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Using Ecological Site Concepts to Assess Restoration Success: A Case Study on MLRA 98 Mucky Depressions

Soil Science Division

Natural Resources Conservation Service

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Resource Question

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Study Design: Sample According to DSP Guidance

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DSP Guidance

Dynamic Soil Properties – properties that change with land use, management and disturbance. Soil survey focuses on properties that change on the human time scale (~decades).

Guidance: for this project – Soil Change Guide, current Ch. 9

Both rely on space-for-time substitution (based on ecological site concepts) and multi-scale replication

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Ecological Site - frames inference space and comparisons

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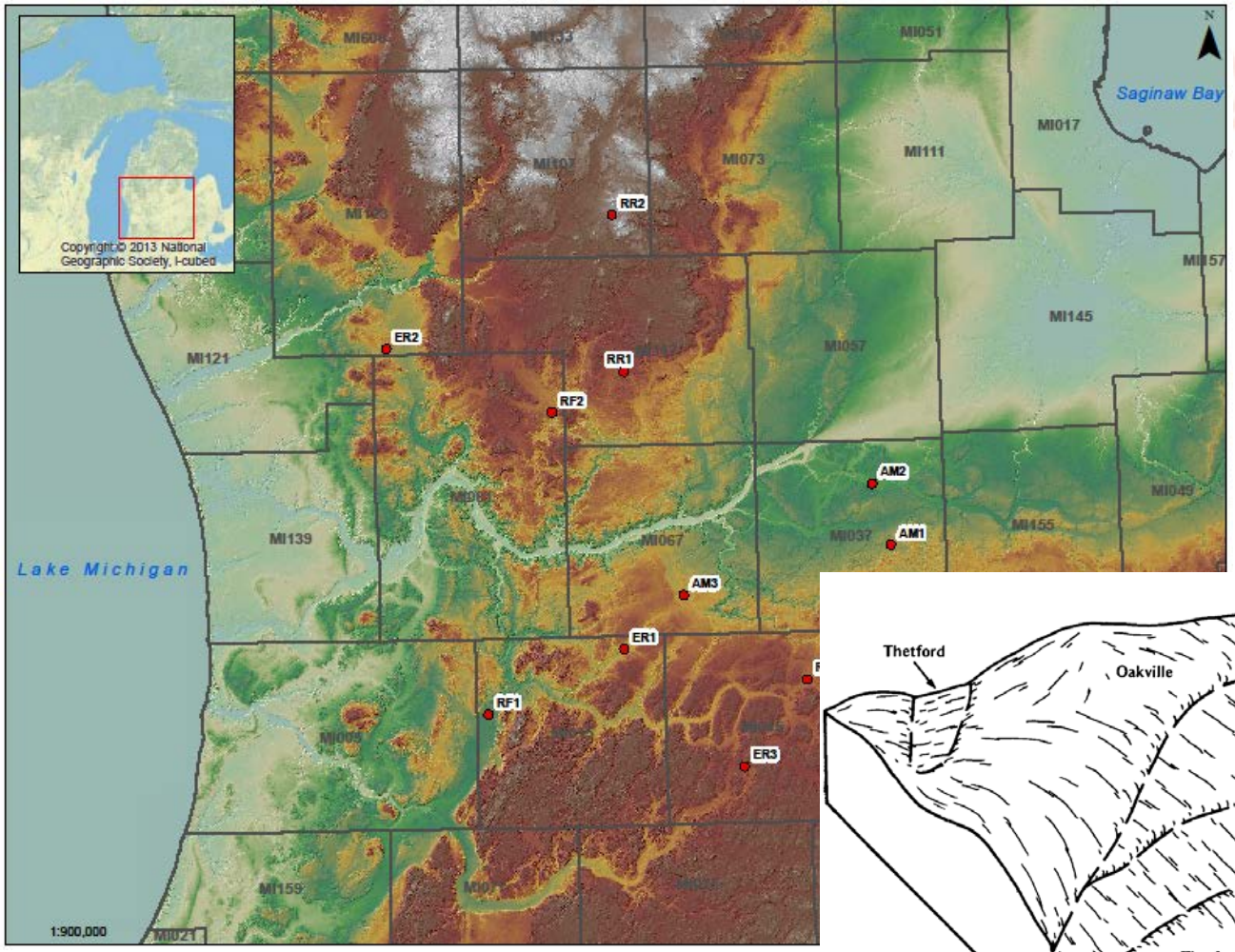
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Saginaw Bay
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MI049
MI155
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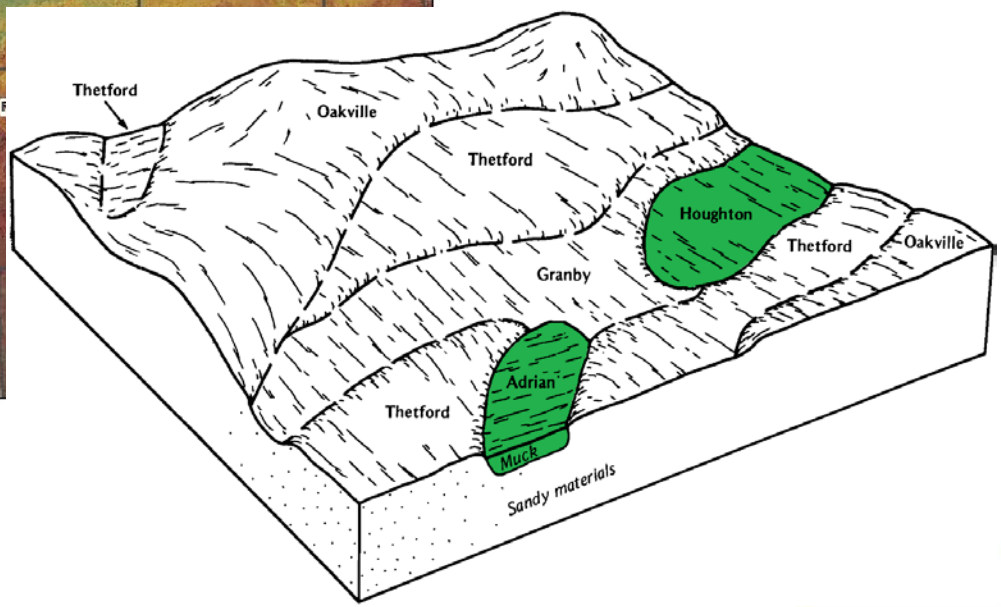
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Houghton
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Granby
Adrian
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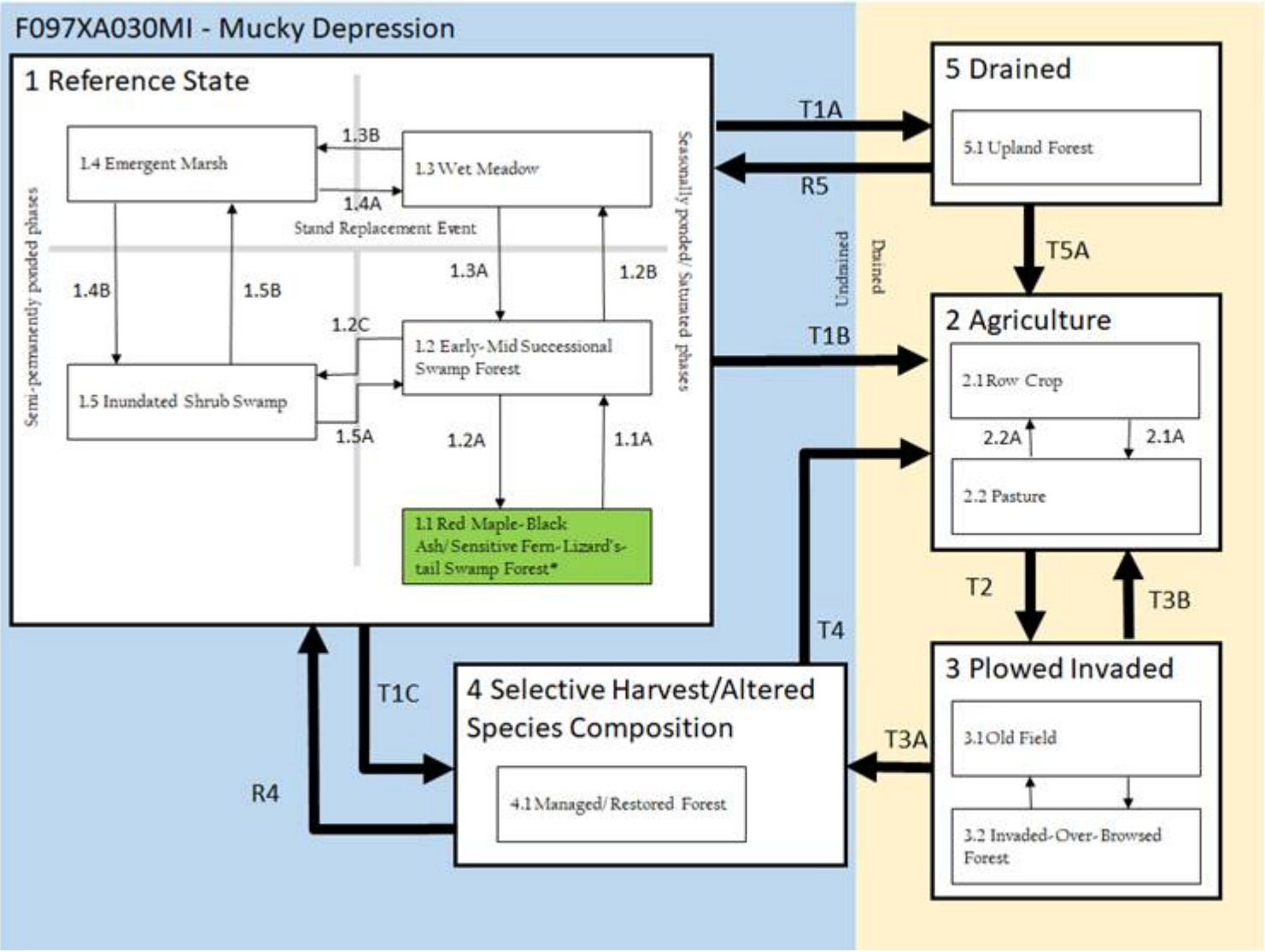
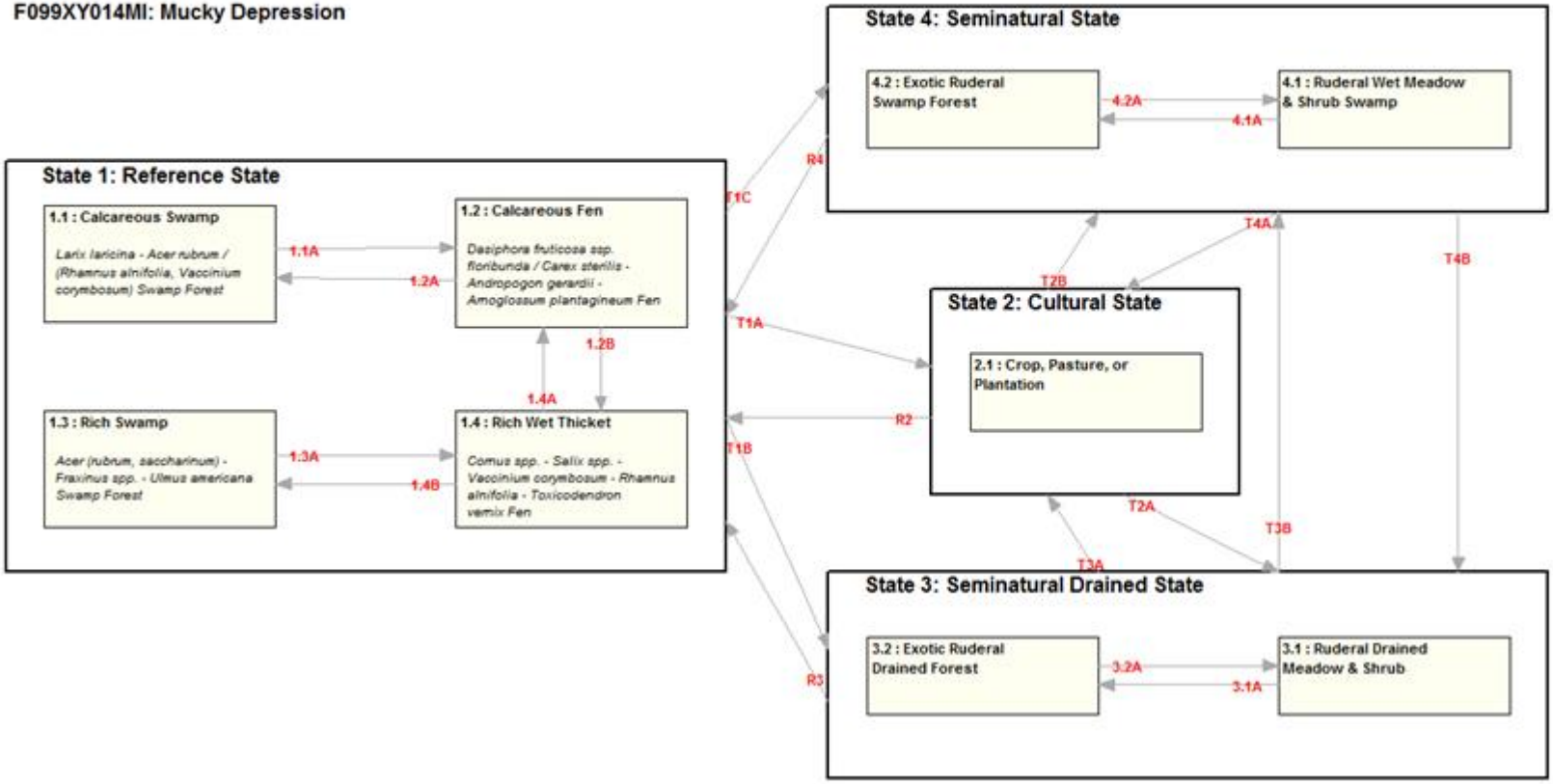
Muck
Sandy materials



Legend	Activity/Process
1.1A	Partial tree removal/minor disturbance
1.2A	Succession
1.2B	Complete tree removal/major disturbance
1.2C	Water table rises
1.3A	Tree establishment
1.3B	Water table rises
1.4A	Water table drops
1.4B	Shrub establishment
1.5A	Water table drops
1.5B	Shrub removal/major disturbance
2.1A	Plant forage grasses, graze or harvest hay
2.2B	Cultivation
3.1A	Succession
3.2B	Clearcut
R4	Complete invasive species removal, complete species restoration, restored faunal commun balance, restored natural processes
R5	Restored Hydrology
T1A	Drained
T1B	Drained, clearcut plus cultivation, introduced species (weeds, earthworms, pests, pathoge predator-prey disequilibrium (deer over pop
T1C	Selective harvest, partial invasive species introduction, partial predator-prey disequilib
T2	Succession, colonization by invasive species
T3A	Restored hydrology, partial invasive species partial native species restoration
T3B	Clearcut plus cultivation
T4	Drained, clearcut plus cultivation
T5A	Clearcut plus cultivation, introduced invasive (weeds, earthworms, pests, pathogens), pre prey disequilibrium (deer over population)

F099XY014MI: Mucky Depression



Legend

T1A	Drain; clear vegetation; cult domesticated species
T1B	Drain; clear vegetation, inv introduced
T1C	Clear vegetation, invasive s introduced
1.1A	Blowdown/fire
1.2A	Succession
1.2B	Decreased groundwater inp
1.3A	Blowdown/fire
1.4A	Increased groundwater inpu
1.4B	Succession
R2	Restore hydrology; remove species; restore native speci
T2A	Abandoned, succession
T2B	Restore hydrology; abandon
R3	Restore hydrology; control restore native species
T3A	Clear vegetation; cultivate species
T3B	Restore hydrology
3.1A	Succession
3.2A	Blowdown/clearout
R4	Control invasive species; re species
T4A	Drain; clear vegetation; cult domesticated species
T4B	Drain
4.1A	Succession
4.2A	Blowdown/clearout

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Reference condition sets benchmark conditions (soil properties and vegetation)

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1.1 Red Maple-Black Ash/ Sensitive Fern-Lizard's-tail Swamp Forest*

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Alternate Conditions

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AM -
Actively
Managed
Agricultural
Land

ER –
Established
Restoration
> 5 years

RR –
Recently
Restored
Wetlands
< 5 years

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Replication

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1 project (ecological site defines the entire relevant area)

- **4 conditions**
  - Reference
  - Recent Restoration
  - Established Restoration
  - Agriculture
- **Replicate locations across each condition**
  - 3 – 5 locations in each
- **Plot assessment of species composition and cover**
- **Replicate pedons at each location**
  - One center pedon
  - Four satellite pedons
  - Vegetation data collected within plot formed by pedons

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Results

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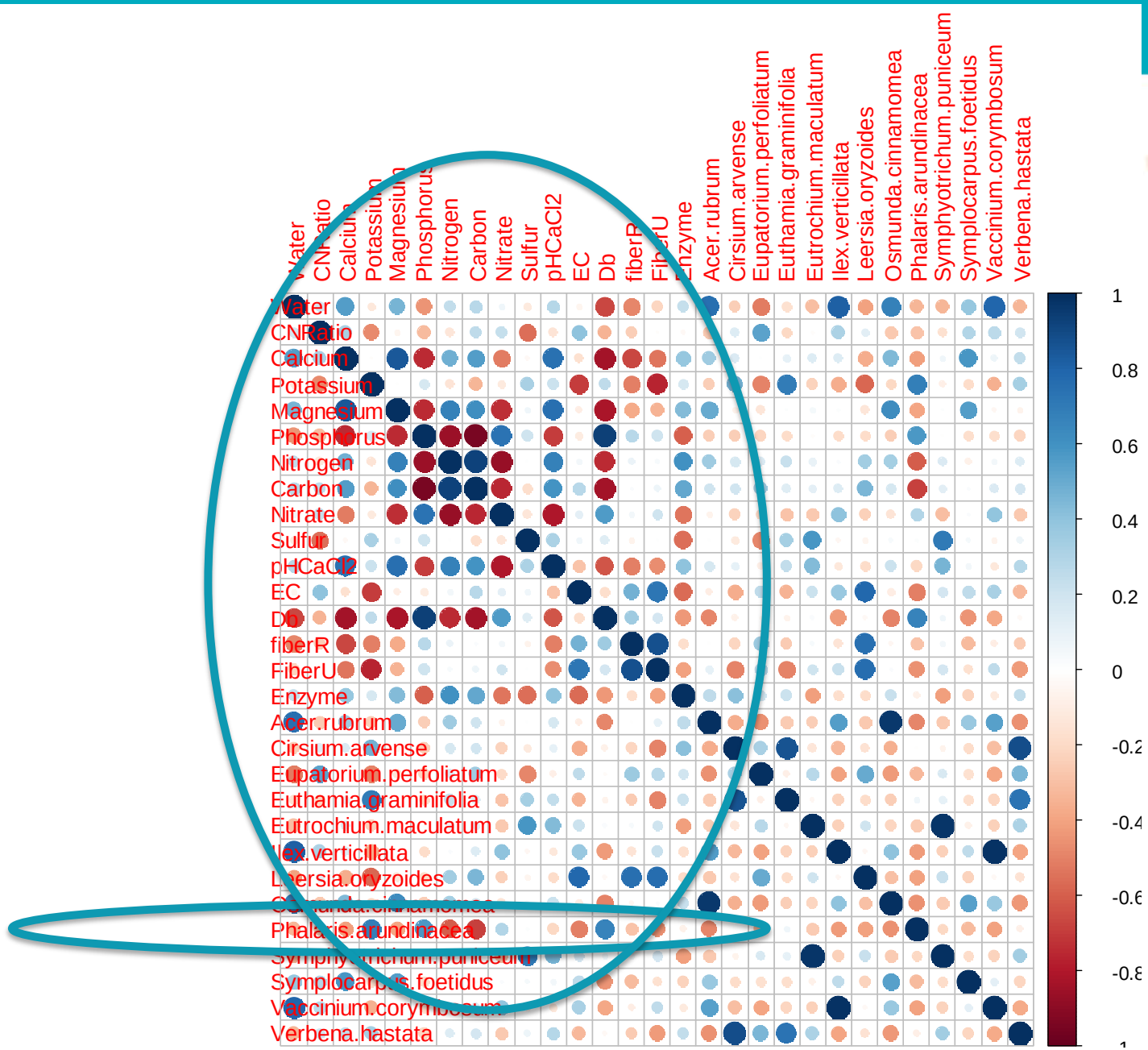

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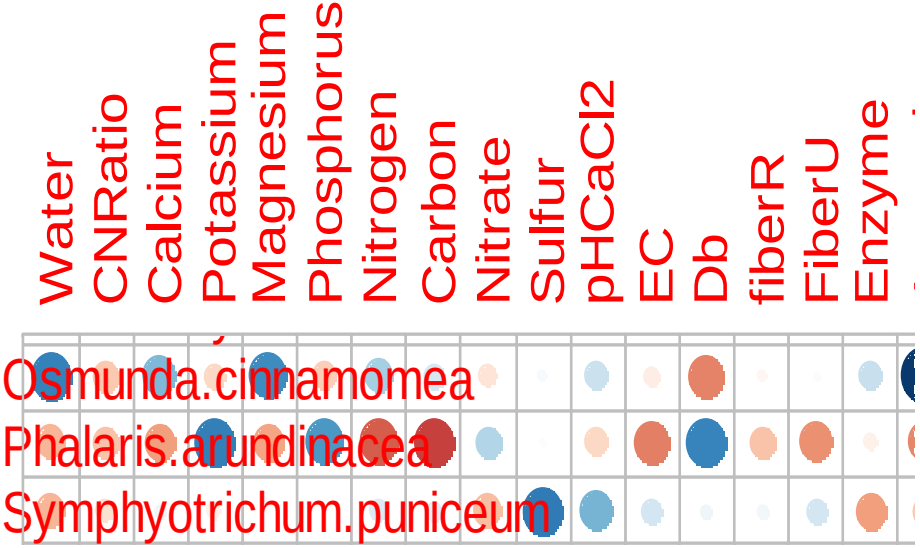
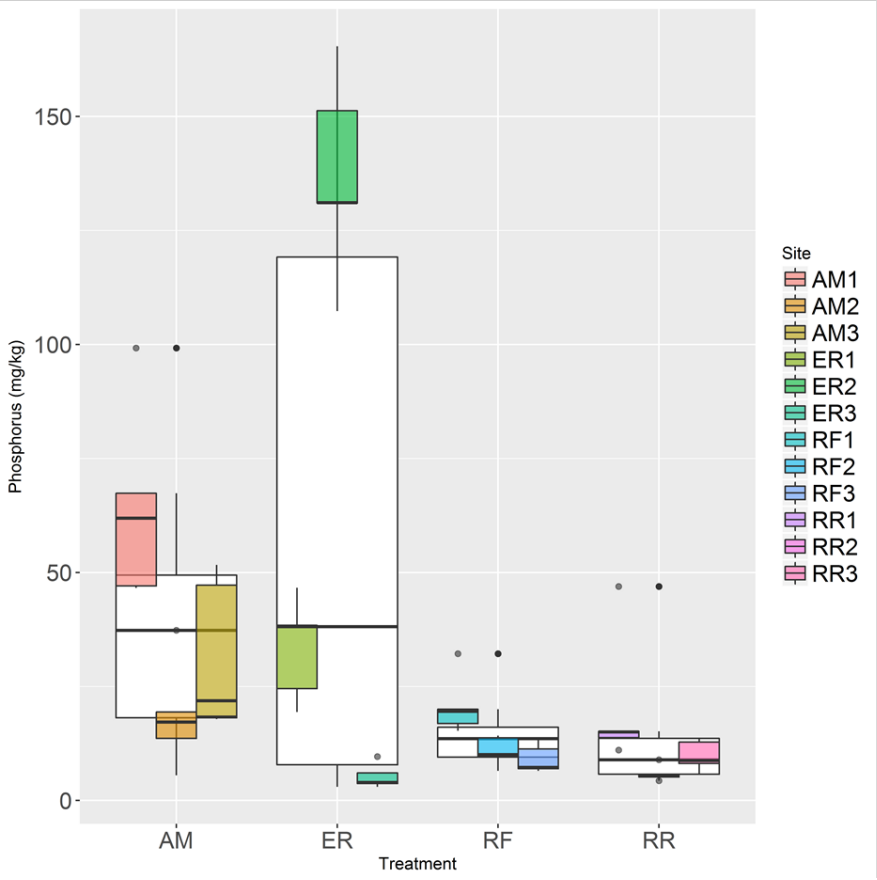
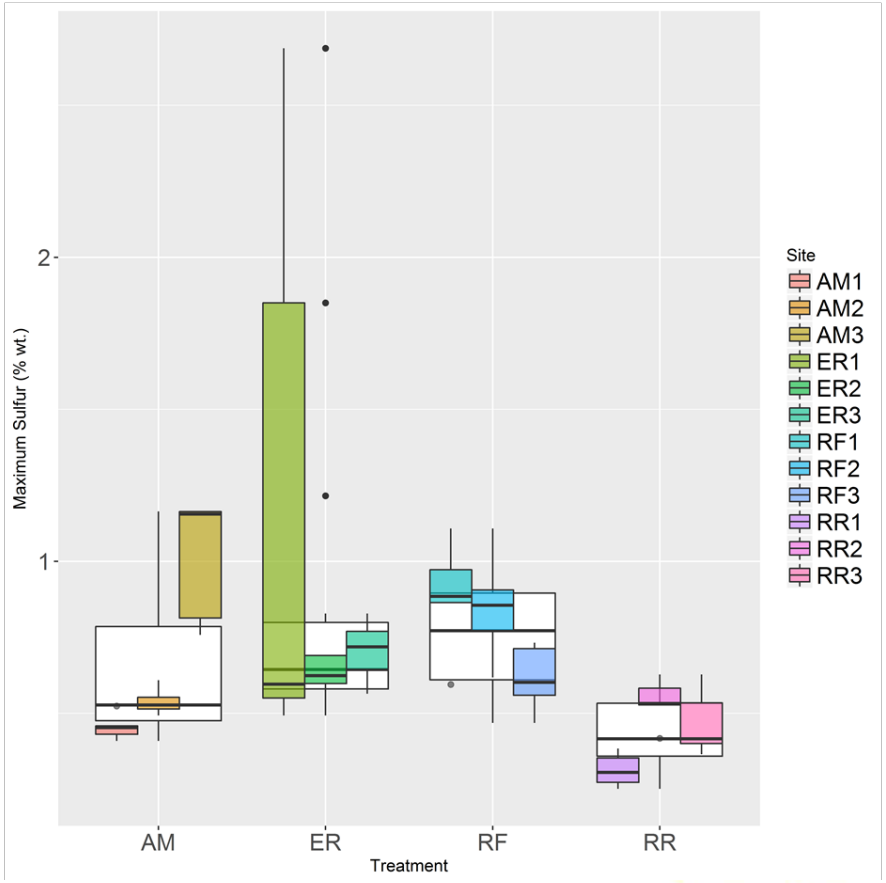

Water
CNRatio
Calcium
Potassium
Magnesium
Phosphorus
Nitrogen
Carbon
Nitrate
Sulfur
pHCaCl2
EC
Db
fiberR
FiberU
Enzyme
Osmunda.cinnamomea
Phalaris.arundinacea
Symphyotrichum.puniceum

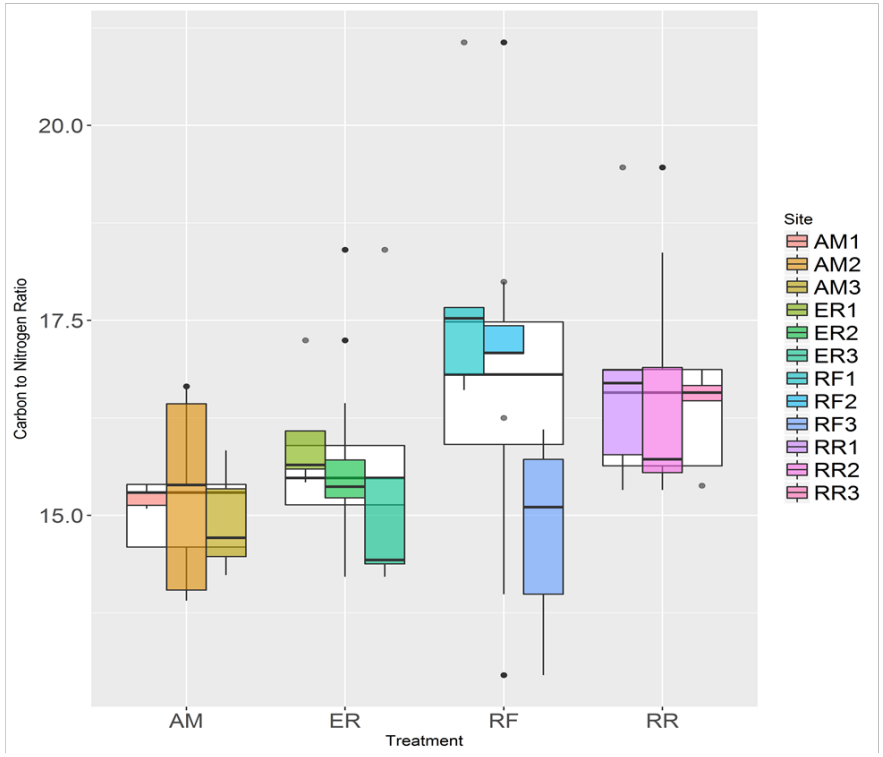
Total Phosphorus Content in Upper 50 cm

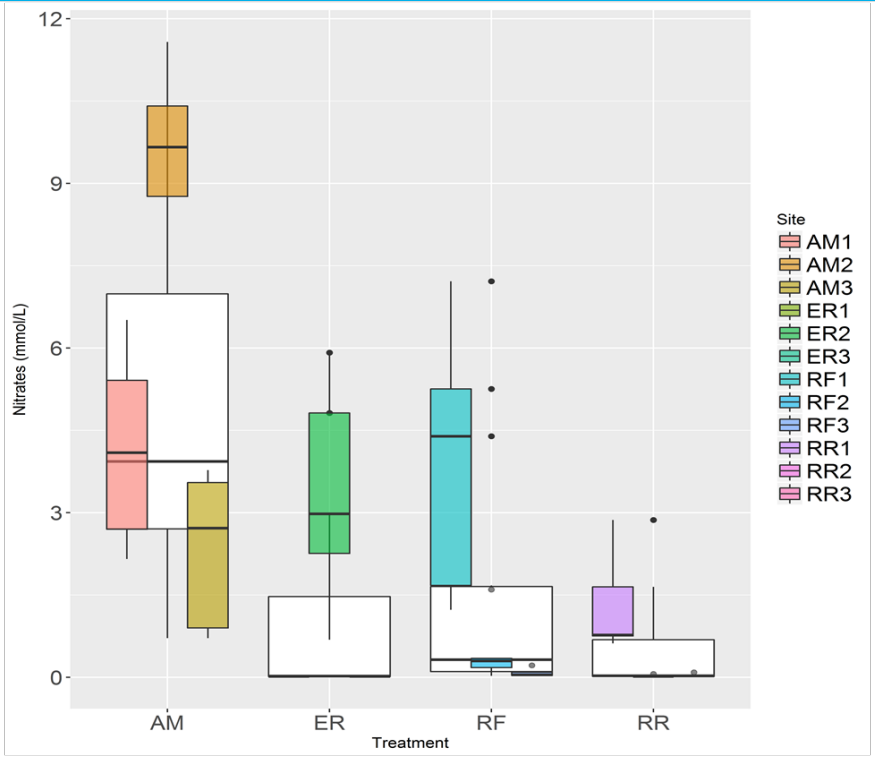


Maximum Sulfur Content in Upper 100 cm

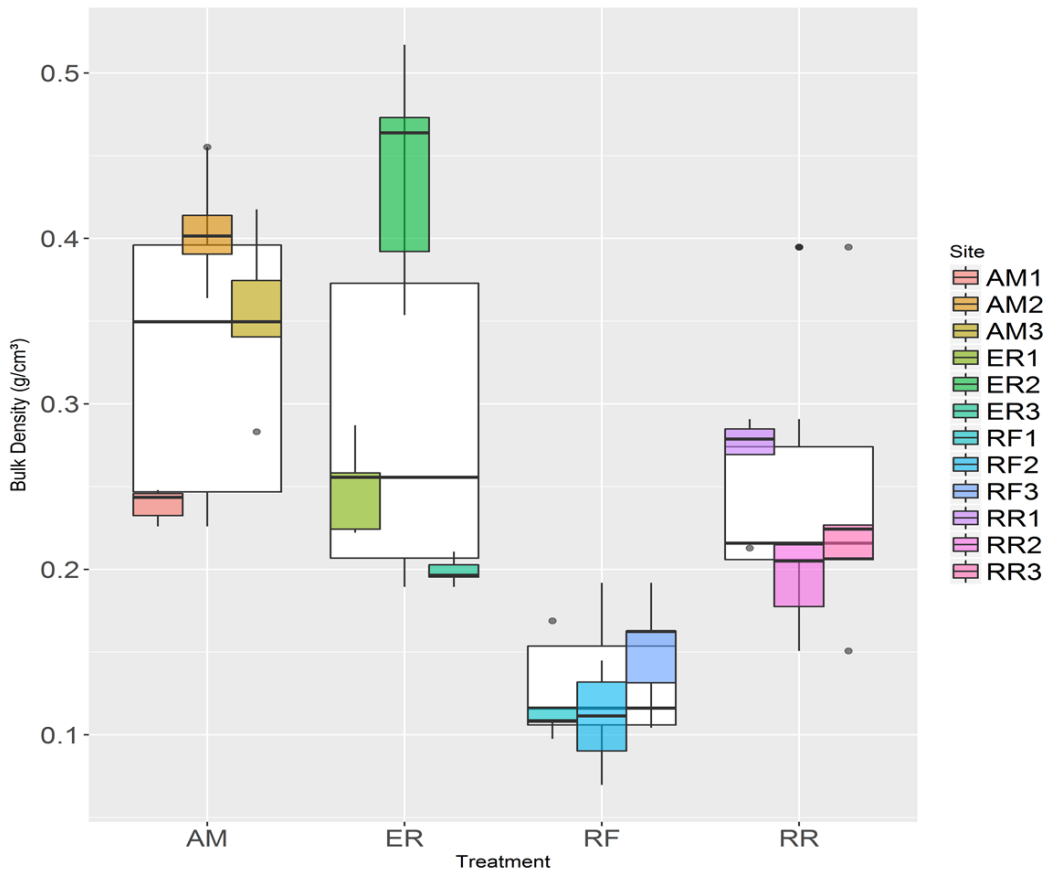


Carbon to Nitrogen Ratio and Nitrate in upper 50 cm by Treatment/Site

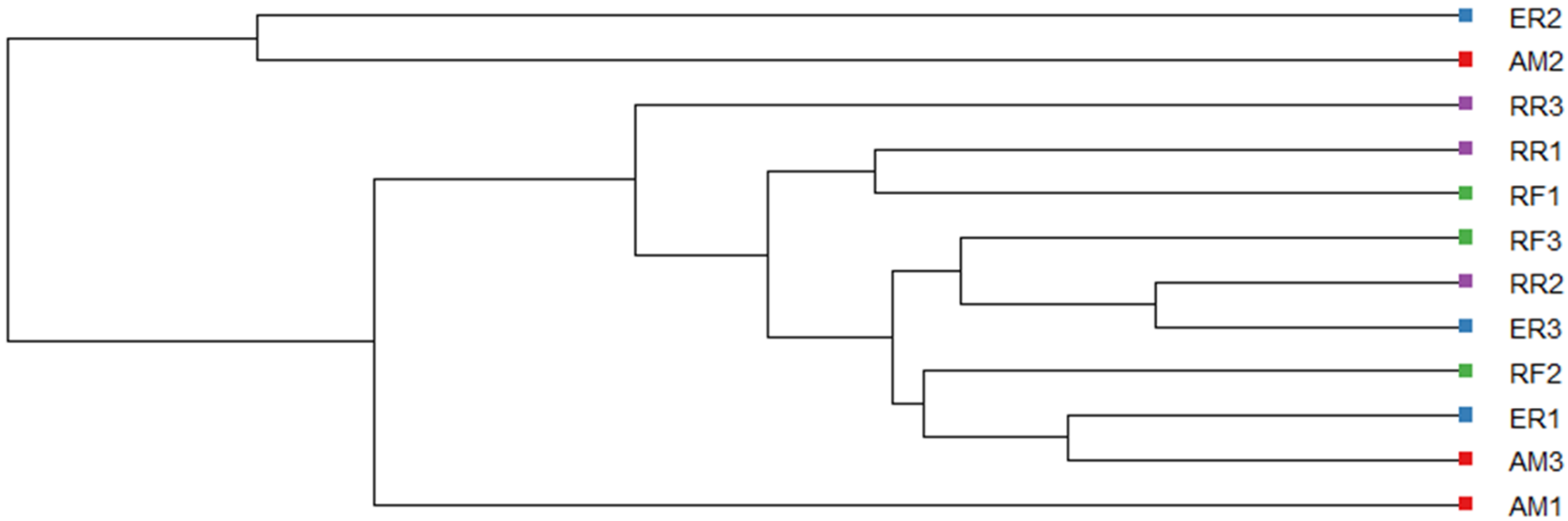




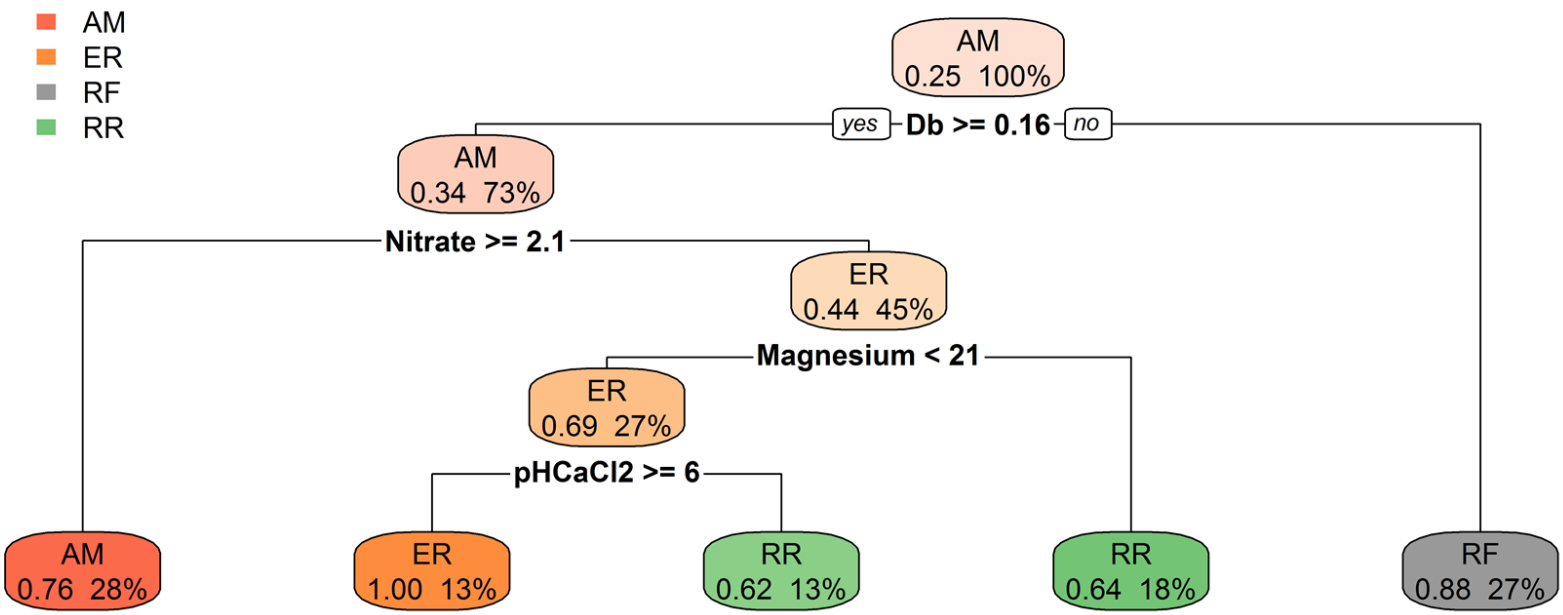
Bulk Density in Upper 50 cm by Treatment/Site



Relationships Among Sites Based on Abiotic Properties



Classification Tree of Abiotic Properties by Treatment



Conclusions

- **Dynamic Soil Properties were significantly different by condition**
- **The RR sites were more similar (successful) than ER sites at restoring DSPs to reference conditions**
  - despite being more recently restored, the newer techniques gave better results
  - neither treatment was as wet as the reference.
- **The abundance of invasive *Phalaris arundinacea* (reed canary grass) in the restored sites was not related to treatment, but was associated with changed DSPs**
- **Decades of tree development are required before restored sites resemble reference vegetation.**

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Next Steps

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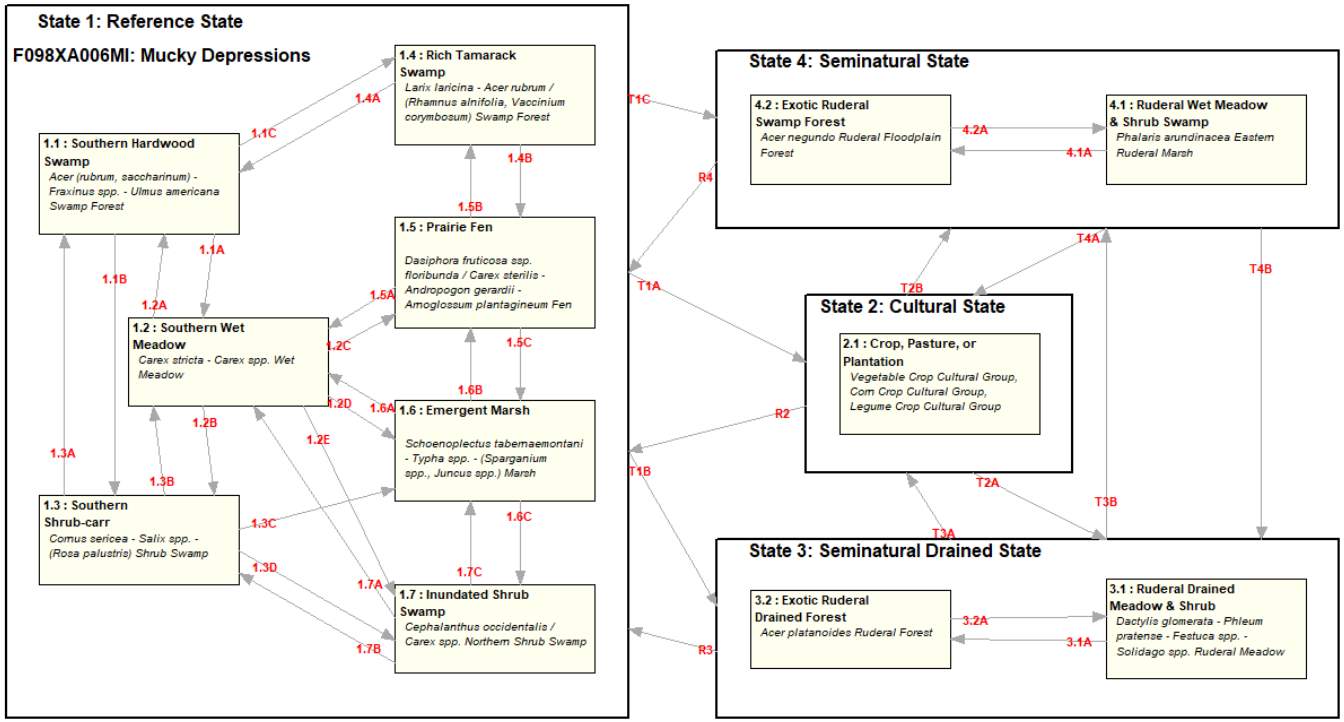
Complete State and Transition Model

Update guidance to incorporate complex systems in sampling scheme



Legend

T1A	Drain; clear vegetation; cultivate domesticated species
T1B	Drain; clear vegetation, invasive species introduced
T1C	Clear vegetation, invasive species introduced
1.1A	Temporary prolonged inundation/Fire
1.1B	Clearcut/Blowdown/Fire
1.1C	Increase peat or marl thickness, decrease nitrogen or phosphorus availability
1.2A	Succession
1.2B	Succession
1.2C	Increase peat or marl thickness, decrease nitrogen or phosphorus availability
1.2D	Permanent inundation
1.2E	Permanent inundation
1.3A	Succession
1.3B	Temporary prolonged inundation/Fire
1.3C	Permanent inundation
1.3D	Permanent inundation
1.4A	Decrease peat or marl thickness, increase nitrogen or phosphorus availability
1.4B	Clearcut/Blowdown/Fire
1.5A	Decrease peat or marl thickness, increase nitrogen or phosphorus availability
1.5B	Succession
1.5C	Permanent inundation
1.6A	Drop water table
1.6B	Drop water table
1.6C	Temporary drop water table; shrub establisment
1.7A	Drop water table, fire
1.7B	Drop water table
1.7C	Temporary drought and fire; shrub mortality
R2	Restore hydrology; remove domesticated species; restore native species
T2A	Abandoned, succession

T2B	Restore hydrology; abandoned; succes
R3	Restore hydrology; control invasive sp restore native species
T3A	Clear vegetation; cultivate domestica species
T3B	Restore hydrology
3.1A	Succession
3.2A	Blowdown/clearcut
R4	Control invasive species; restore nativ species
T4A	Drain; clear vegetation; cultivate domesticated species
T4B	Drain
4.1A	Succession
4.2A	Blowdown/clearcut

Michigan Natural Features Inventory	Group	Alliance	Association
Southern Hardwood Swamp	Central Hardwood Flatwoods & Swamp Forest	Red Maple - Ash - Swamp White Oak Swamp Forest	Acer (rubrum, saccharinum) - Fraxinus spp. - Ulmus americana Swamp Forest
Rich Tamarack Swamp	Laurentian-Acadian-Appalachian Alkaline Swamp	Black Ash - Red Maple Swamp Forest	Larix laricina - Acer rubrum / (Rhamnus alnifolia, Vaccinium corymbosum) Swamp Forest
Rich Conifer Swamp	Laurentian-Acadian-Appalachian Alkaline Swamp	Northern White-cedar - Red Maple Swamp Forest	Larix laricina - Thuja occidentalis Swamp Forest
Hardwood-Conifer Swamp	Laurentian-Acadian-Appalachian Alkaline Swamp	Northern White-cedar - Red Maple Swamp Forest	Thuja occidentalis - Fraxinus nigra Swamp Forest
Prairie Fen	Midwest Prairie Alkaline Fen	Midwest Prairie Fen	Cornus amomum - Salix spp. - Toxicodendron vernix - Rhamnus lanceolata Fen
Prairie Fen	Midwest Prairie Alkaline Fen	Midwest Prairie Fen	Dasiphora fruticosa ssp. floribunda / Carex sterilis - Andropogon gerardii - Arnoglossum plantagineum Fen
Southern Wet Meadow	North-Central & Northeastern Seep	Northern Calcareous Seep	Symplocarpus foetidus - Mixed Forbs Seep
Emergent Marsh	Eastern North American Freshwater Marsh	Bulrush - Cattail Shallow Marsh	Schoenoplectus tabernaemontani - Typha spp. - (Sparganium spp., Juncus spp.) Marsh
Inundated Shrub Swamp	Eastern North American Shrub Swamp	Buttonbush - Swamp-loosestrife Shrub Swamp	Cephalanthus occidentalis / Carex spp. Northern Shrub Swamp
Southern Shrub-carr	Eastern North American Shrub Swamp	Red-osier Dogwood - Willow Shrub Swamp	Cornus sericea - Salix spp. - (Rosa palustris) Shrub Swamp
Southern Wet Meadow	Midwest Wet Prairie & Wet Meadow	Midwest Sedge - Bluejoint Wet Meadow	Carex stricta - Carex spp. Wet Meadow
Emergent Marsh	Eastern Ruderal Wet Meadow & Marsh	Ruderal Non-tidal Common Reed Marsh	Phragmites australis ssp. australis Eastern Ruderal Marsh
none	Eastern Ruderal Wet Meadow & Marsh	Eastern Ruderal Reed Canarygrass Marsh	Phalaris arundinacea Eastern Ruderal Marsh