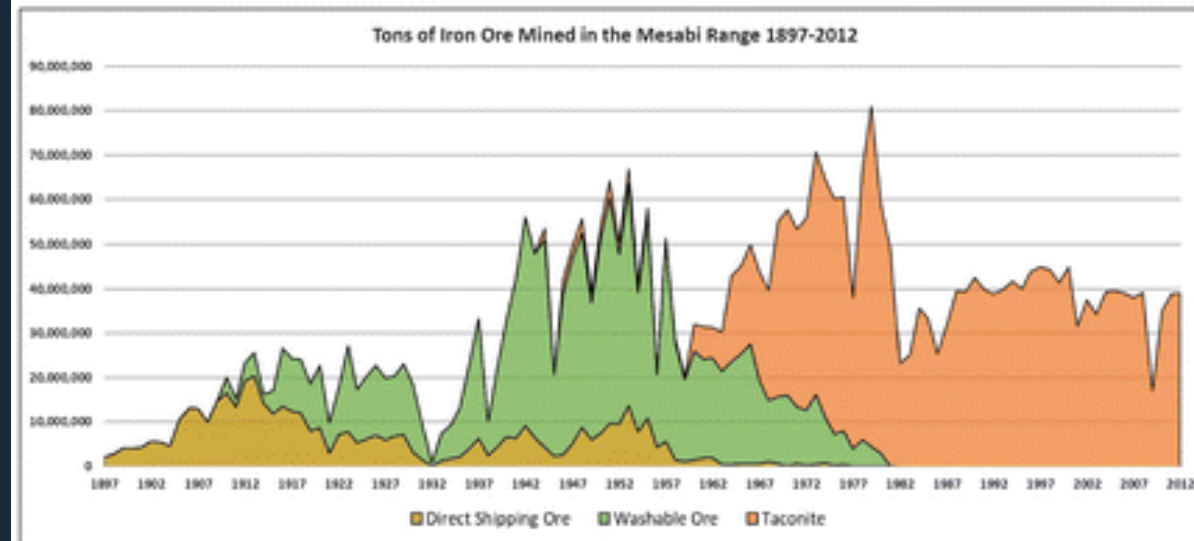
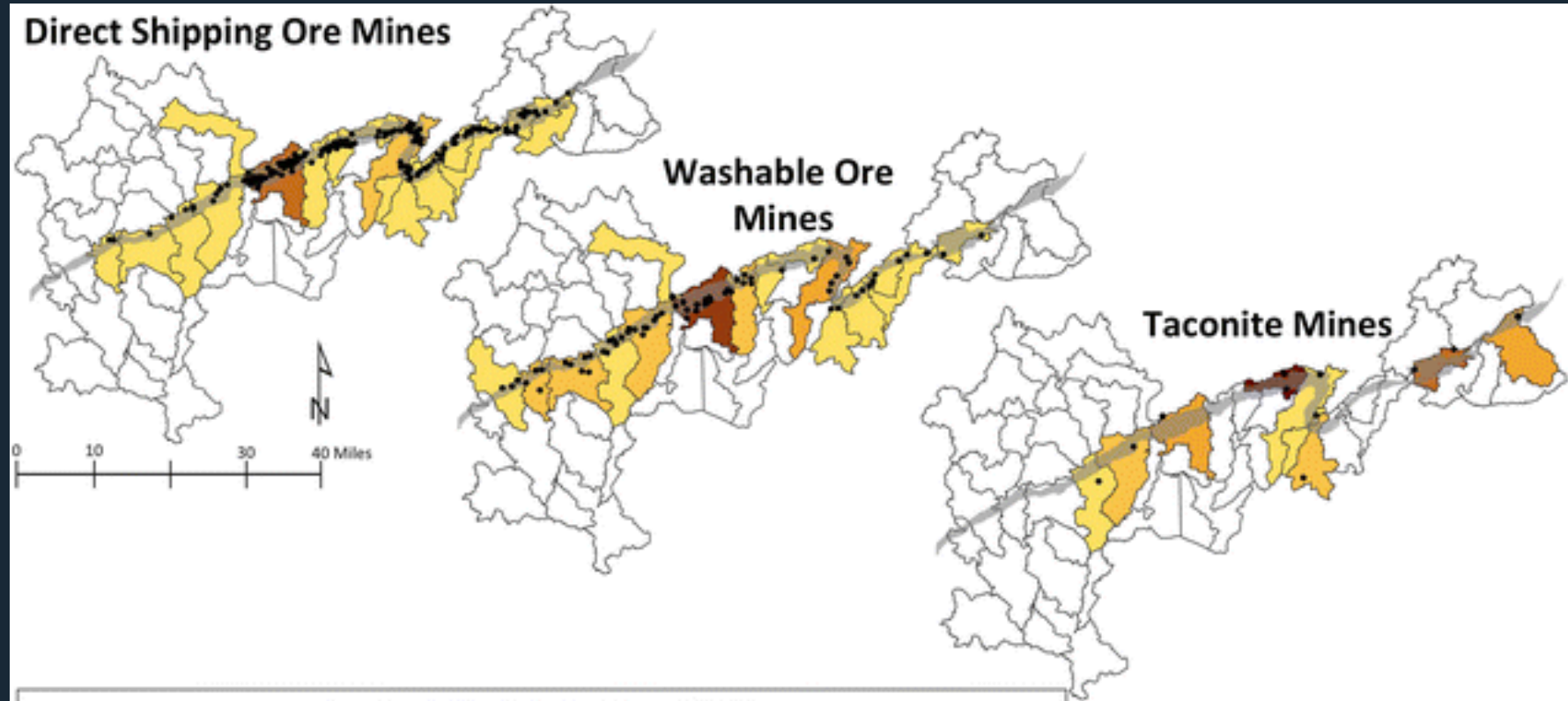
# Iron Ore Mining History



“Natural Ores”:  
Underground and open-pit

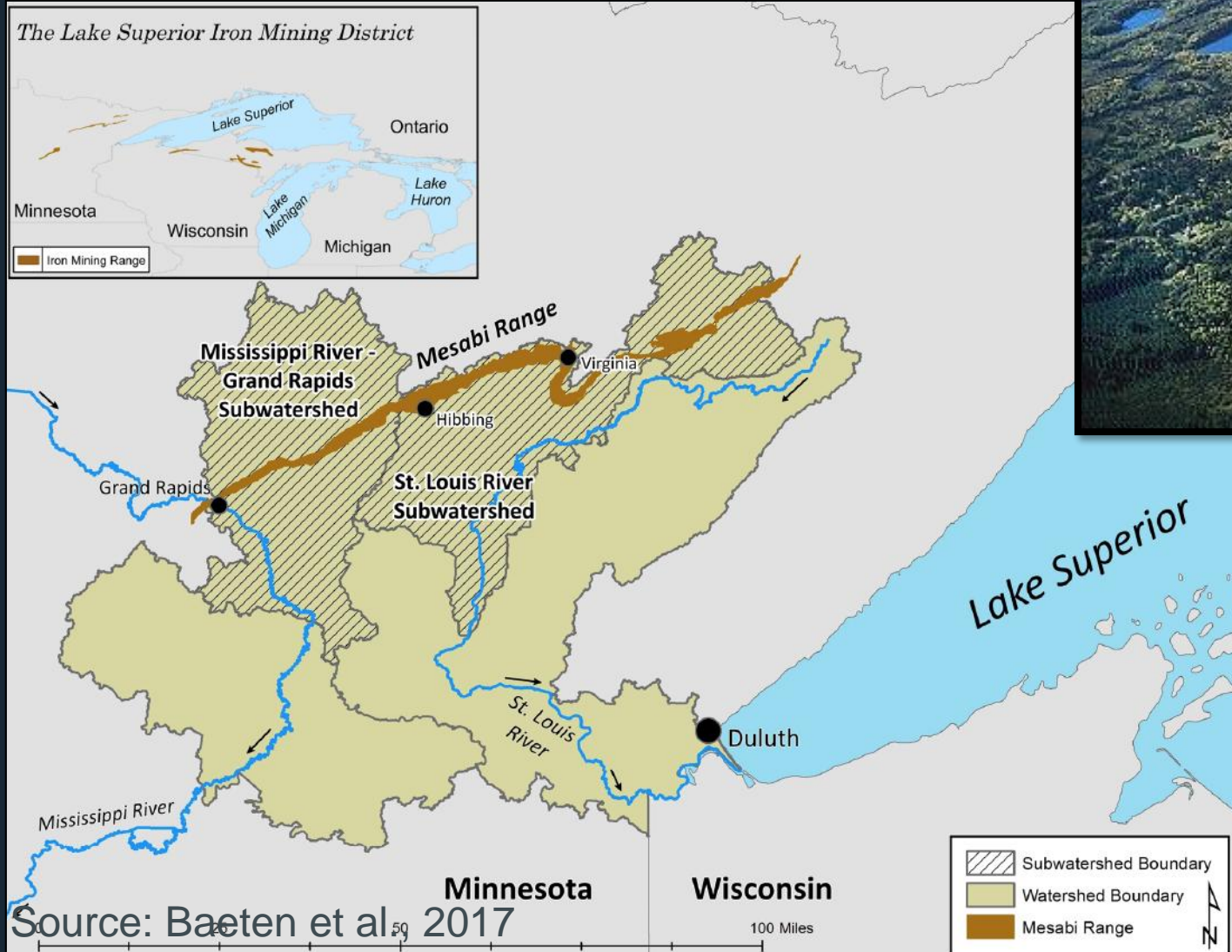
Taconite: Open-pit

Tailings & Stockpiles

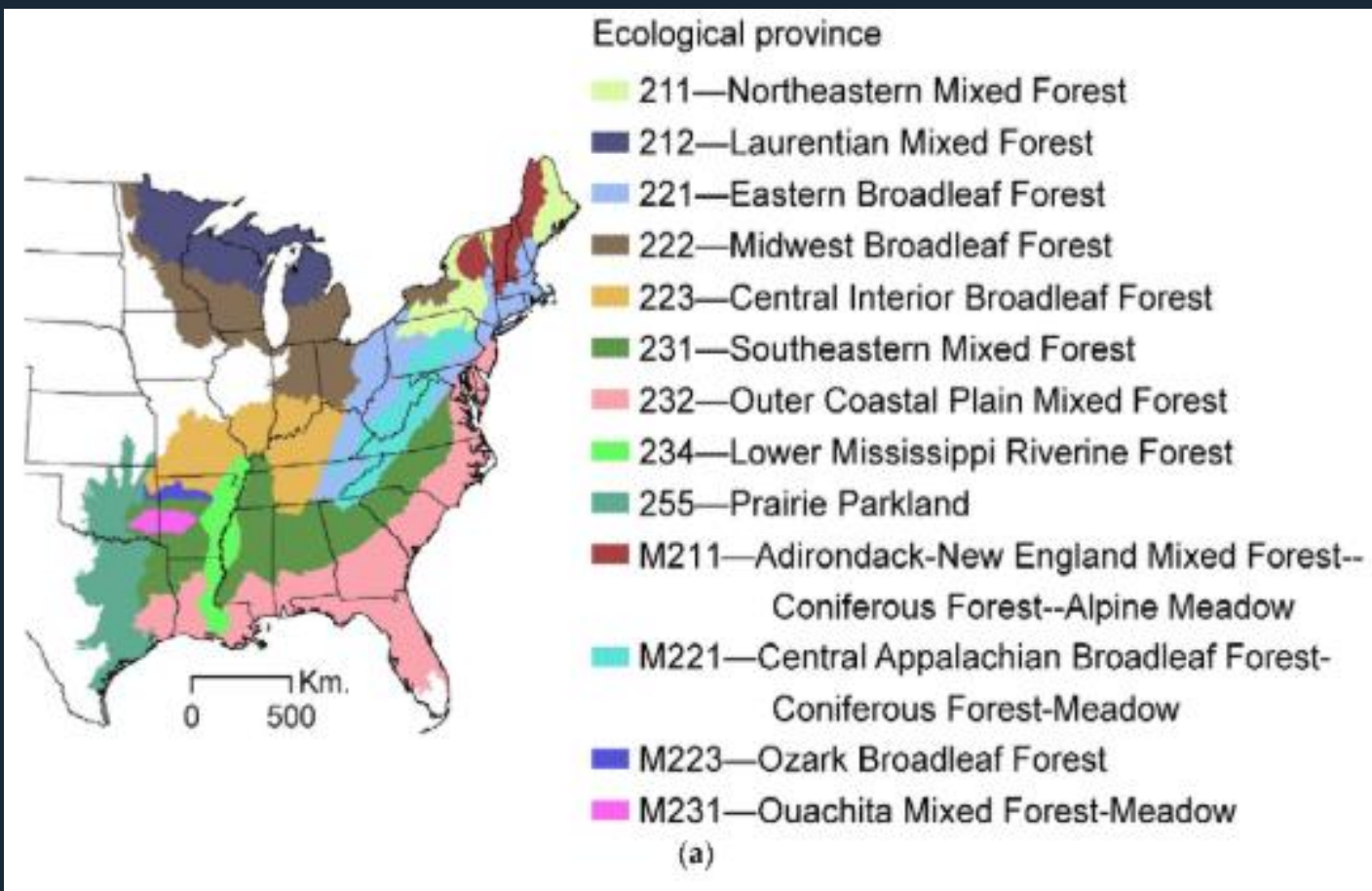


Tons of Ore Mined	
White	0
Light Yellow	1 – 100 Million
Yellow	100.1 Million – 200 Million
Orange	200.1 Million – 300 Million
Dark Orange	300.1 Million – 400 Million
Brown	400.1 Million – 500 Million
Dark Brown	500.1 Million – 600 Million

# Land of Water and Mines . . .



# But also forests and communities and post-mining land uses!



Laurentian Mixed Forest Ecoregion



# MN Reclamation Rules

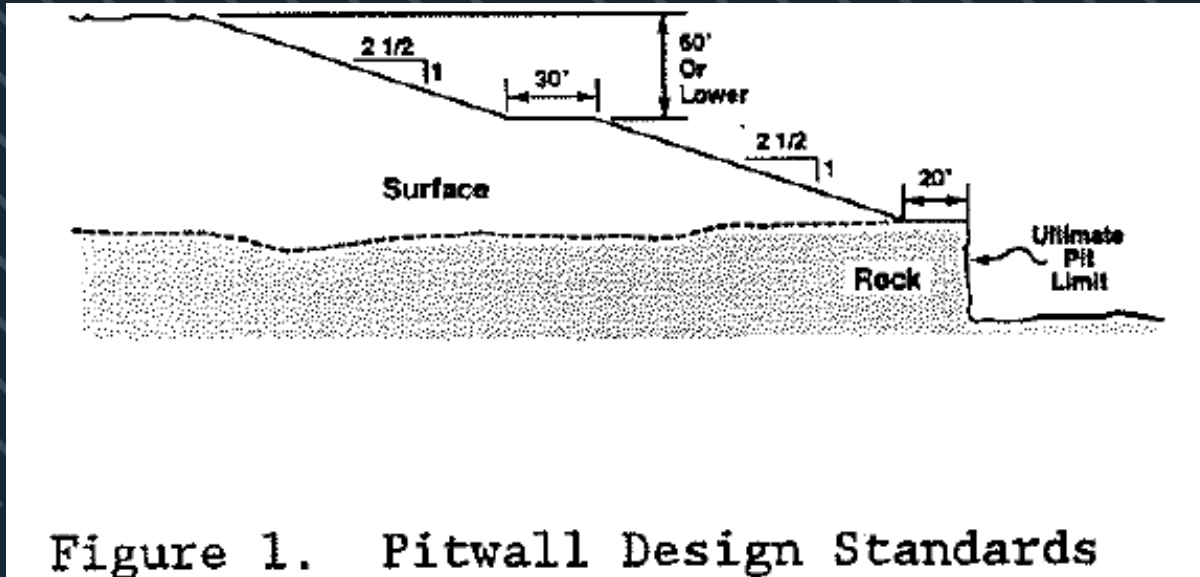


**1969:** *Mineland Reclamation Act passes*

**1977:** *“only one state in the union has done less in mine-land reclamation than Minnesota”* Governor Rudy Perpich (inaugural State of the State Address)

**1980:** Adoption of rules

- Slope stability, bonding
- Revegetation: control erosion, prevent leaching of toxic substances, visual screening,
  - 3/5-year standard: 90% ground cover, living vegetation and its litter, no gullies or rills more than nine inches deep
  - 10-year standard: Vegetative community with characteristics similar to those in an approved reference area. May be planted or naturally occurring. Self-sustaining, regenerating, provides wildlife habitat or other uses



**Figure 1. Pitwall Design Standards**



# ASRS, ARRI and FRA



## 2017 Joint ARRI/ WVMDTF, and ASMR – Morgantown, WV

Jim Burger, ARRI Scientist gave Plenary address:

- History of ARRI, and development and implementation of Forestry Reclamation Approach
- Developed FRA in *response* to prevailing practices:
  - Compact soils, rapidly establish vegetative cover
- Represents a PARADIGM SHIFT in applied science, and took decades to develop and obtain regulatory acceptance

## 2022 ASRS Meeting – Duluth, MN

- Brought together taconite environmental staff, reclamationists and Appalachian FRA experts



## Appalachian Regional Reforestation Initiative

And the Forestry Reclamation Approach

### Who is ARRI?

ARRI is a branch of OSMRE and an alliance of stakeholders that are dedicated to forest restoration on active, abandoned, and legacy site (bond released) mine lands using a reclamation technique known as the Forestry Reclamation Approach (FRA).



Before



After

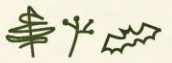


### ARRI Goals

- Plant more high-value native trees on reclaimed coal mined lands in Appalachia.
- Increase the survival rates and growth rates of planted trees.
- Expedite the establishment of forest habitat through natural succession, by exposing soil and allowing native seed to move in.



### Benefits of Reforestation



- Biodiversity
- Wildlife Habitat
- Timber Production
- Water Quality
- Air Quality
- Carbon Storage
- Job Creation
- Outdoor Recreation
- Aesthetics

### 5 Steps of Forestry Reclamation Approach



Create suitable reforestation growth medium.



Minimize compaction of growth medium.



Plant tree compatible growth plants.



Plant native trees and shrubs.



Use proper tree planting techniques.



# Paradigm Shifts



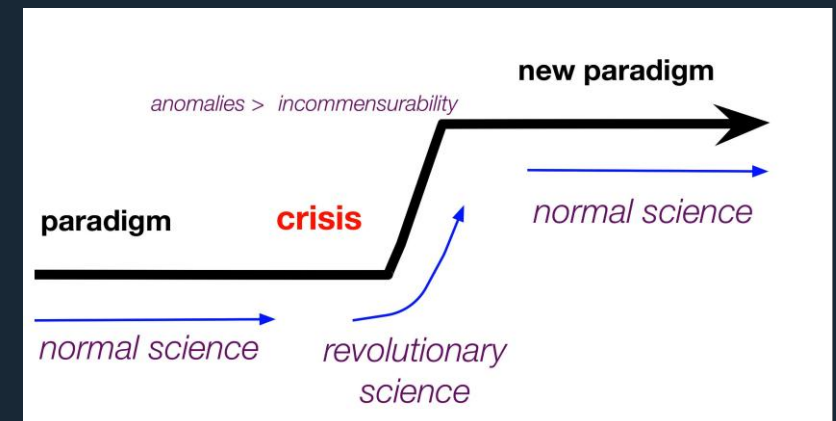
Normal Science -> Outliers -> “extra-ordinary” science -> model crisis  
-> adoption of new paradigm (Thomas Kuhn)

Difficulty of paradigm shifts in reclamation:

- Practitioners committed to dominant techniques
- Regulations are slow to change

FRA *should* have fertile ground in MN, but **will need to demonstrate**:

- Assess implementability
- Assess restoration success
- Gain regulatory acceptance



“Earthrise”; taken on December 24, 1968,  
by Apollo 8 astronaut William Anders



## Project 1 - 2023



## Assessment of Forested Areas & Opportunistic Planting

*Warren Overburden Stockpile Lower Bench. (Restored Pre-1990)*

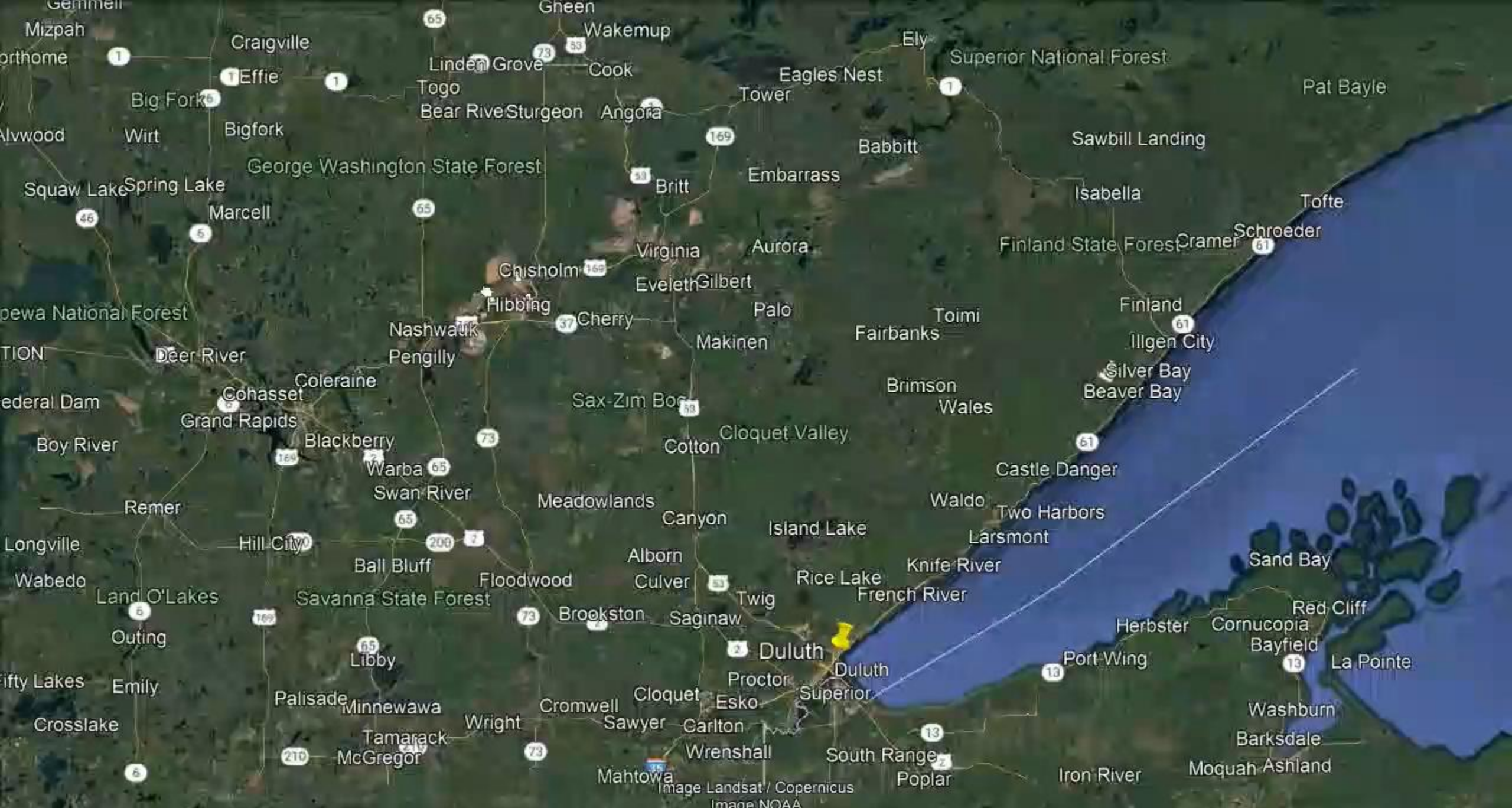


Image Landsat / Copernicus  
Image NOAA

# Comparative Sites Selected - Planted in 2013, 2015, and 2021/2022



*Grass/Forb Community – 5012 Stockpile. (2013)*

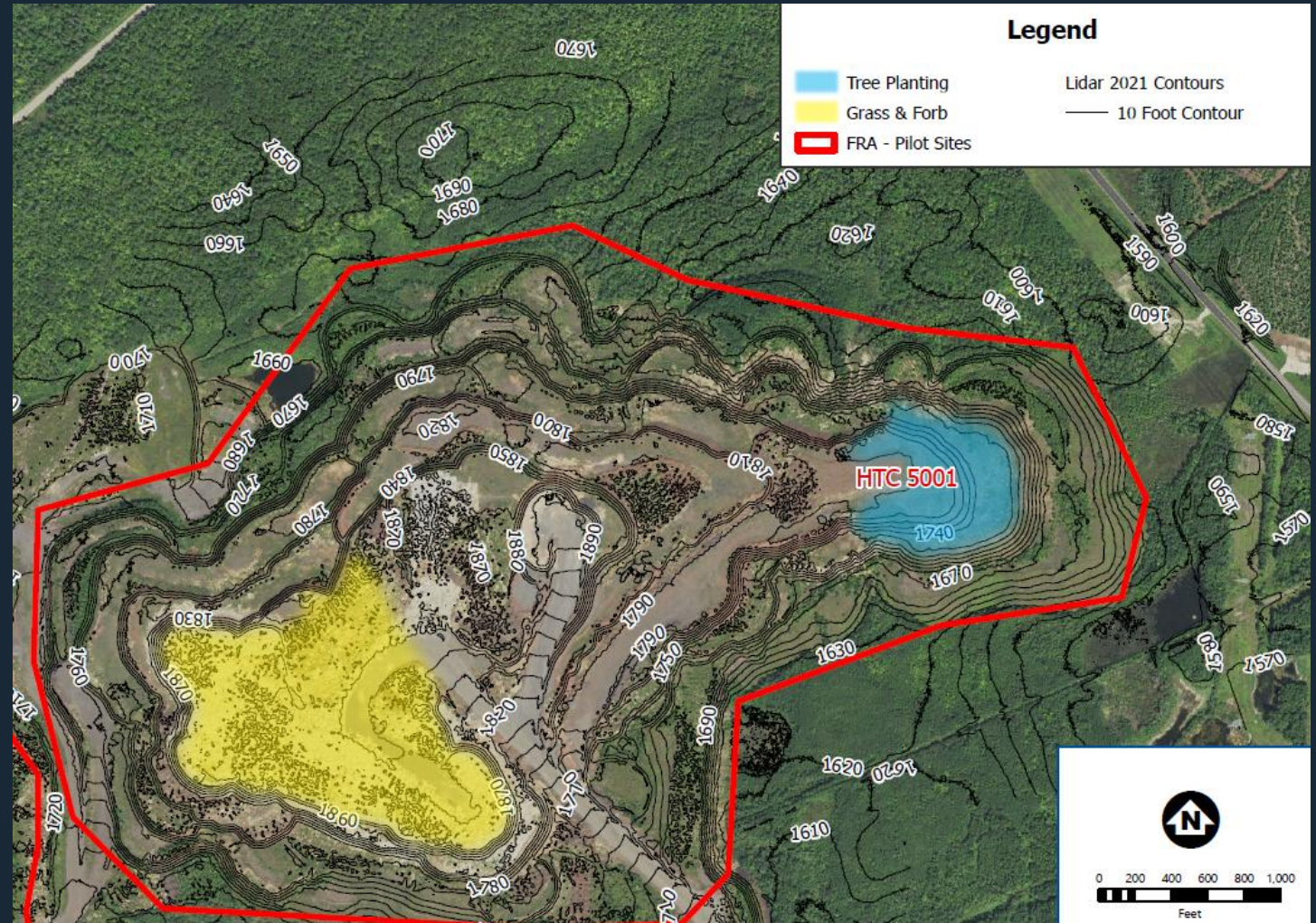


*Intentional Tree Planting Community (2013)*

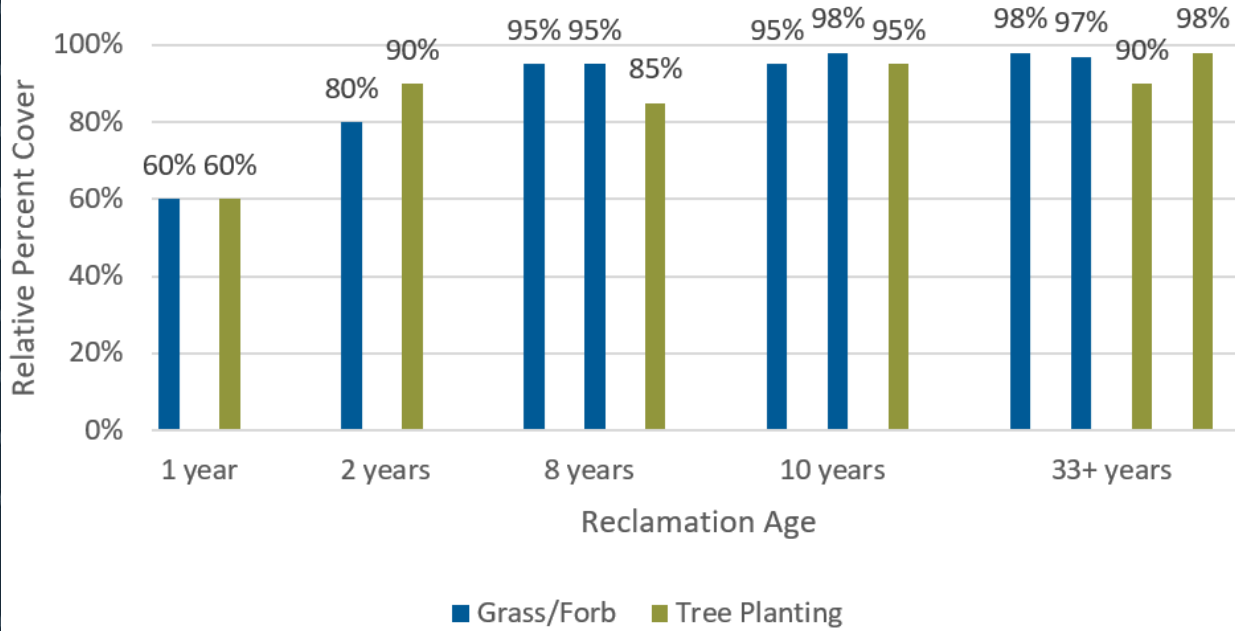
**Also included some assessment of areas that were >30 years old (“pre-law”),  
undergoing natural succession**

# Survey Methods:

- vegetation inventory - timed meanders
  - species and stratum class (herbaceous/shrub/tree/vine)
- estimate of absolute percent cover by living vegetation and its litter
  - to compare with the reclamation vegetation standards
- assessment of stability and erosion such as gully formation, excessive settlement, and slumping



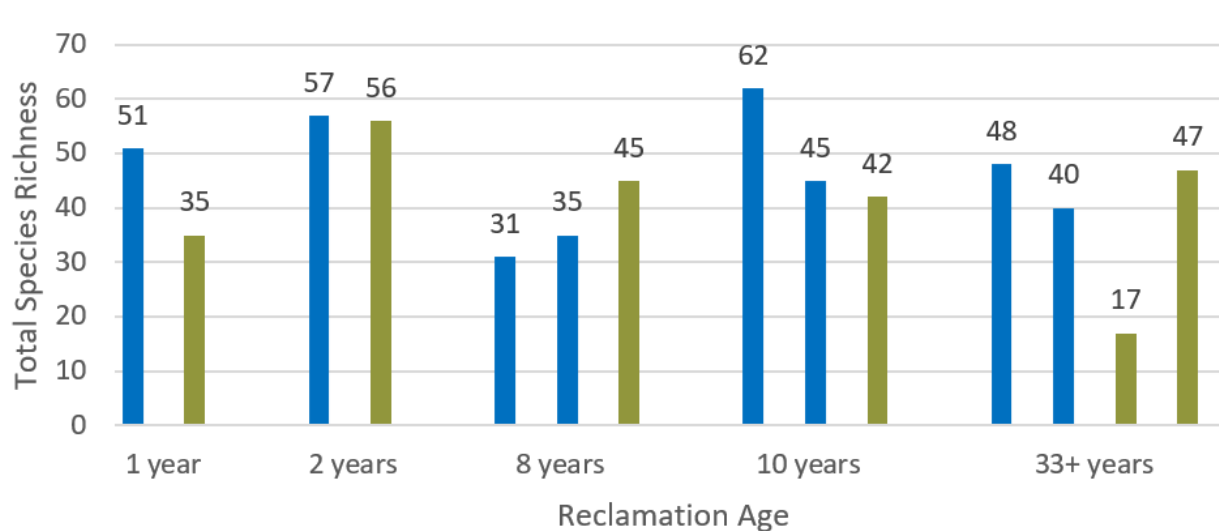
### Absolute Percent Cover by Reclamation Method



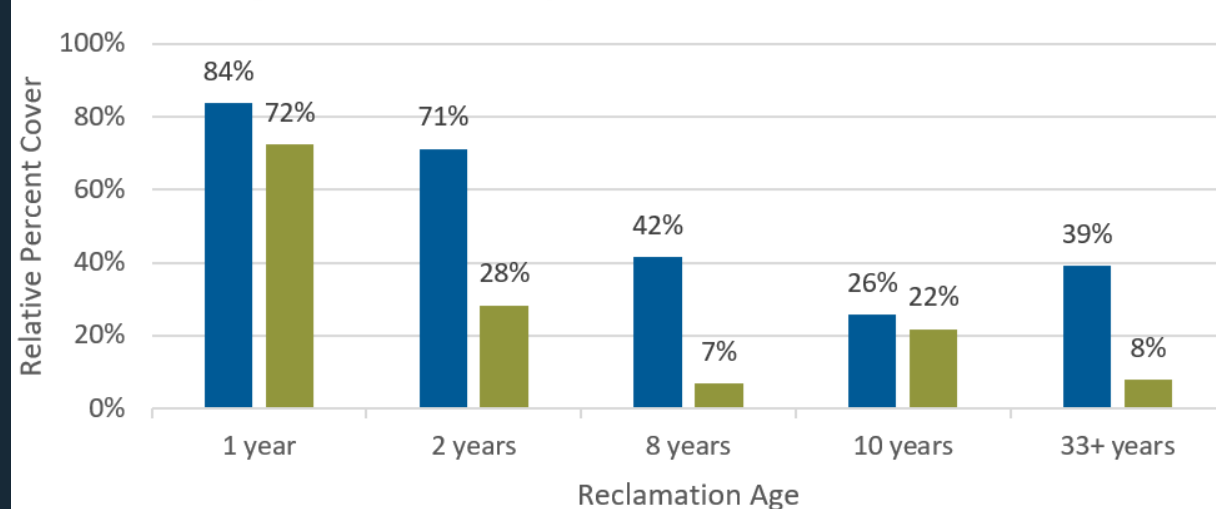
## Data Comparisons

- Absolute cover keep pace w/ grass/forb planting
- Species richness ~similar to grass/forb
- Non-native species lower and then much lower in tree plantings

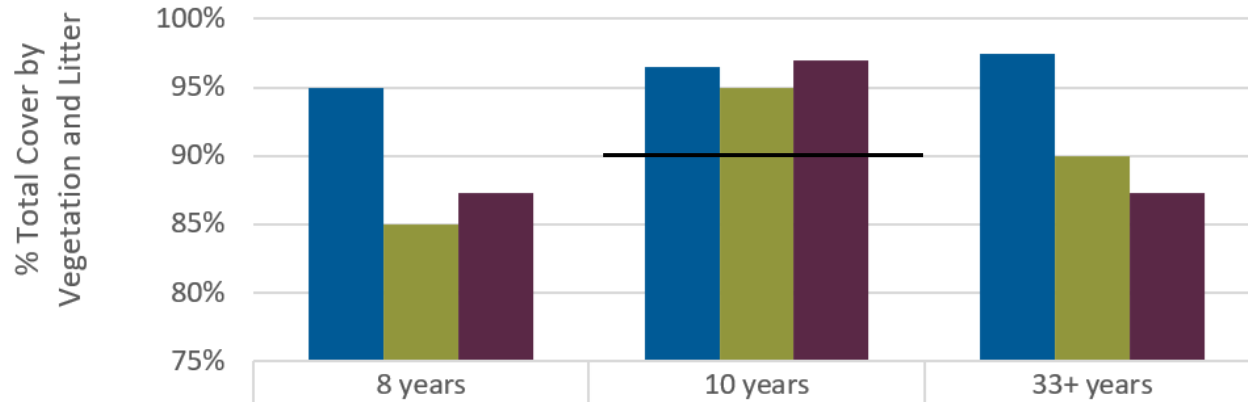
### Total Species Richness by Reclamation Method



### Average Non-Native Species Relative Percent Cover



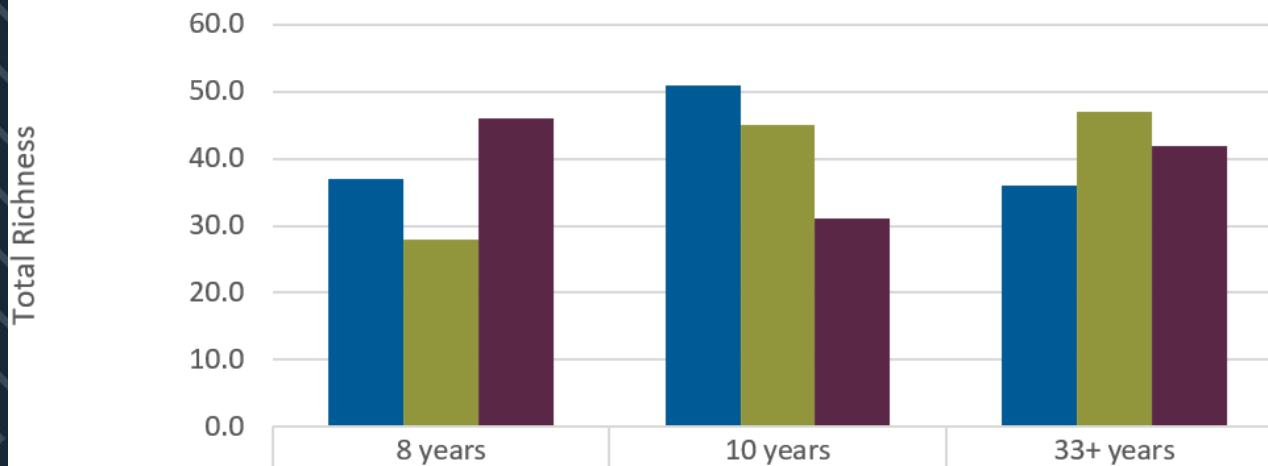
Absolute Percent Cover by Reclamation Method over time



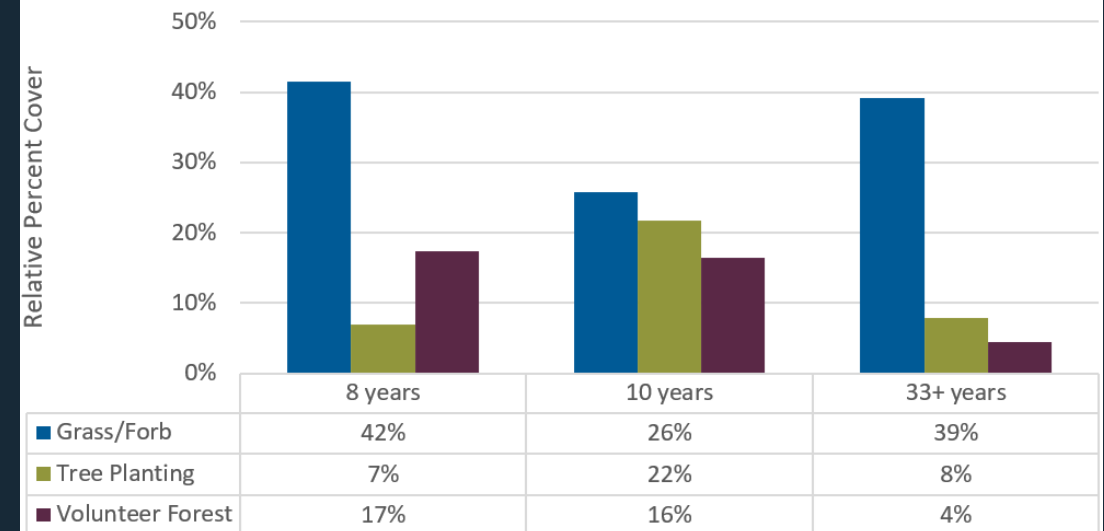
## Performance

- Absolute cover similar at 10-year mark
- Species richness similar to grass/forb at 10-year mark
- Non-native species much lower in tree plantings

Total Richness by Reclamation Method over time



Average Non-Native Species Relative Percent Cover by Reclamation Method over time



# Observed really nice growth!



Planted 2013



Pre-Law



Planted 2015



# Project 2 - 2024



## Project Greenwood

## Community Opportunities and Benefits

This project represents a touchstone for creative reclamation approaches for the region. Regulatory acceptance and appropriate demonstration of FRA would lead to opportunities to assess:

- The potential for value in CO<sub>2</sub> sequestration benefits or credits;
- Ideas that complement healthy forests, like wildlife, small game and pollinator habitat functions;
- Opportunity for community uses such as recreational trails and environmental education; and
- Economic impacts such as future timber or crop harvesting.

## Anticipated Project Outline






Steps	Est. completion date	Anticipated Costs
1. Apply for IRRRB Reclamation Research Funding	August 2023	In kind
2. Design FRA Demonstration Project	January 2024	\$15,000
3. Site Preparation	April 2024	In kind
4. Planting	June 2024	\$90,000
5. Monitor and Survey	July 2025	\$10,000
	<b>Total</b>	<b>\$115,000</b>



## Project Milestones

- Developed Reclamation Research Grant Proposal – fall, 2023
  - Awarded late 2023
- Developed Planting Plan – spring 2024
  - Collaborated w/ Dr. Kenton Sena
  - Quickly changed plan to a different stockpile – b/c of mining
- Site Prep – April 2024
- 20,000 seedlings planted – May 2024
  - Drought and watering
- Year 0 Study Design and Survey -
  - Permanent fixed radius vegetation plots

**Legend**

-  Stockpile 5037
-  Crosshatch Ripping
-  Strike Hoosiers and Apply Biochar
-  Bio Char Application Area
-  End Dumps/ Hoosiers

Possibly too steep to plant?

**5037 Total Acreage Including Slope: 25 acres**

**3 Acres Strike Hoosiers and Biochar Application**

**Variables:**

- Surface Prep
- Slope/Aspect
- Biochar
- Seedling Mix

**5037 FRA Study**  
Planned Work

HTC

**Figure 1**

Department *Environmental*

Date Created 4/8/2024

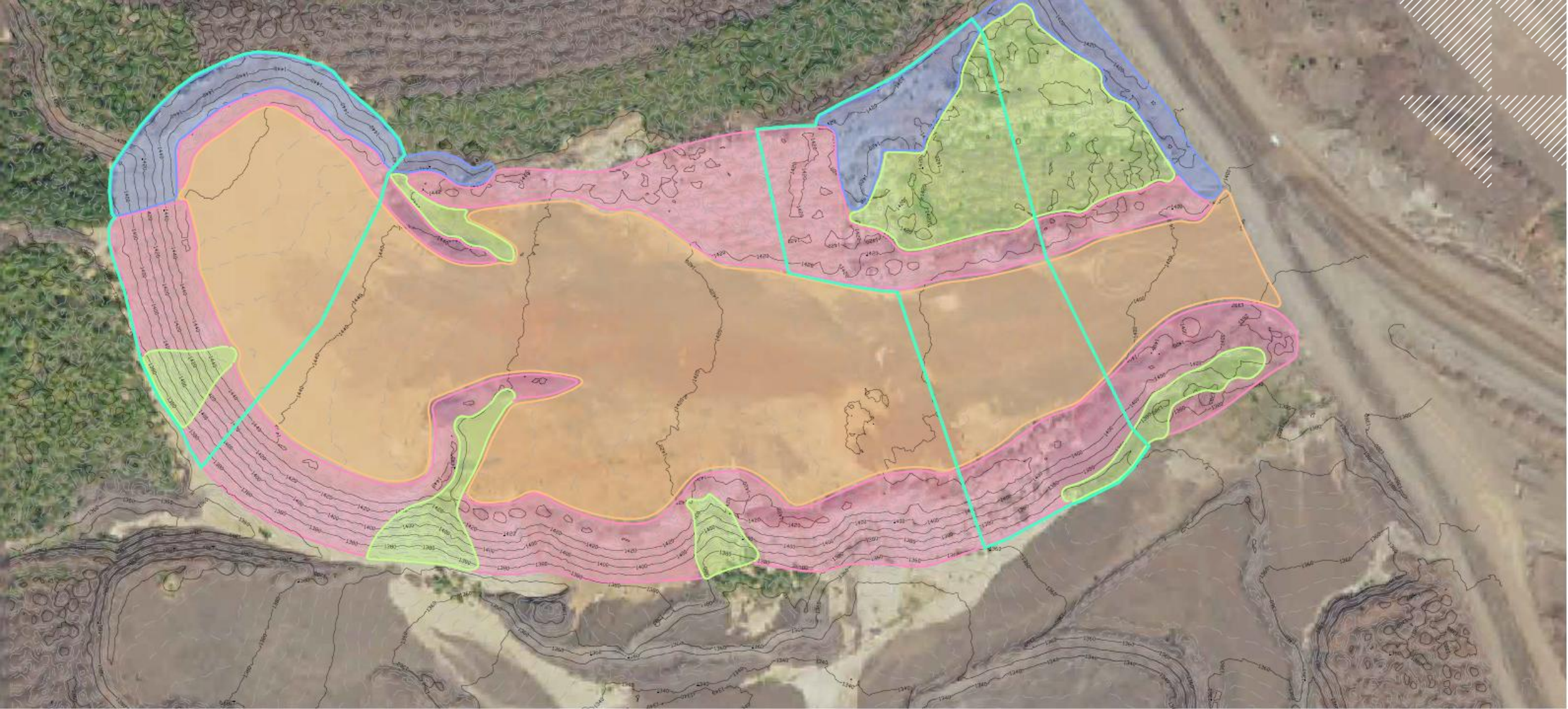
Author J. Erickson

**Data Source**

MN GeoSpatial Commons WMS Aerial Imagery Server [https://www.mngeo.state.mn.us/ohouse/wms/geo\\_image\\_server.html](https://www.mngeo.state.mn.us/ohouse/wms/geo_image_server.html)

**13 Acres Crosshatch Ripping**

**7 Acres Biochar Application**



TREE PLANTING SPECIES MIX LEGEND					
	MIX A	MIX B	MIX C	MIX D	Totals
Acreage	3.4	8.0	2.0	11.9	25.3
Red Pine ( <i>Pinus resinosa</i> )	0	4,300	200	5,500	10,000
White Pine ( <i>Pinus strobus</i> )	1,200	0	700	2,100	4,000
White Spruce ( <i>Picea glauca</i> )	1,500	0	600	1,900	4,000
Bur Oak ( <i>Quercus macrocarpa</i> )	0	2,000	0	0	2,000

- TREE MIX ZONES LEGEND:**
- A: LOWER ELEVATION AREAS OR AREAS PRONE TO MOISTURE COLLECTION, TREES SPECIES SELECTED ARE BETTER SUITED TO WETTER AREAS.
  - B: HIGHER LOCALIZED ELEVATIONS (TOPS OF RIDGES), OR SOUTH FACING SLOPE ASPECTS, TREE SPECIES SELECTED ARE BETTER SUITED TO DRIER AREAS.
  - C: NORTH FACING SLOPES, THESE SLOPES WILL BE A VARIETY OF THE HARDIER CONIFER SPECIES OPTIONS.
  - D: SMOOTH GRADED AND CROSS RIPPED AREA, CONIFER SPECIES ARE SELECTED FOR THIS AREA AND THE BUR OAK IS NOT SELECTED AS THE OAK IS BEST SUITED TO THE DRIER AREAS.

- PLANTING MEDIUM PREPARATION LEGEND:**
- PRE-SEED AREAS

- NOTES:**
1. TOPOGRAPHIC DATA SHOWN PROVIDED BY CLIENT.
  2. AERIAL IMAGERY FROM ST. LOUIS COUNTY, 2021
  3. HORIZONTAL DATUM: NAD27, MINNESOTA STATE PLANE, NORTH ZONE,
  4. PLANTING QUANTITIES BASED UPON EIGHT FEET (8') ON CENTER, TRIANGULAR-ARRAY LAYOUT CALCULATION METHOD, SEEDLING COUNTS ROUNDED TO THE NEAREST HUNDRED (100), EXACT SPACING IN FIELD WILL VARY BASED ON EASE OF PLANTING AFTER SUBGRADE TREATMENT IS COMPLETE.
  5. SEED MIX FOR GROUND COVER, AND/OR SHRUB UNDERSTORY PLANTING, IS RECOMMENDED FOR FURTHER STABILIZATION TO BE INSTALLED IN FUTURE PLANTING PHASES.
  6. ENGINEER RECOMMENDS STABILIZATION OF SLOPES WHEN FUTURE SEEDING OR UNDERSTORY PLANTING OPERATIONS OCCUR, EXAMPLES OF STABILIZATION INCLUDE HYDROMULCH TACKIFIER OR EROSION CONTROL BLANKET, SELECTED STABILIZATION METHOD SHALL BE DETERMINED BY OBSERVED FIELD CONDITIONS OF TREE PLANTINGS AT TIME OF FUTURE RESTORATION PHASES.



# Survey Plan



Fixed radius plots

Herbaceous - % cover by species and stratum, species richness


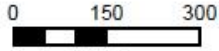
Shrub - woody species stem counts

Tree – DBH measurements

Year 3 and 5 follow-up planned



- 2024 Established Monitoring Plots
- 30-Foot Plot Radius
- Planting Medium Preparation**
- Biochar Application Area (10 acres total)
- Subgrade Cross-Ripping (13 acres total)
- Hoosier Dump Strikes
- Pre-Seed Areas
- Tree Planting Species Mix**
- A
- B
- C
- D
- Public Land Survey Section

0 150 300  
Feet

Imagery: St. Louis County Pictometry, 2023

TREE PLANTING SPECIES MIX LEGEND					
	MIX A	MIX B	MIX C	MIX D	Totals
Acreage	3.4	8	2	11.9	25.3
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White Spruce <i>(Picea glauca)</i>	1,500	0	600	1,900	4,000
Bur Oak <i>(Quercus macrocarpa)</i>	0	2,000	0	0	2,000
<b>Totals</b>	<b>2,700</b>	<b>6,300</b>	<b>1,500</b>	<b>9,500</b>	<b>20,000</b>

**2024 Year 0**  
**Project Greenwood**  
**Baseline Monitoring**  
 Stockpile 5037  
 Hibbing Taconite;  
 Hibbing, MN  
 FIGURE 2



Eastern White Pine, *Pinus strobus*

## What Comes Next?



“Acceptable Research” and the MN  
Reclamation Rules

**mn** DEPARTMENT OF IRON RANGE  
RESOURCES & REHABILITATION



**Thank you!**

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