

Aboveground biomass and native vegetation cover exceed reference conditions three years after reclamation on abandoned roads and well pads in a semi-arid natural gas field in the Powder River Basin, Wyoming.

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In collaboration with:





Focused efforts to advance reclamation in the Powder River Basin

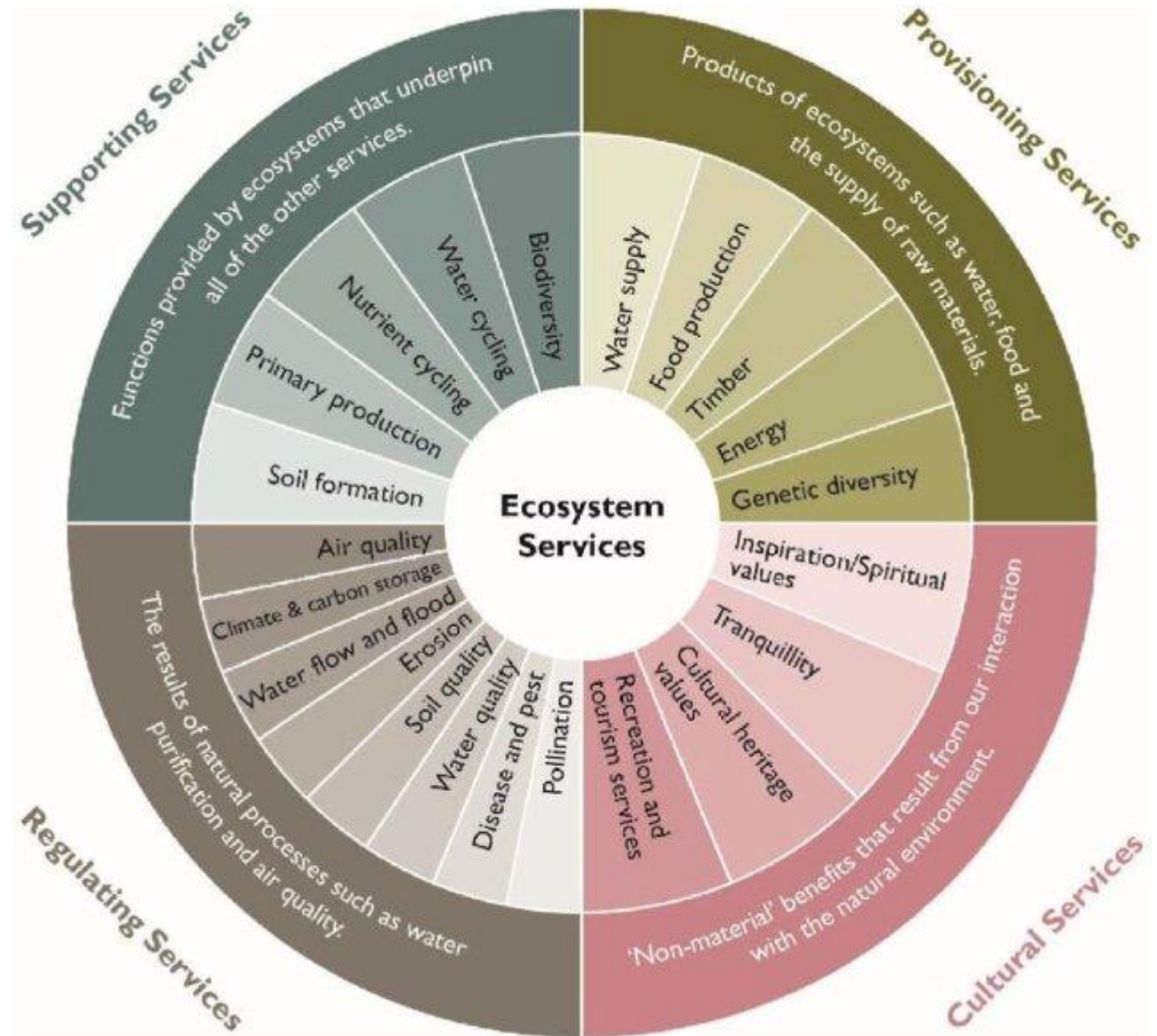
- Utilize data-driven approach and innovative practices to improve reclamation outcomes.

Collaborated on two-year Abnova study (2024-2025) to assess ecosystem services and reclamation on abandoned wells and roads.

- Partnered with University of Wyoming Natural Diversity Database (WYNDD)

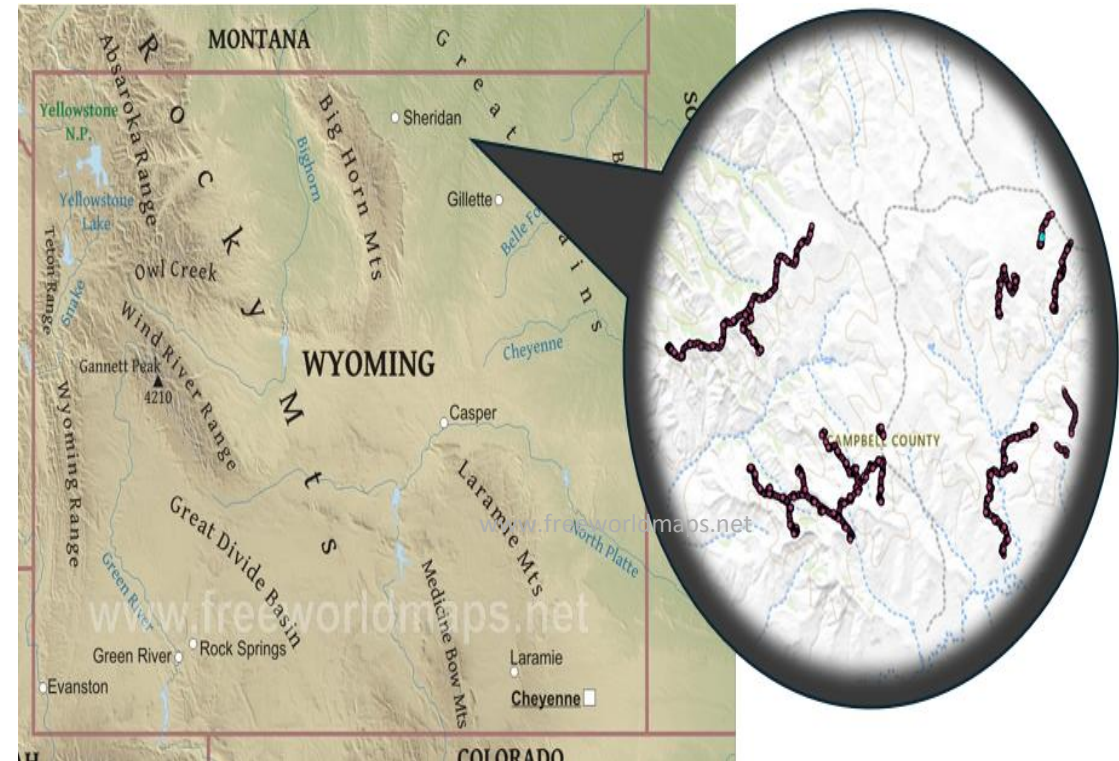
Healthy Ecosystems and Reclamation

- Primary production/biomass
- Carbon storage
- Biodiversity
- Habitat for species
- Pollination
- Soil quality
- Erosion Control
- Maintenance of genetic diversity
- Nutrient cycling



2024 & 2025 Summer Studies

- Covered ~8 miles of reclaimed roads and associated plugged and abandoned well pads in Powder River Basin
 - Roads split into 100 foot sections and 20% of them monitored with image-based photography which was geotagged and mapped
- Measured aboveground biomass, various soil parameters, vegetation coverage and diversity, insect abundance and diversity
- Compared sites to adjacent 'reference' area



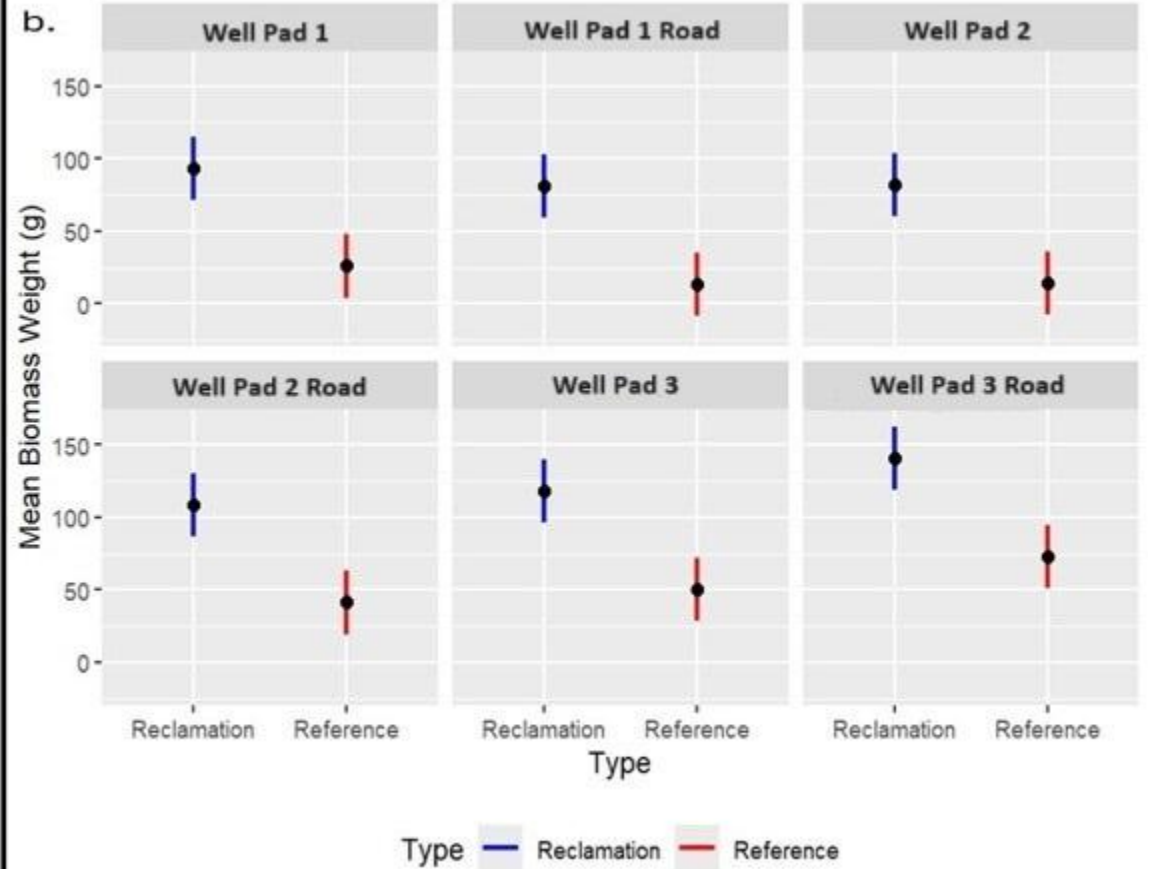
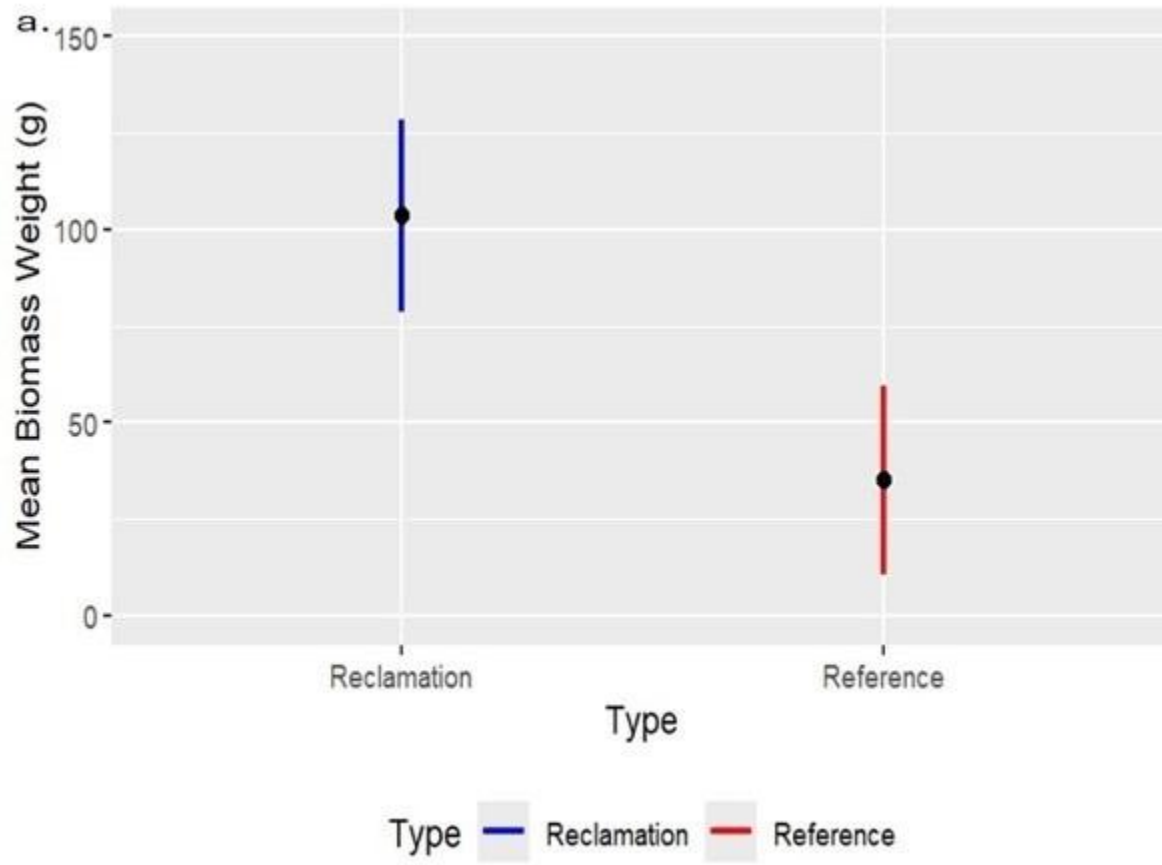
Initial findings

- Significantly higher biomass on reclamation compared to reference
- More vegetation diversity and typically similar or greater vegetation cover on reclamation compared to reference
 - Atypical for weeds to be present on reclamation unless also present in reference area
- More insect abundance and diversity

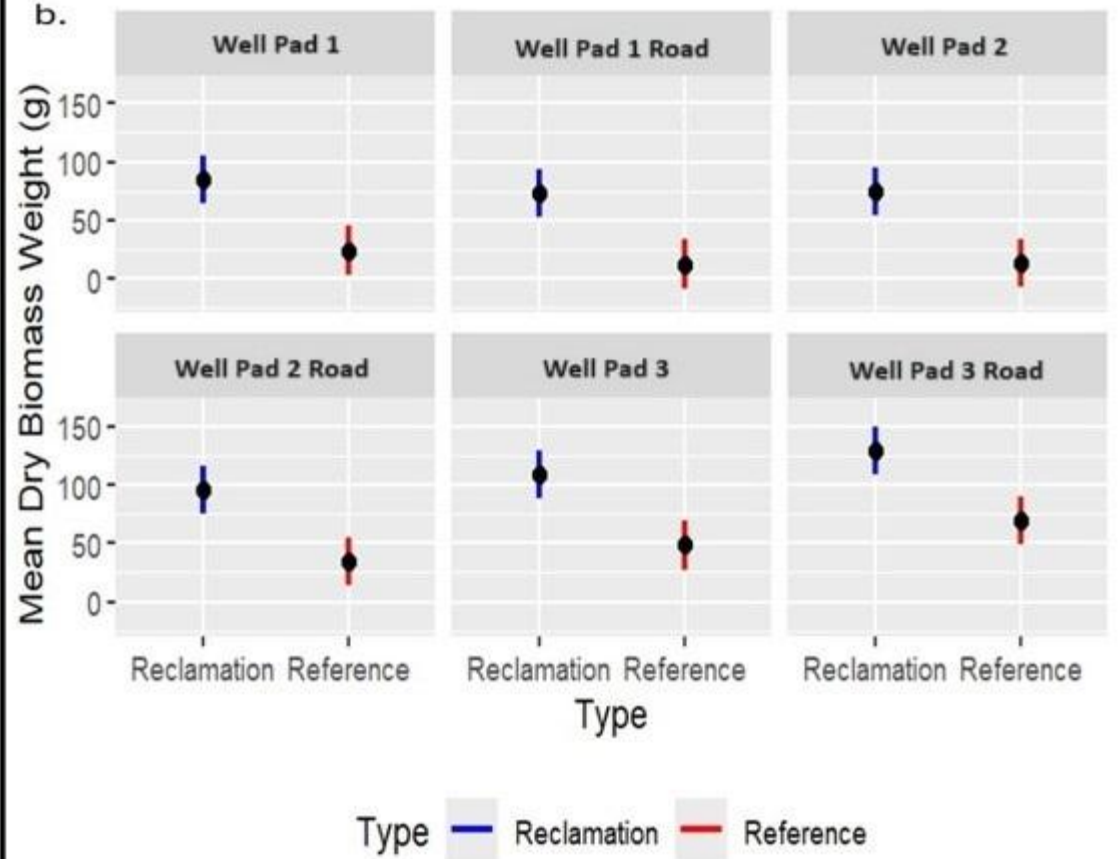
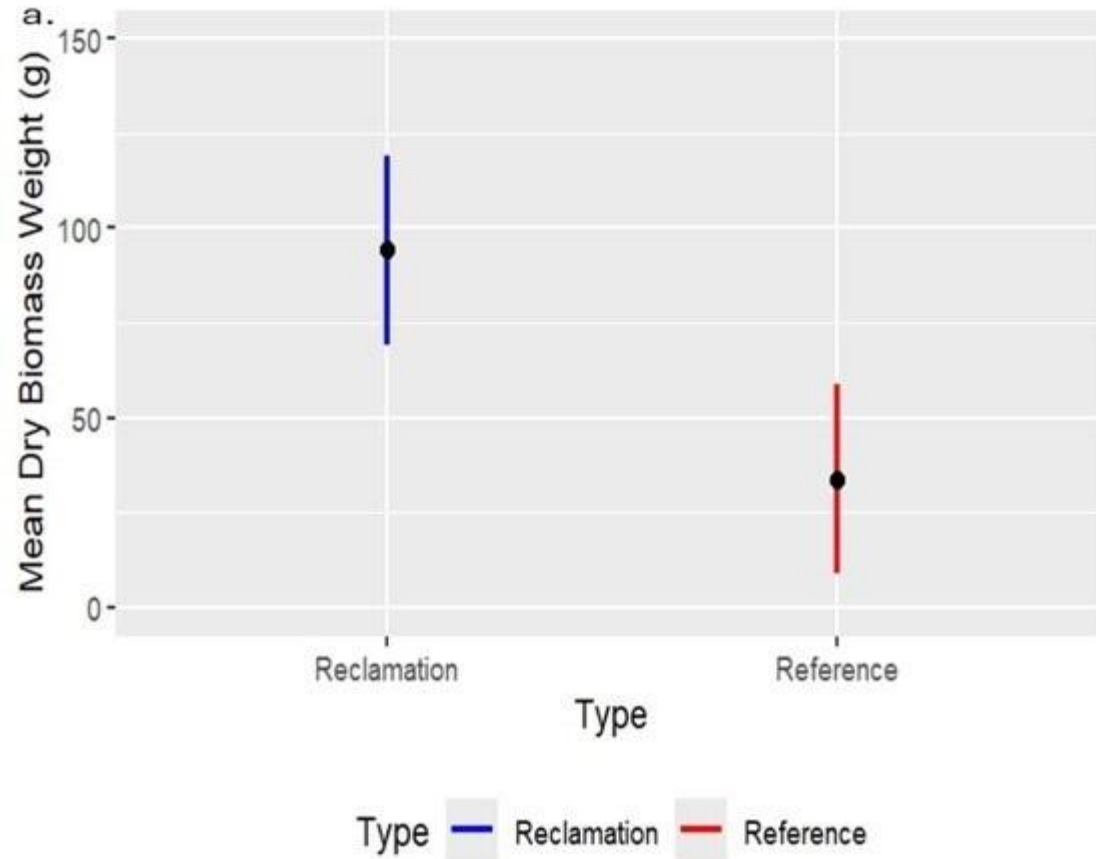
Increased aboveground biomass

- Aboveground biomass = the total mass of living, organic plant matter (leaves, stems, branches, and trunks) above the soil at a specific point in time
- Fundamental and supporting ecosystem service which is 'the basis for life on earth'
- Essential for other ecosystem services
 - Carbon storage/sequestration
 - Biodiversity
 - Food production/wildlife forage

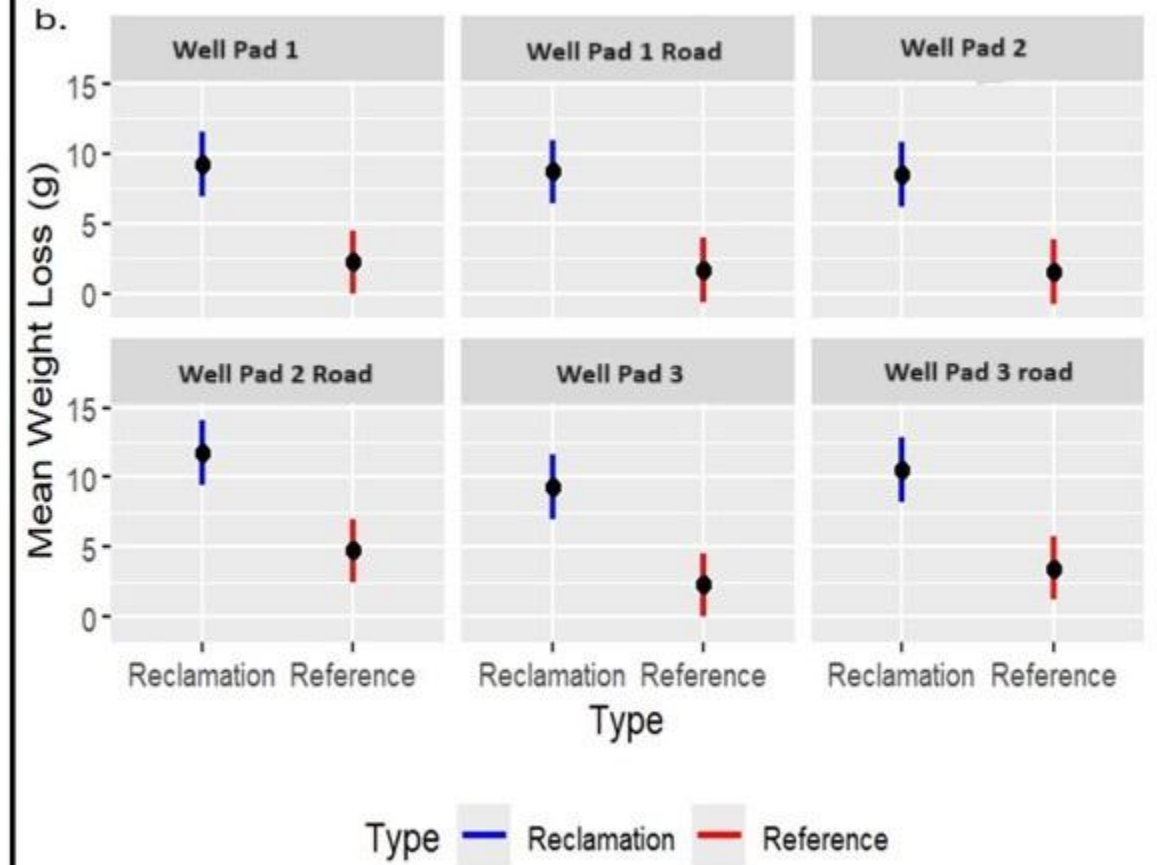
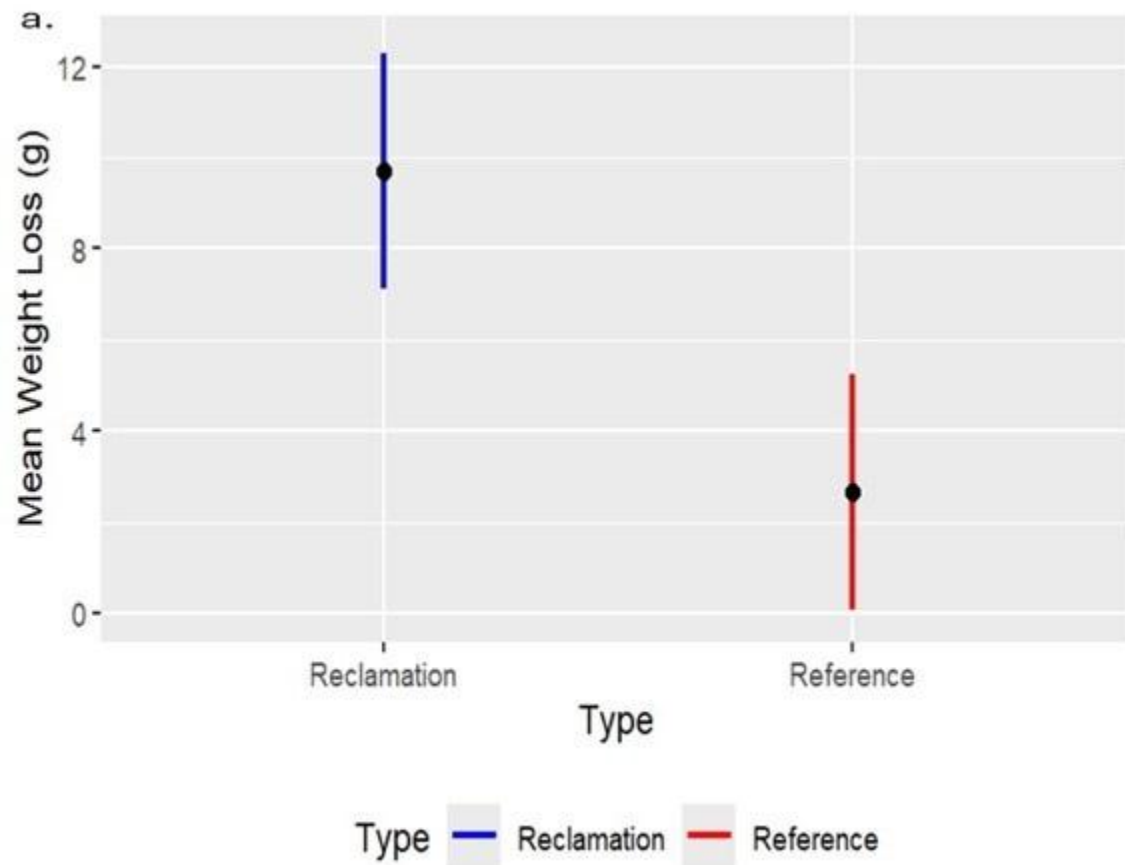
Biomass before drying



Biomass after drying



Mean weight loss

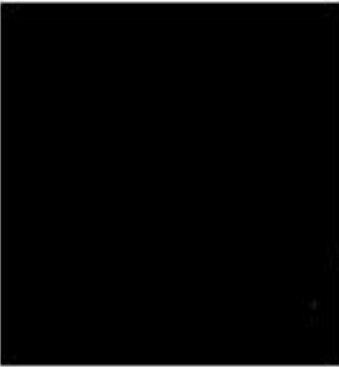


Vegetation Coverage and Diversity

- Vegetation coverage is a proxy for erosion control and essential to soil formation
- Vegetation diversity is also critical
 - Wildlife and pollinator habitat
 - Site resiliency
 - Genetic diversity
- Important for regulatory compliance

Example SamplePoint Data (2024)

A table depicting which categories drove significant differences between reclaimed sites and reference sites in chi-square tests. All sites were significantly different ($p < 0.0001$), individual categories with a * are those which were responsible for significance. Numbers in parentheses indicate the proportion of the chi-square statistics accounted for by the given category.

Site	Bare Ground	Herbaceous Litter	Woody Litter	Shrub	Forb	Bunchgrass	Rhizomatous Grass	Weed
	*(28.6)	*(27.4)	*(8.7)	*(20.1)	(0.2)	*(13.3)	(1.4)	(0.3)
	*(32)	*(27.1)	*(11.3)	*(11)	*(3.9)	*(10.6)	(2.6)	(1.6)
	*(28)	*(29)	*(7.8)	*(13.3)	(0.6)	*(6.6)	*(12.6)	(2)
	*(29.4)	*(29.3)	*(10.6)	*(13)	(2.3)	*(9.25)	(3.3)	(2.9)
	*(38.9)	*(40.7)	(0.1)	(3.6)	*(5)	(2.3)	(6.4)	(3)
	*(48.8)	*(26.3)	(0.1)	(0)	2	*(10)	*(8.7)	*(4)

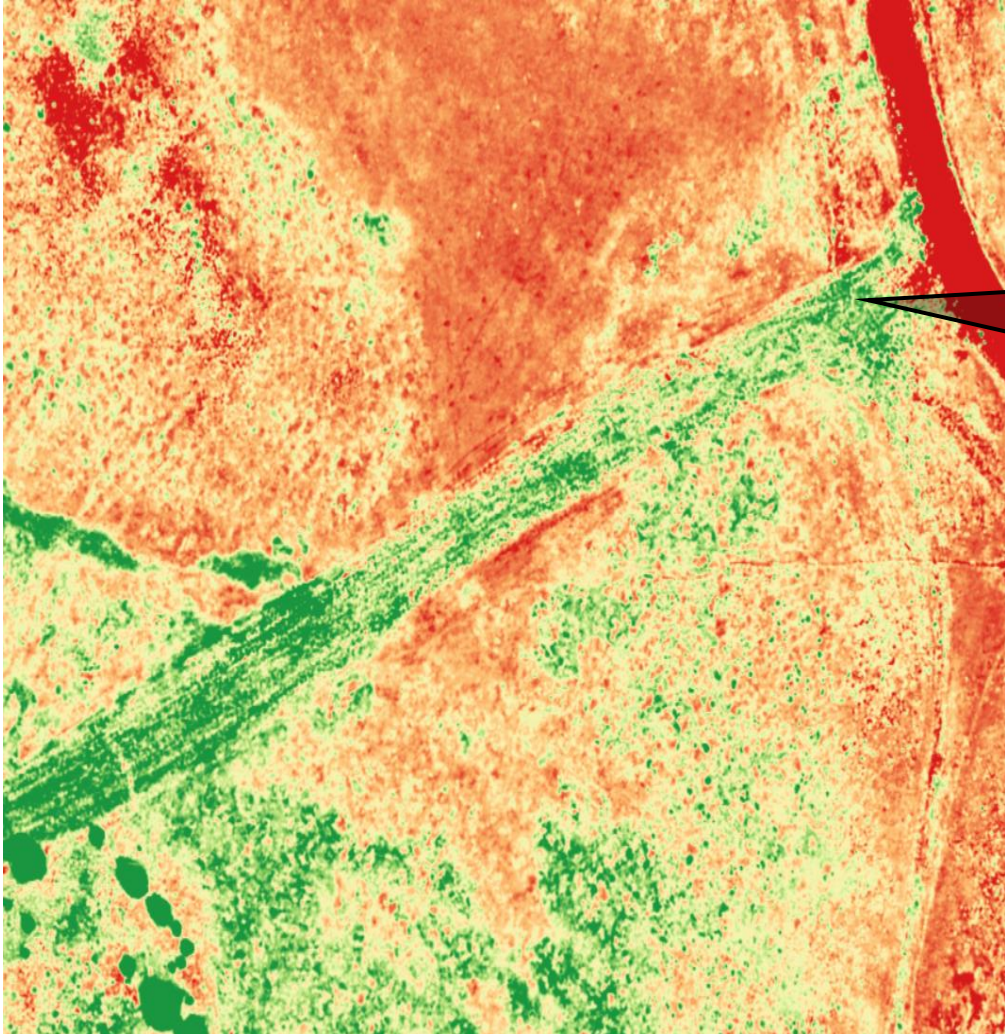
Well Pad 3 Summary

- Reclamation site has 24% less bare ground (30.5%) than reference (54.5%) (passes SWPPP criteria)
- Reclamation site contained 4% Japanese brome vs. 15% on reference (likely Japanese brome on reclamation came from reference)
- Reclamation site has 6 species present vs. 4 in reference (150% increase in vegetation diversity)
- Reclamation site contains 37% native grass cover vs. 8.5% in reference
- Reclamation site contains 2.5% native forb cover vs. 0% in reference
- Reclamation site contains 1% shrub cover vs. 5.5% in reference

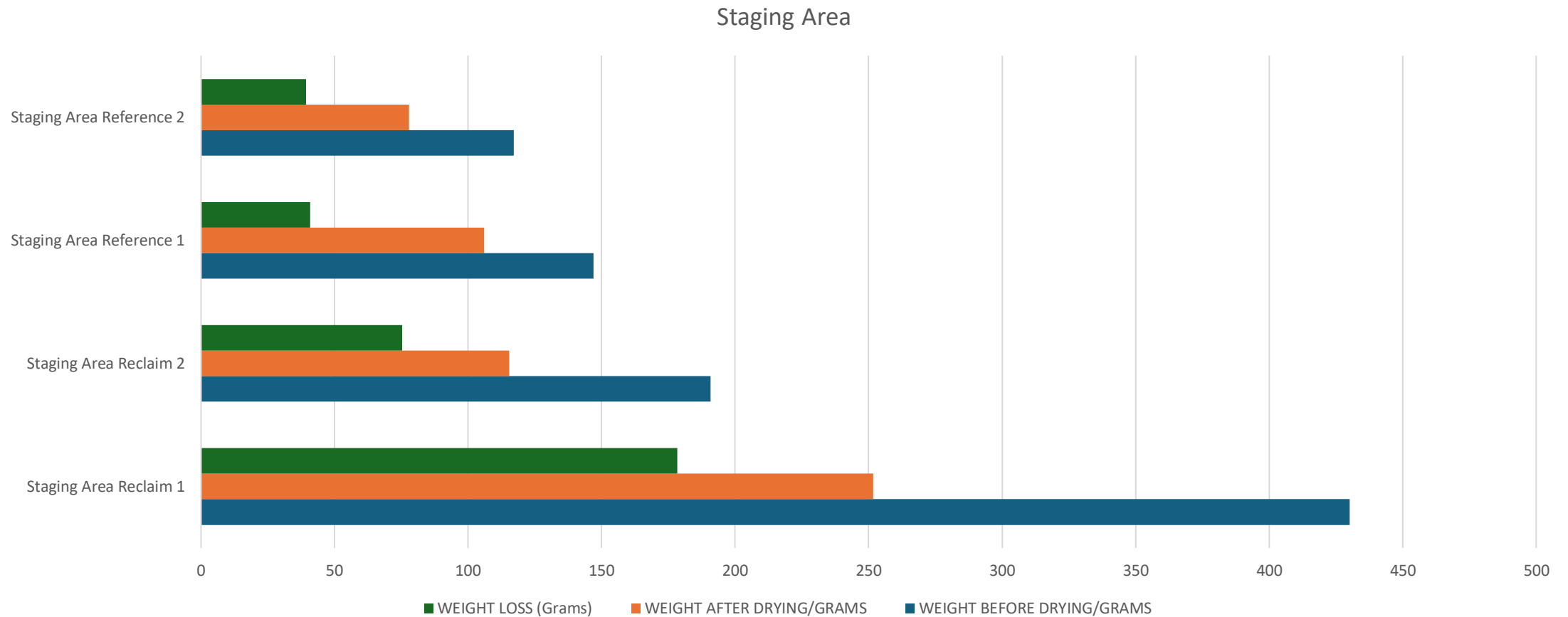
2025 Monitoring

- Four (4) plugged and abandoned well pads paired with adjacent reference locations
- Four (4) roads associated with those well pads paired with adjacent reference locations
- One (1) reservoir paired to adjacent reference location
- One (1) road site next to area where we staged equipment paired to adjacent reference area
- All sites were sampled by randomly selecting areas to clip vegetation from following protocols from 2025 (Curran et al. *Ecological Solutions and Evidence*)

Weed suppression along reclaimed ROW

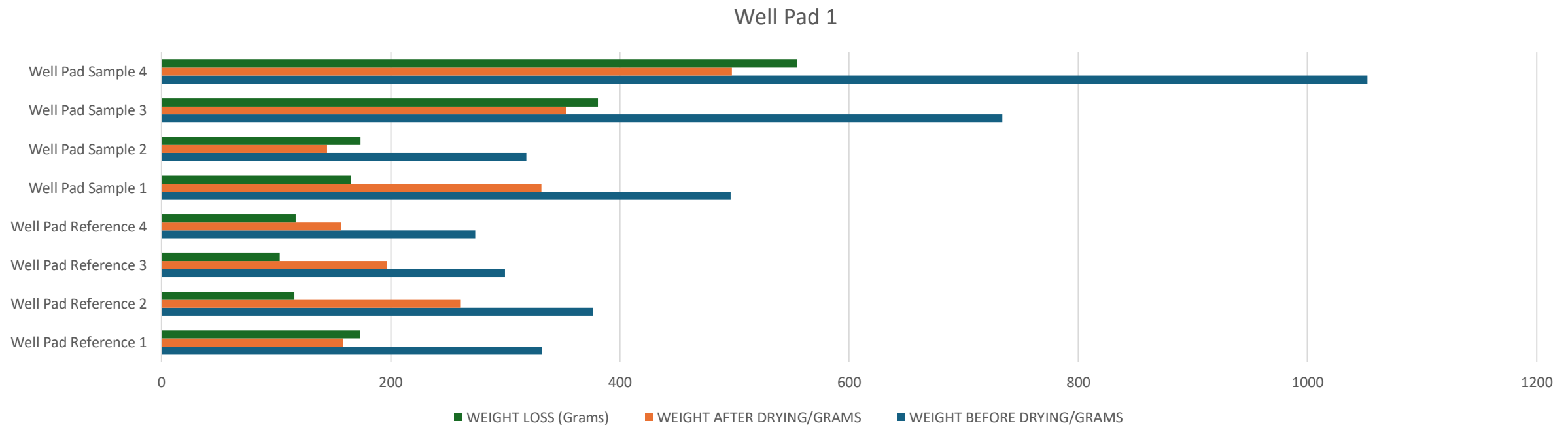


Summary of Data Collected in June 2025 (associated with previous slide)

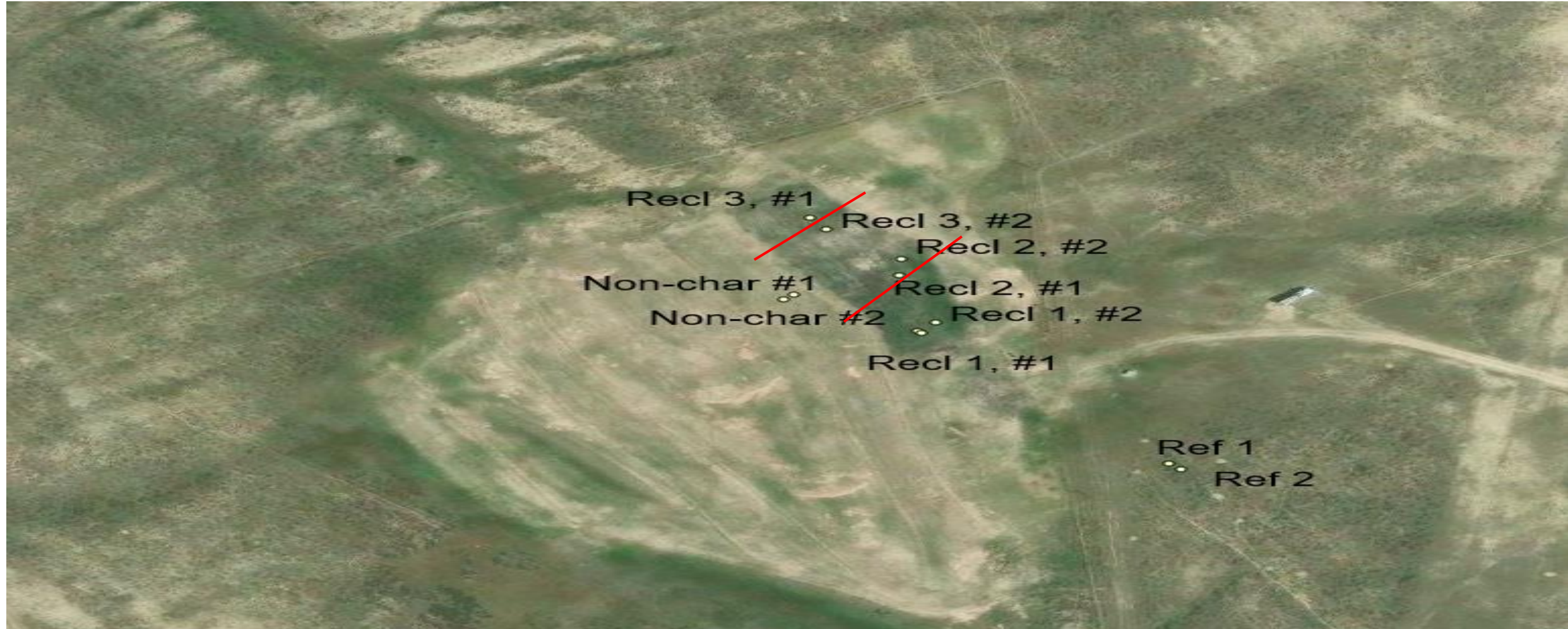


Reclaimed Pad & Road Data (2025)

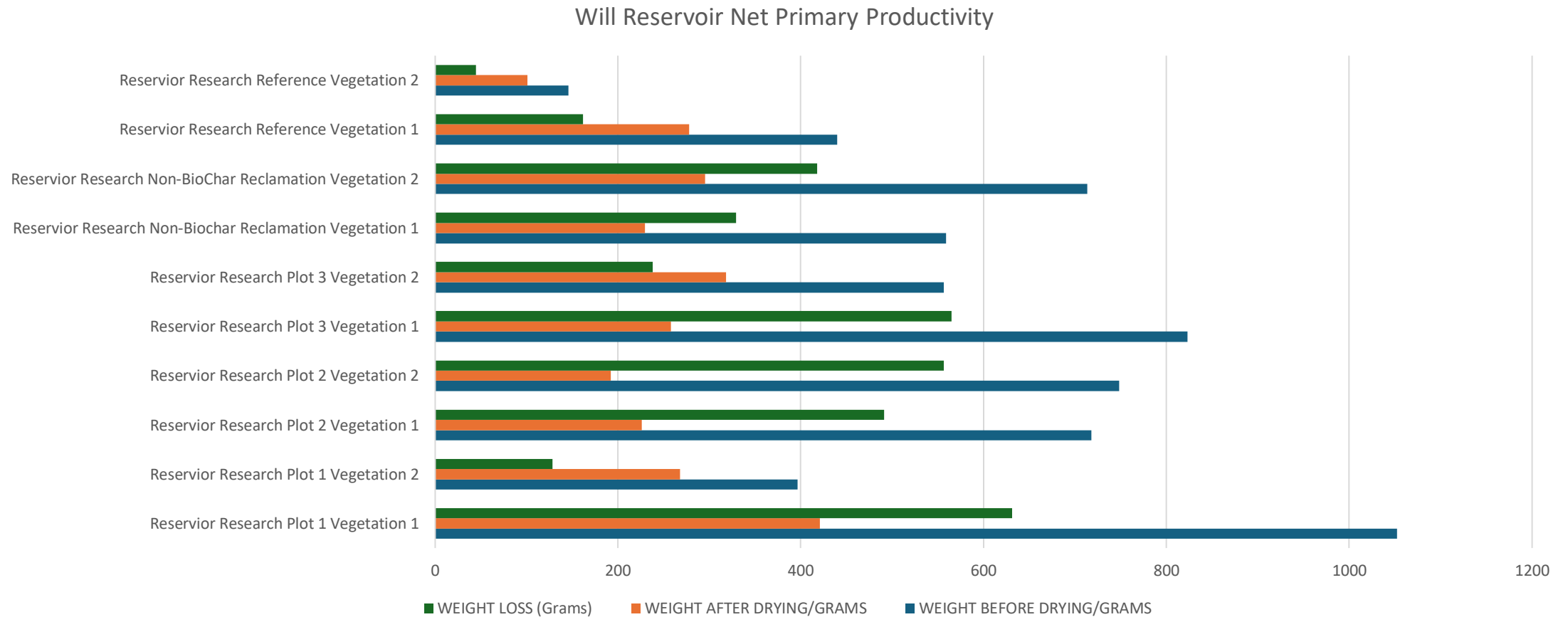
- Data aligned with 2024 data – all reclamation sites had more biomass (wet and dry) and more loss of weight after drying than reference sites



Pilot Study - reclaimed reservoir with biochar amendments (2025)



Reservoir Aboveground Biomass Data (2025)



Conclusions

- Within 3 years, it is possible for final reclamation on both well pads, pipelines, and reservoirs to achieve greater NPP than adjacent reference areas
- It is also possible to achieve higher native plant diversity and plant cover within this short time frame
- Although a pilot study, it appears biochar amendments are capable of positively impacting reclamation outcomes
- With the reclamation methods and seed mix utilized on these sites, weeds were only found on reclamation sites when they were heavily present in reference areas, but at much lower levels
- Measuring ecosystem services in a scientifically sound manner, as opposed to simply measuring for compliance standards, has numerous benefits
- Side note**: Multiple other studies ongoing within this area also suggest reclamation efforts are benefitting insects/pollinators and that wildlife are utilizing these areas

Other benefits to scientific monitoring approach

- Understand what reclamation practices work and do not work to reduce future risk of failure and costs of rework associated with reclamation
 - Efficiently track compliance metrics
 - Inform decision making (e.g., where to treat weeds, tailored seed mixes, etc.)
- Enhances ability to work with various stakeholders

Future Directions



Collaborate with various stakeholders



Expand study area and move study timing to peak bloom periods



Build on research questions



Understand long-term trends





Galaxy A15 5G



Galaxy A15 5G





Questions?

