DOE Bioenergy Technologies Office (BETO) 2023 Project Peer Review

PoSIES: Populus in the Southeast for Integrated Ecosystem Services

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Data Modeling and Analysis

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Project Overview - Background

- Short rotation woody crops like poplar (*Populus* spp.) are well positioned to support climate change mitigation and other ecosystem services
  - Renewable, carbon neutral energy particularly for aviation
  - Ecosystem service and carbon offset markets
  - Hardwood supply markets

Project Overview - Background

- Populus and its hybrids …
  - Grow fast, woody structure allows for “storage” in the field
  - Can be established from cuttings to control and improve genetics
  - Will resprout after harvest in coppice production

Project Overview - Background

- Growth and productivity has a large role in the final cost of the feedstock
- Ecosystem services co-benefits could potentially be monetized to reduce final costs, but need to be verified
- Large scale *Populus* production should not have unintended ecological disservices

Project Overview - Risks

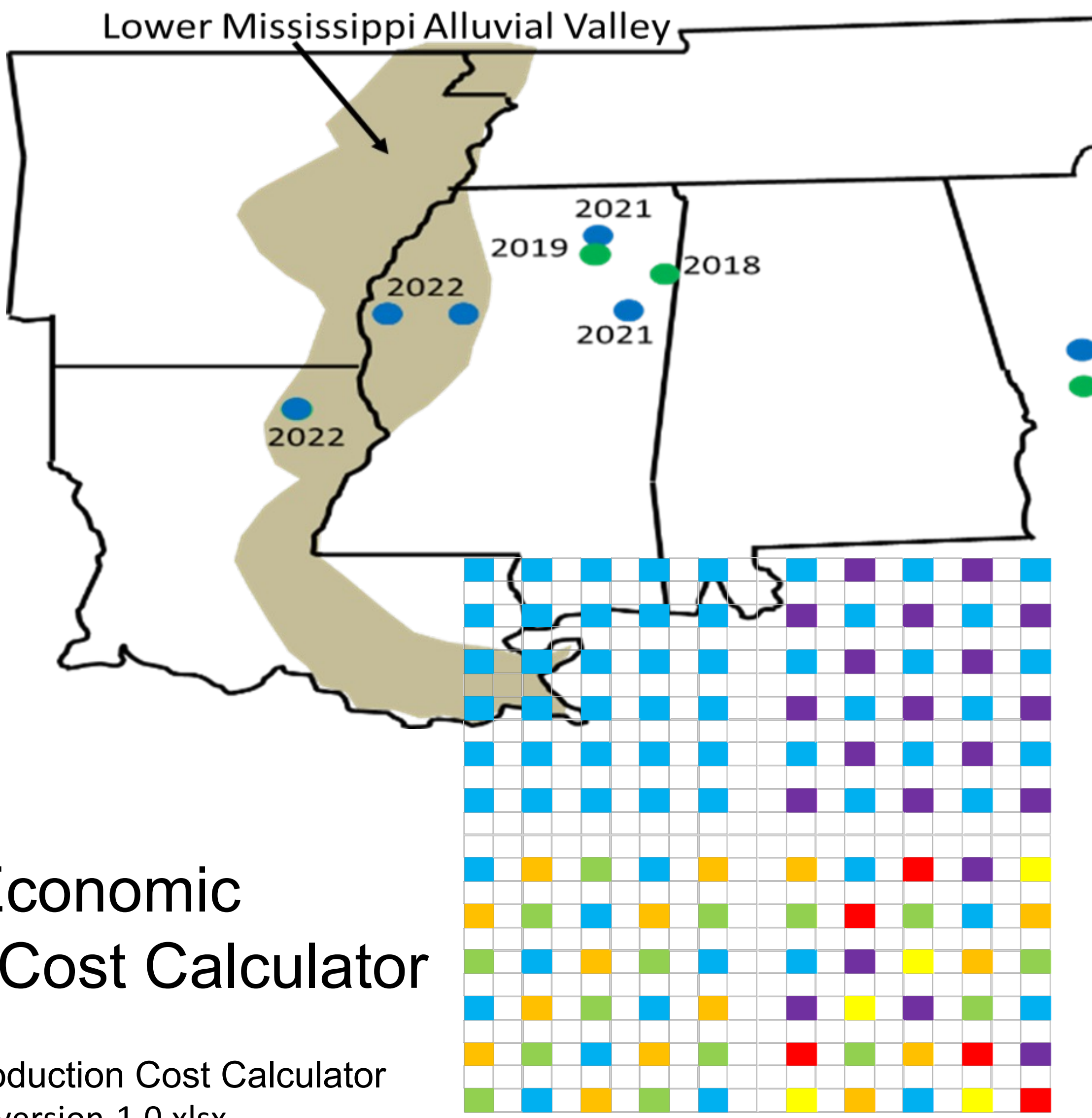
- Risks to productivity and ecosystem services co-benefits potentially include…
  - Variation in productivity based on site quality
  - Diseases like Septoria stem canker affect production
  - Ecosystem service markets may not develop as expected

Project Overview - Goals

- Determine ways to make poplar biofuels more cost competitive with fossil fuel energy sources ($3.00 gasoline gallon equivalent)
  - Field test production methods to increase productivity of poplar in the Southeast
  - Measure ecosystem service provision and utilize ecosystem service markets to reduce the overall cost of poplar production
  - Test technologies to quickly estimate biomass and ecosystem services
  - Quantify potential ecosystem disservices

1 – Approach: Quantifying and Increasing Production

- Eight research sites planted throughout the Southeast
  - Established between 2018 and 2022
- Production increased by…
  - Identifying genetically superior genotypes for the Southeast
  - Utilizing endophytic nitrogen fixing bacteria
  - Planting varieties in mixtures to better utilize site resources
- New production costs for Techno-Economic Analysis obtained from a Biomass Cost Calculator
  - Shuren R, Busby G and B Stanton. 2019. Biomass Production Cost Calculator https://s3.wp.wsu.edu/uploads/sites/2182/2020/04/BPCC-version-1.0.xlsx

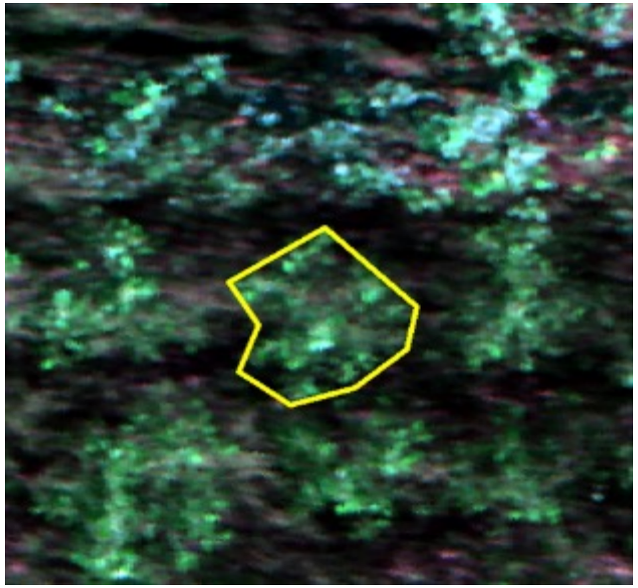


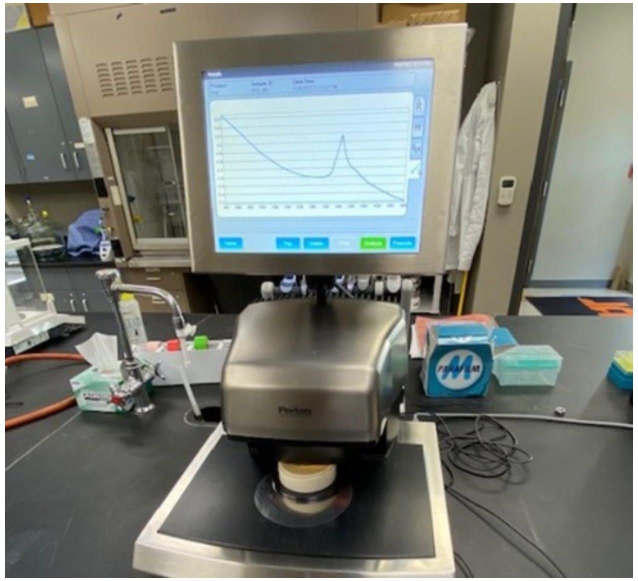
1 – Approach: Ecosystem Services

- Determine belowground carbon storage for potential carbon markets
- Determine improvement in water quality through fertilizer mitigation
- Revenue to landowners used to update Techno-Economic Analysis calculations

1 – Approach: Improving data collection

- Test technologies to quickly estimate biomass and ecosystem services
  - LiDAR – Light Detection and Ranging
  - Hyperspectral remote sensing
  - NIR –near infrared analysis of biomass and soil samples





1 – Approach: Ecosystem Disservices

- Potential effects on …
  - Wildlife biodiversity compared with other land cover types
  - Water use
  - Greenhouse gas emissions

1 – Approach: Stakeholders

- Stakeholder advisory panel includes…
  - Industry
  - Non-profits
  - Government agencies
  - Agencies representing landowners and farmers

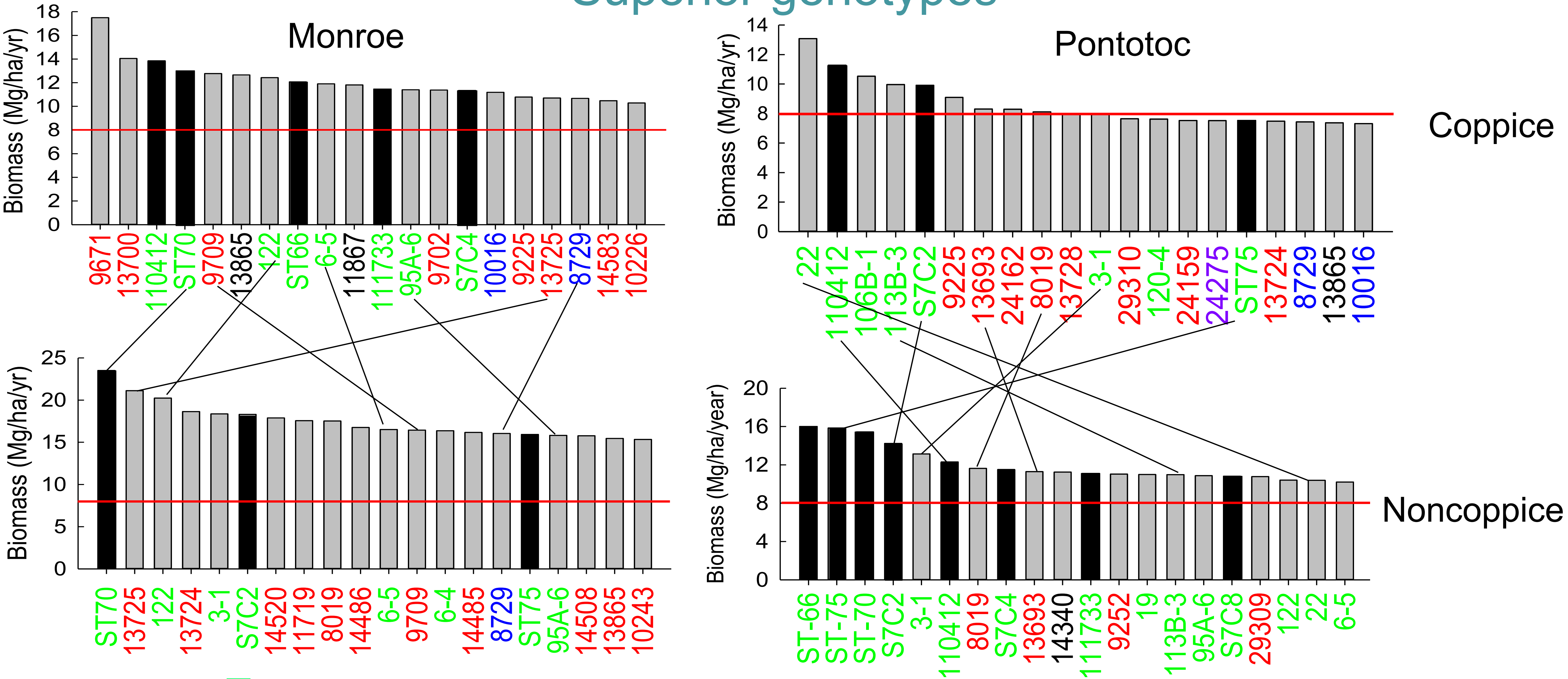
- Yearly meetings and semi-annual email reports

2 – Progress and Outcomes – Timeline and Plan

	2021				2022				2023				2024				2025
Task	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM
Cutting acquisition	■				■												
Site establishment		■				■											
Field measurements		■	■			■	■			■	■			■	■		
Coppice sites								■	■							■	■
Develop soil models				■	■	■	■	■									
Develop biomass models										■	■	■	■	■			
Collect aerial data							■				■				■		
Develop TechnoEconomic analysis													■	■	■	■	■
Milestones																	
Quantify baseline conditions		■	■	■													
Coppice stands and achieve 8Mg/ha/year biomass								■	■								
Demonstrate 10% nitrate removal and 10% soil C accumulation compared with ag.												■	■				
Demonstrate 20% nitrate removal, 20% increase in soil C and 10% reduction in CO_2 emissions compared with ag.																■	■
Incorporate ecosystem services into a techno economic analysis and achieve 10% reduction in minimum fuel selling price																■	■

2 – Progress and Outcomes – Increasing productivity

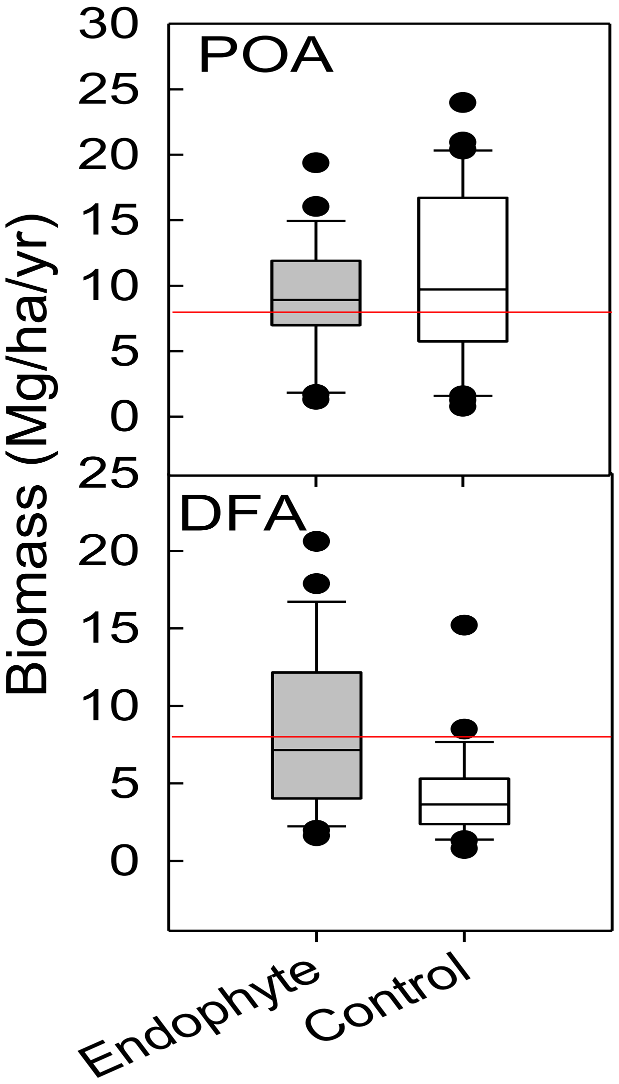
- Superior genotypes

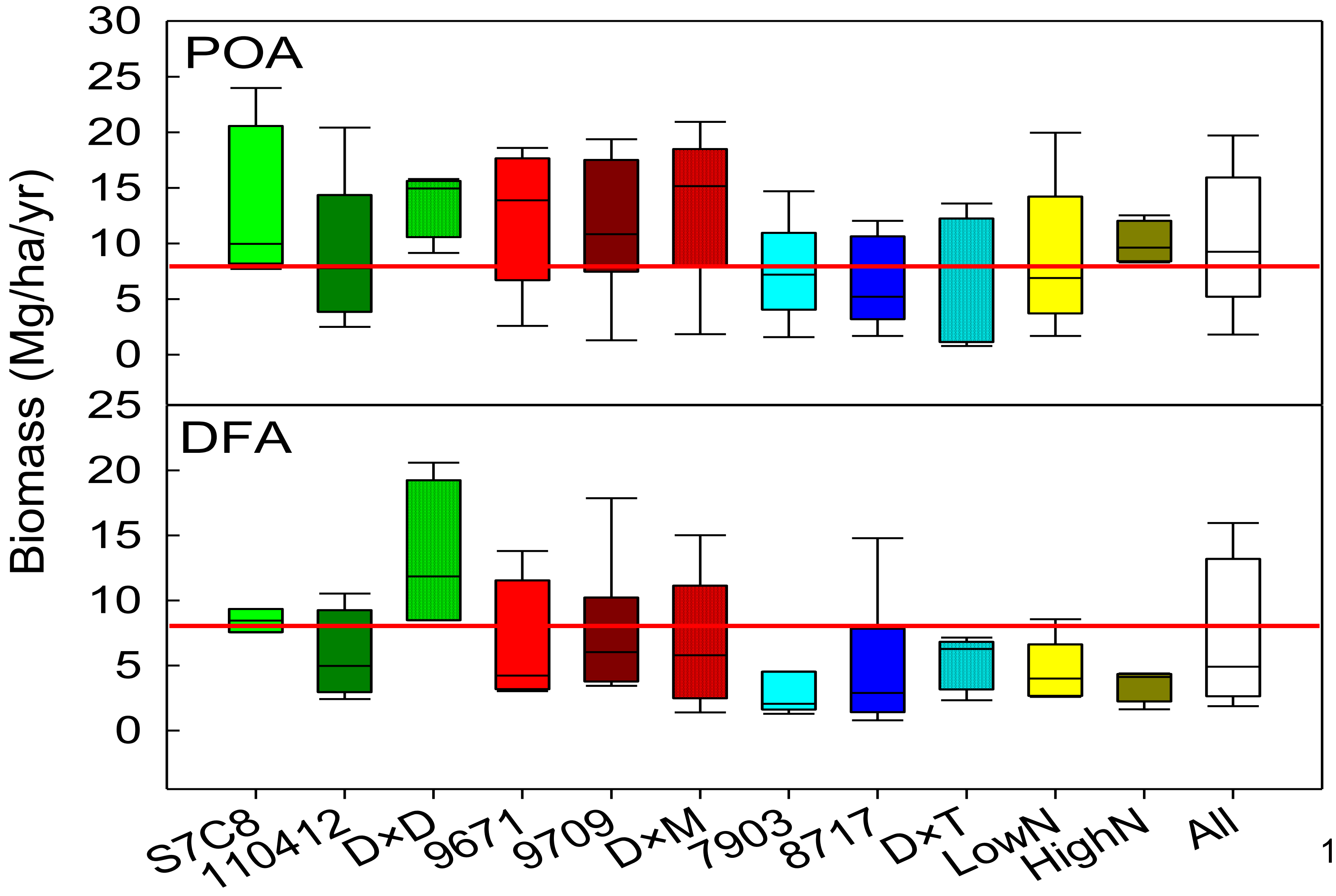


Older genotypes | Newer genotypes | *P. deltoides* × *P. deltoides* (D×D) | *P. deltoides* × *P. maximowiczii* (D×M) | *P. deltoides* × *P. nigra* (D×N) | *P. deltoides* × *P. trichocarpa* (D×T) | *P. trichocarpa*× *P. maximowiczii* (T×M)

2 – Progress and Outcomes – Increasing productivity

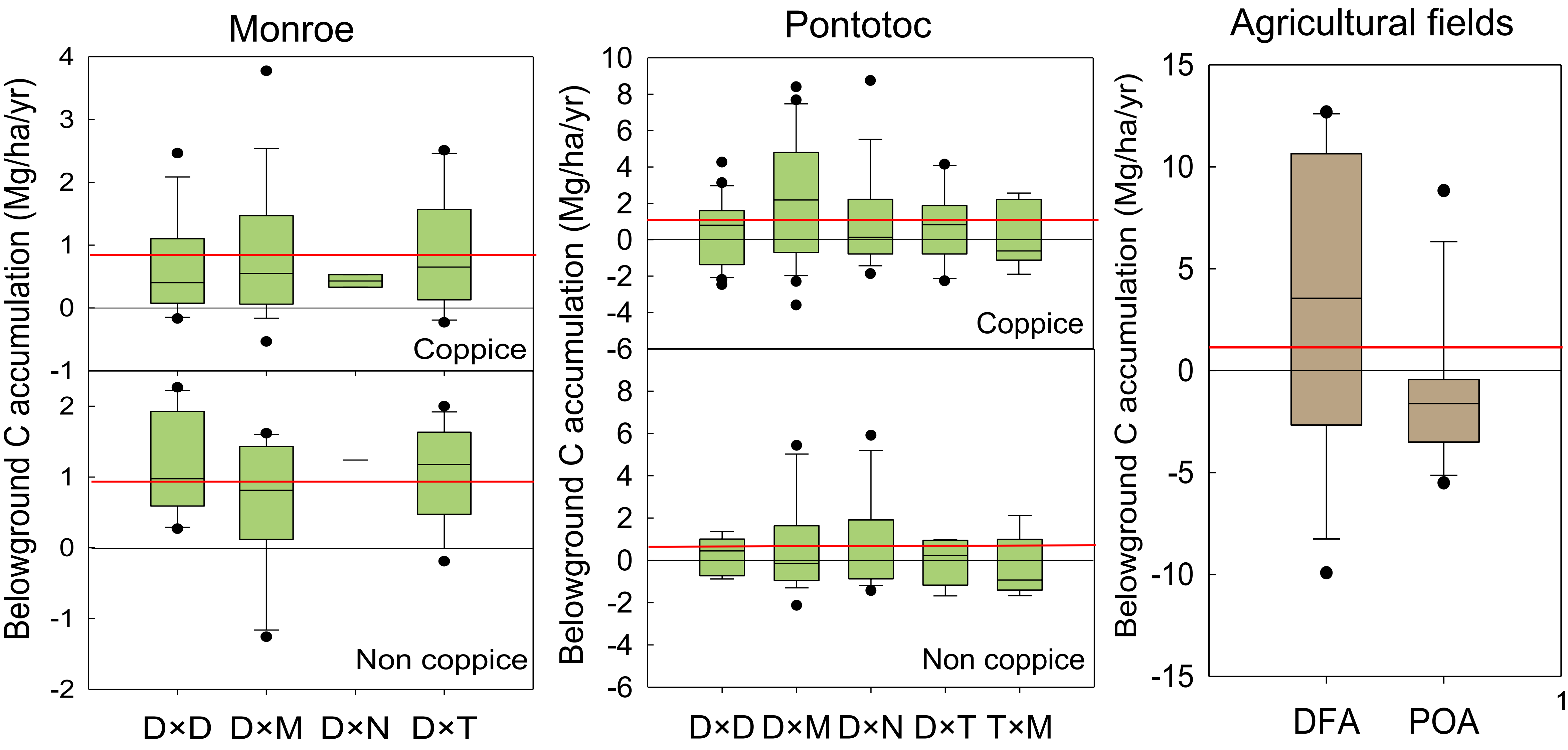
- Endophytes and planting mixtures





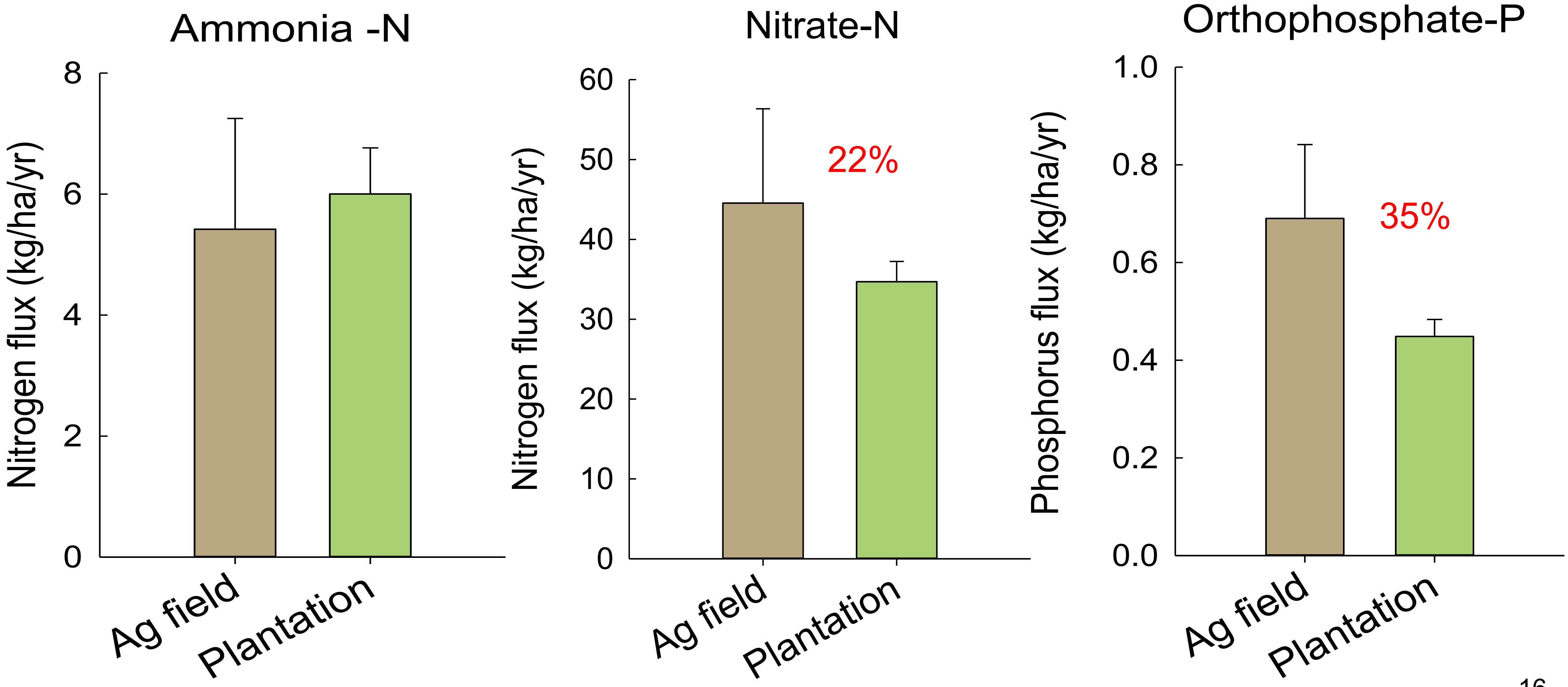
2 – Progress and Outcomes – Ecosystem Services

- Belowground carbon sequestration



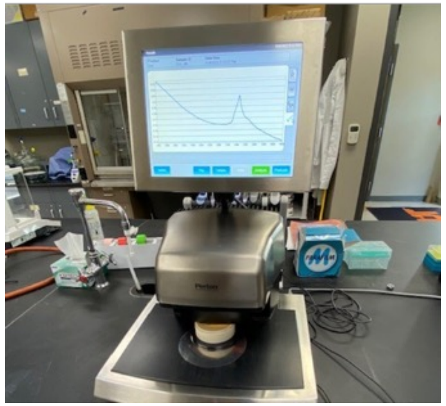
2 – Progress and Outcomes – Ecosystem Services

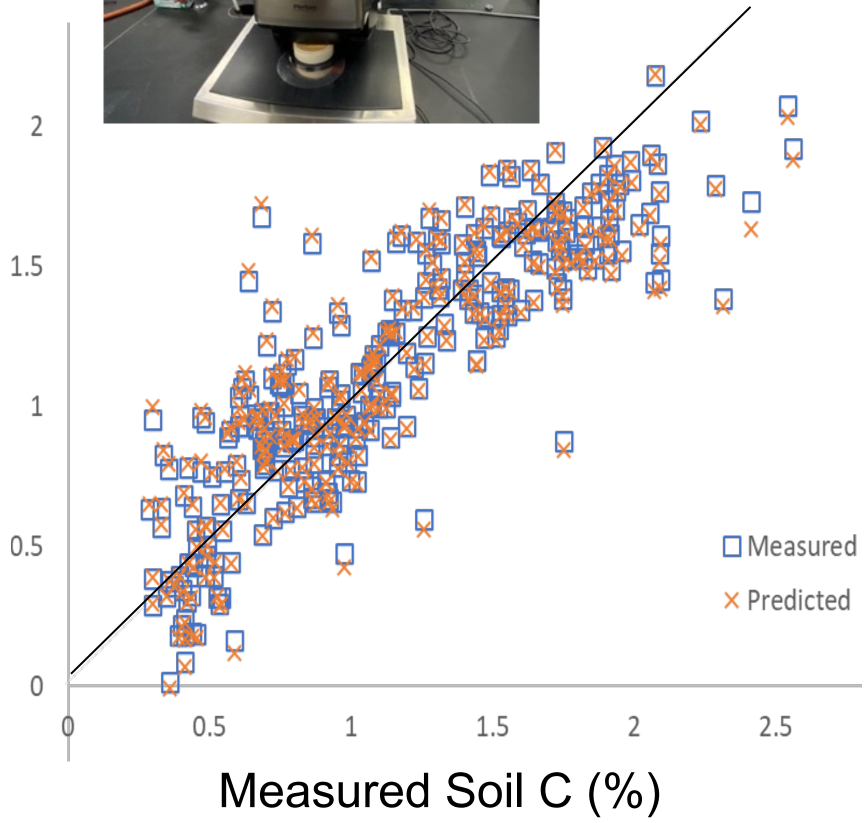
- Nitrogen and phosphate mitigation



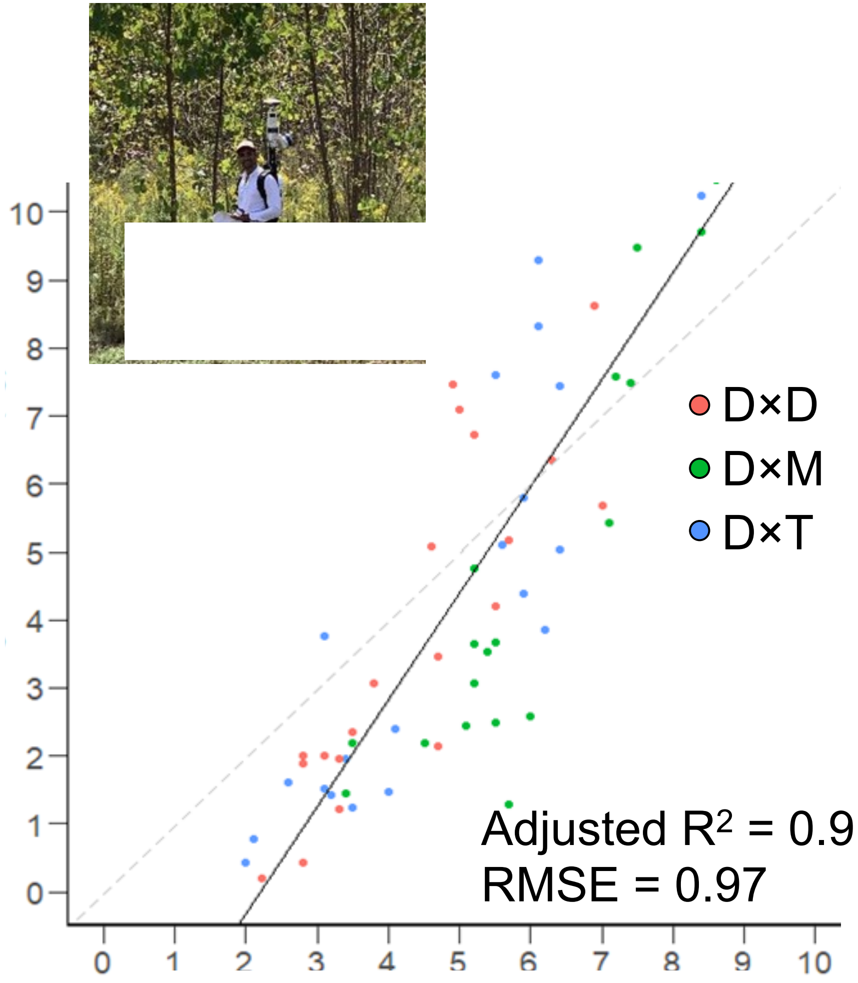
2 – Progress and Outcomes – Improving Data Collection

- Soils and biomass





Element	R^2	RMSE
Ca (mg/kg)	0.92	157
K (mg/kg)	0.56	13.5
Mg (mg/kg)	0.67	9.9
P (mg/kg)	0.75	10.3
N (%)	0.67	0.03
C (%)	0.73	0.27



3 – Impact

- Financial Impact of Study Results
  - Increased productivity of the best performing cultural planting practices will reduce feedstock production costs by $10-20/dry Mg for 2 - 3 year coppice cutting cycles compared to traditional practices
  - Soil carbon potential benefit of $4 - 9 per ha/yr based on a carbon offset payment of $9 per ton CO_2
  - Potential for water quality improvement and nitrate and phosphate payments, but markets are still developing.
- Publications so far
  - Renninger HJ, Pitts JP and RJ Rousseau. 2022. Comparisons of biomass, water use efficiency and water use strategies across five genomic groups of *Populus* and its hybrids. *Global Change Biology Bioenergy*. 15: 99-112. DOI: 10.1111/gcbb.13014. **Impact factor: 5.957**
- Stakeholders board members/Potential partnerships
  - Enviva Biomass – New wood pellet facility in Lucedale, Mississippi
  - Finite Carbon – Forest carbon offset company
  - Green Trees – Intercrop eastern cottonwood (*P. deltoides*) and oaks (*Quercus* spp.) in the Lower Mississippi Alluvial Valley (6,040,000 trees planted so far)

Summary

- Our top performing genotypes and treatment plots achieved almost 20 Mg/ha/year of aboveground biomass production without fertilization or irrigation
  - New hybrid poplar genotypes outperformed most older eastern cottonwood genotypes
  - Endophytic bacteria aided production on a marginal site
  - Evidence that mixed genotype plantings can have greater yields than monocultures
  - Terrestrial LiDAR models predicted aboveground biomass with an R^2 of 0.9
- Soil Carbon
  - Increases of 0.4 to over 1 Mg/ha/yr in tree plantation sites
  - Near infrared spectroscopy modeled soil carbon with an R^2 of 0.73 and RMSEC of 0.27%
- Nutrient mitigation
  - Mitigation of nitrate in shallow ground of over 20% compared with traditional row crop agriculture
  - Mitigation of orthophosphate by about 35% compared with traditional row crop agriculture

Quad Chart Overview

Timeline
- 10/1/2020
- 3/31/2025

	FY22 Costed	Total Award
DOE Funding	(10/01/2021 – 9/30/2022)	$2,035,602
Project Cost Share *	$509,293	

TRL at Project Start:
TRL at Project End:

Project Goal
Identify genetics and cultural practices of *Populus* genotypes that improve productivity and ecosystem service provision to reduce the final cost of bioenergy feedstocks.

End of Project Milestone
A 20% decrease in ground- and surface-water nitrate, a 20% increase in soil carbon and a 10% reduction in soil CO_2 emissions to achieve a 10% reduction in the minimum fuel selling price relative to a $3/GGE Techno-Economic Analysis

Funding Mechanism
DE-FOA-0002203 FY20 Bioenergy Technologies Multi-Topic FOA

Project Partners*
- University of Tennessee Knoxville
- Louisiana Tech University

*Only fill out if applicable.