



# Borrow Pit Reclamation

*Establishment, Survival, and Growth of Vegetation within Two Topsoil Depths in Northeastern AB*

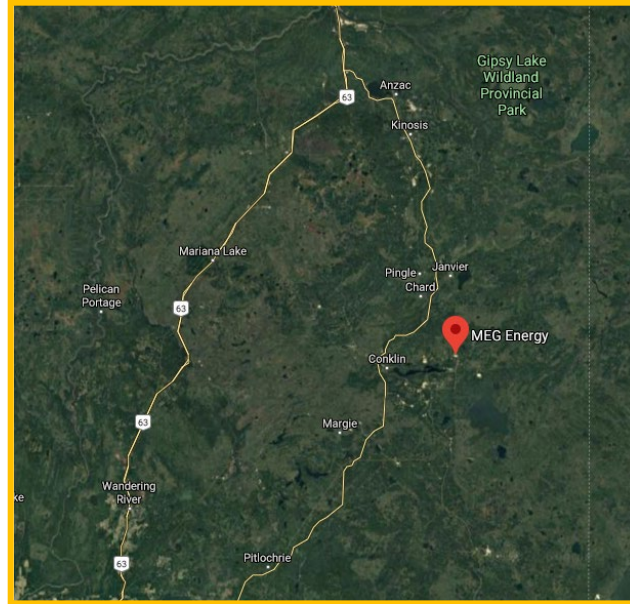
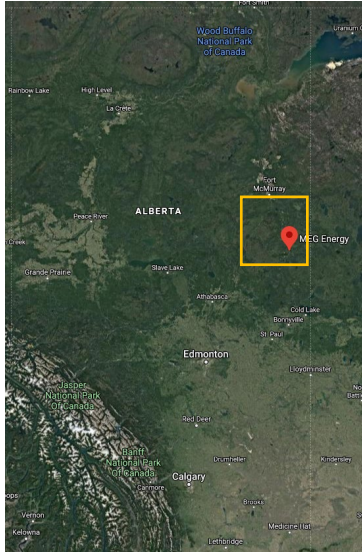
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*Native Plant Researcher, InnoTech Alberta*

# Background

- In 2015, InnoTech retained to design, install, and execute a five-year field trial of borrow pit reclamation at MEG's Christina Lake SAGD facility
- Objective was to provide MEG with context-specific learnings to guide successful reclamation outcomes for riparian areas of reclaimed borrow pits.
  - Also analyzed mounding revegetation technique (Mounding Trial)
  - Tree and shrub planting in 2015, Monitoring in 2016-2017, 2019

# Study Site

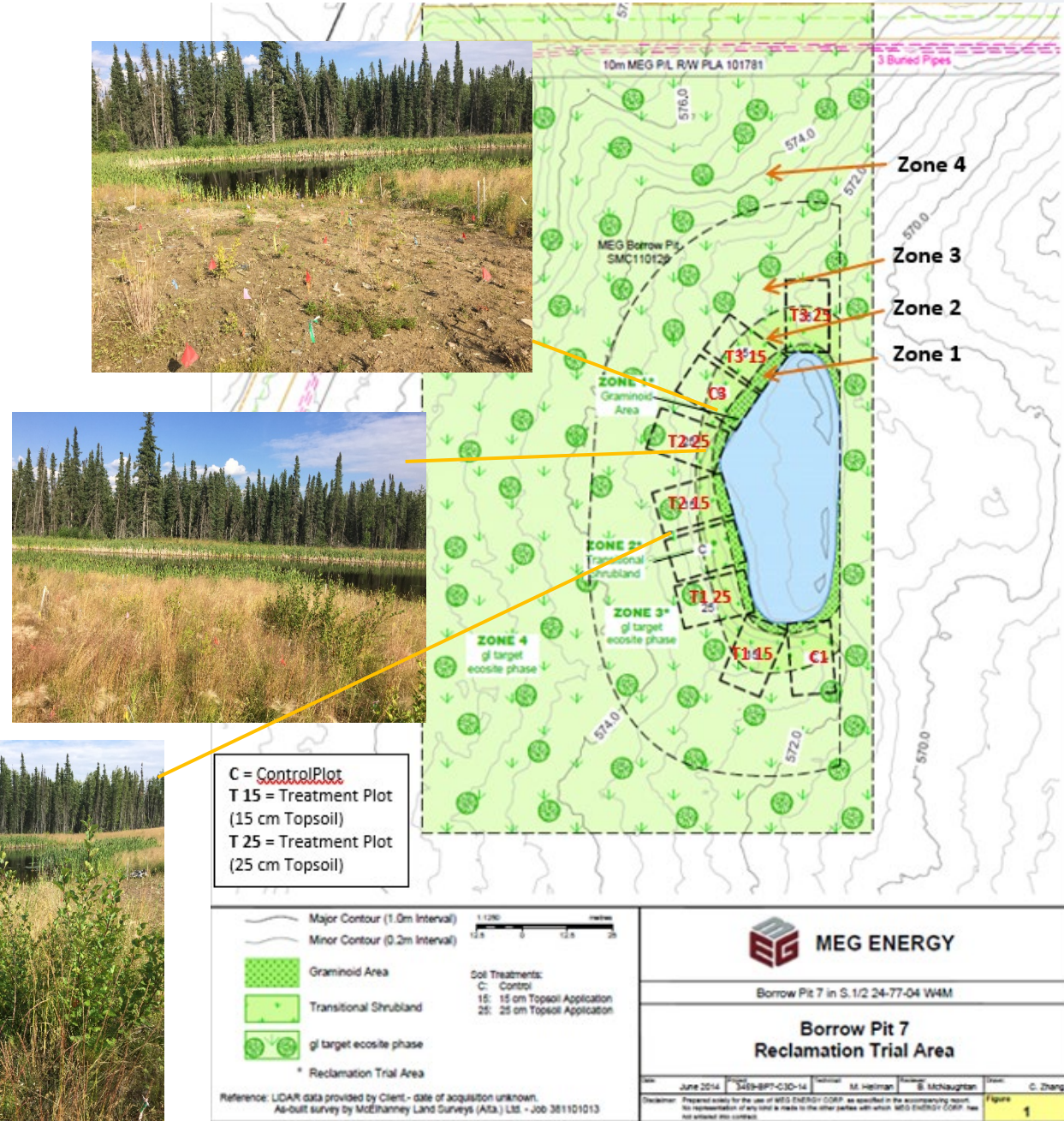


# BP 7 Study Treatments

| Zone | Location  | Site Preparation   | Experimental Treatments  |
|------|---|--|--|
| 1    | Lower boundary of riparian zone, analogous to emergent zone of wetlands     | <ul style="list-style-type: none"> <li>Subsoil de-compacted and recontoured</li> <li>Salvaged subsoil replaced</li> <li>Salvaged topsoil replaced (rough placement) to treatment conditions</li> </ul> | <ol style="list-style-type: none"> <li>15 cm topsoil</li> <li>25 cm topsoil</li> <li>No topsoil (control)</li> </ol> |
| 2    | Upper boundary of riparian zone, analogous to transitional zone of wetlands | <ul style="list-style-type: none"> <li>Revegetation</li> </ul>   |  |
| 3    | Upland community (g1 target ecosite phase)                                  |  |  |
| 4    | Upland community (g1 target ecosite phase)                                  | See above, but topsoil replaced to pre-disturbance depths  | None - topsoil instead replaced to baseline depths   |

12 x 25 m study plots  
15 cm, 25 cm or 0 cm topsoil placed

Jack Pine, Black Spruce, Tamarac, Balsam Poplar planted



# BP7 - Data Collected

- Vegetation community structure
  - 10 m<sup>2</sup> circular plots – tree and shrub cover and growth
    - Six to eight per treatment plot (2-3 per Zone)
    - Height of trees and shrubs (planted and naturally-occurring)
    - Root collar diameter, DBH (if possible)
    - Percent cover for shrubs
    - Growth node spacing (to capture 2017-2019 growth trends)
  - 1 m<sup>2</sup> Daubenmire quadrats – groundcover strata composition
    - Three plots per zone per treatment plot
    - Presence and percent cover (forbs, mosses, lichen, fungi, litter, bare ground)
    - Weed observations

# BP7 – Analogue Site as Reference

- A local analogue site was selected and measured as a means to understand a potential trajectory of reclaimed riparian reclamation
- Former infrastructure borrow pit that had been abandoned approx. 30 years prior
- No topsoil replaced
- Contained open water, narrow riparian zone, same upland forest composition as BP7 site
- Same data collection and analyses as BP7 study plots

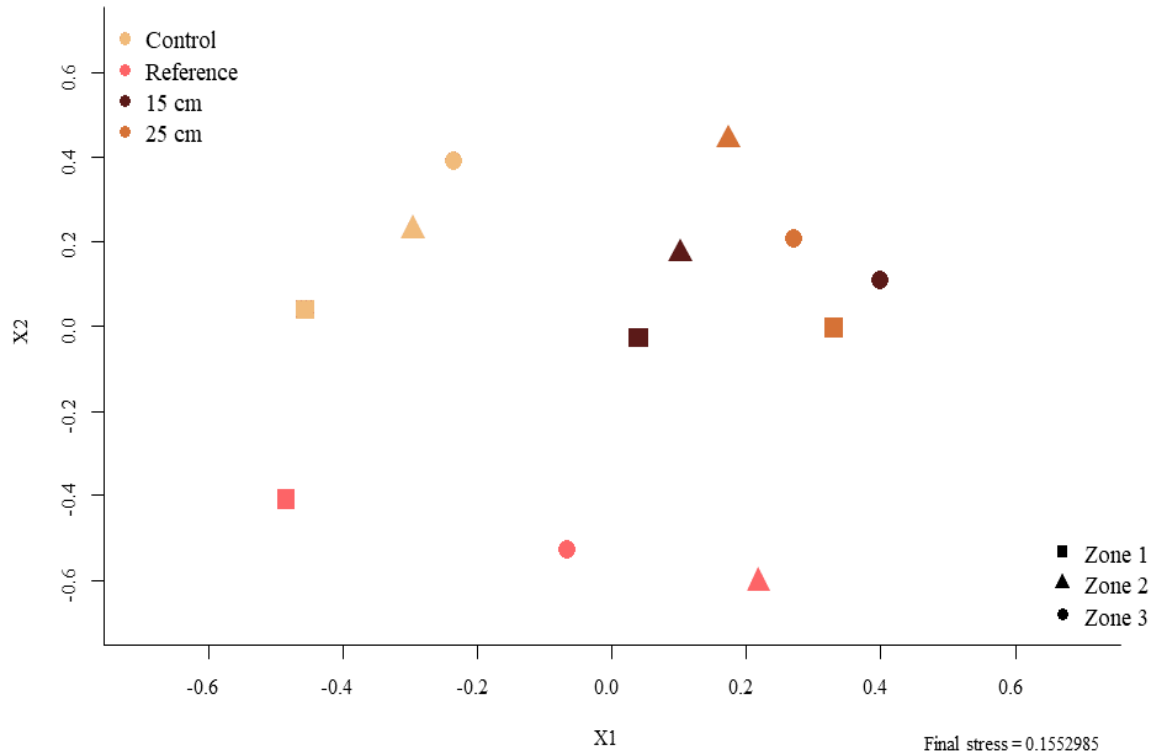


# Results

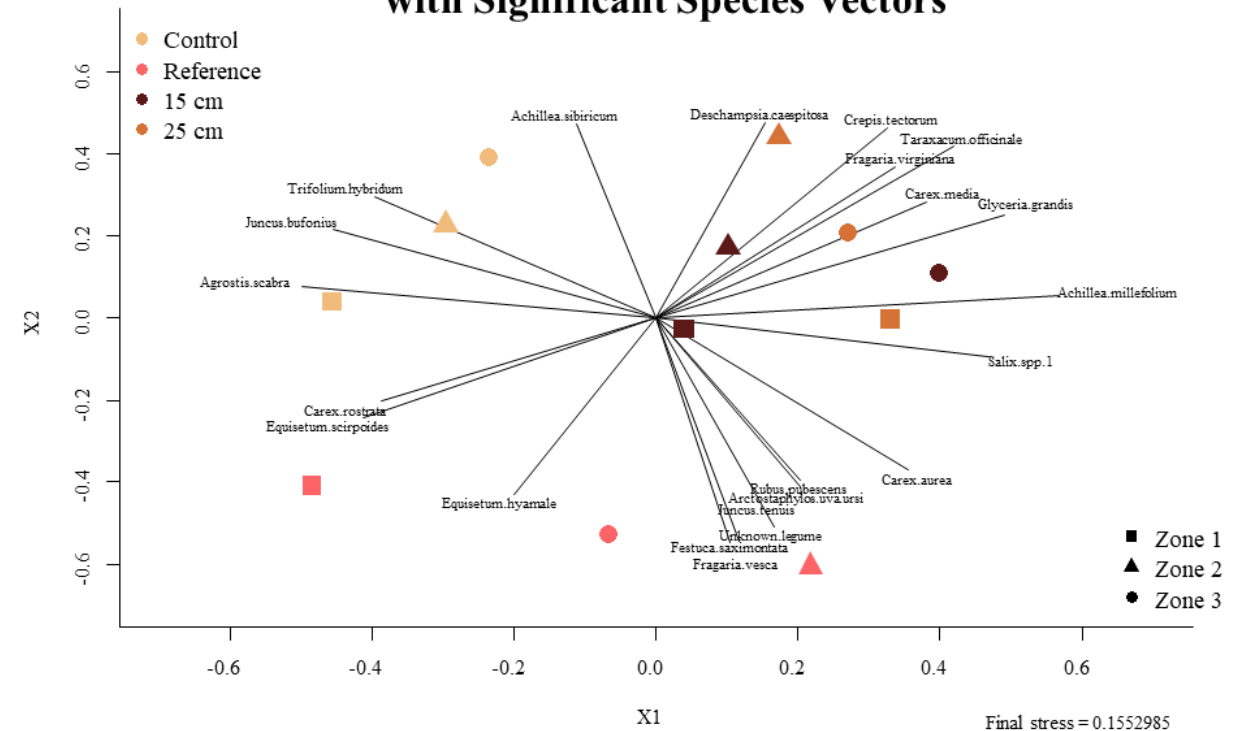
- Vegetation community and cover data used to create nMDS ordinations
- Visualized similarities and differences between communities formed in treatment conditions (15 cm vs 25 cm topsoil) vs. control (no topsoil)
- Used 2017 data to visualize community trajectories between 2017 and 2019
- Permutational ANOVAs, blocked by replicate to compare woody species data in circular plots
  - Treatments (topsoil depths vs. control)

# Results – BP7 Community Structure

2019 Vegetation Community



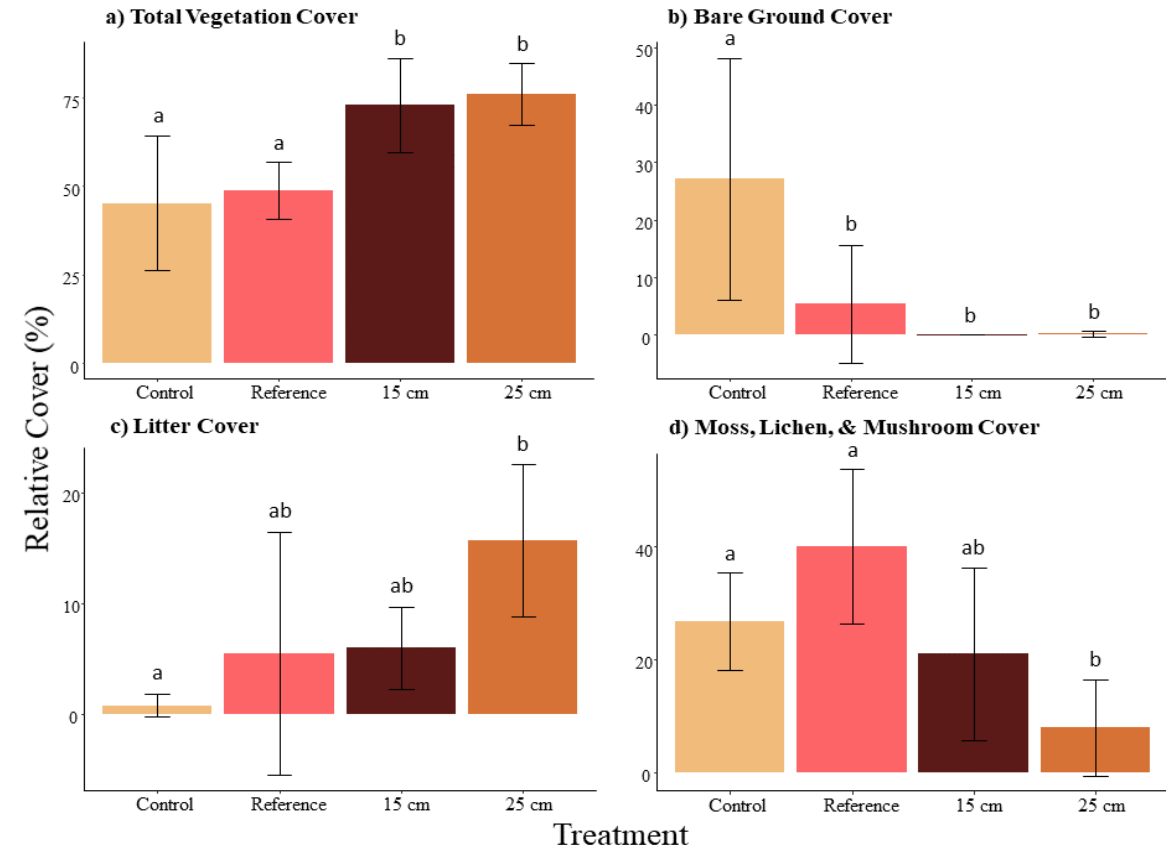
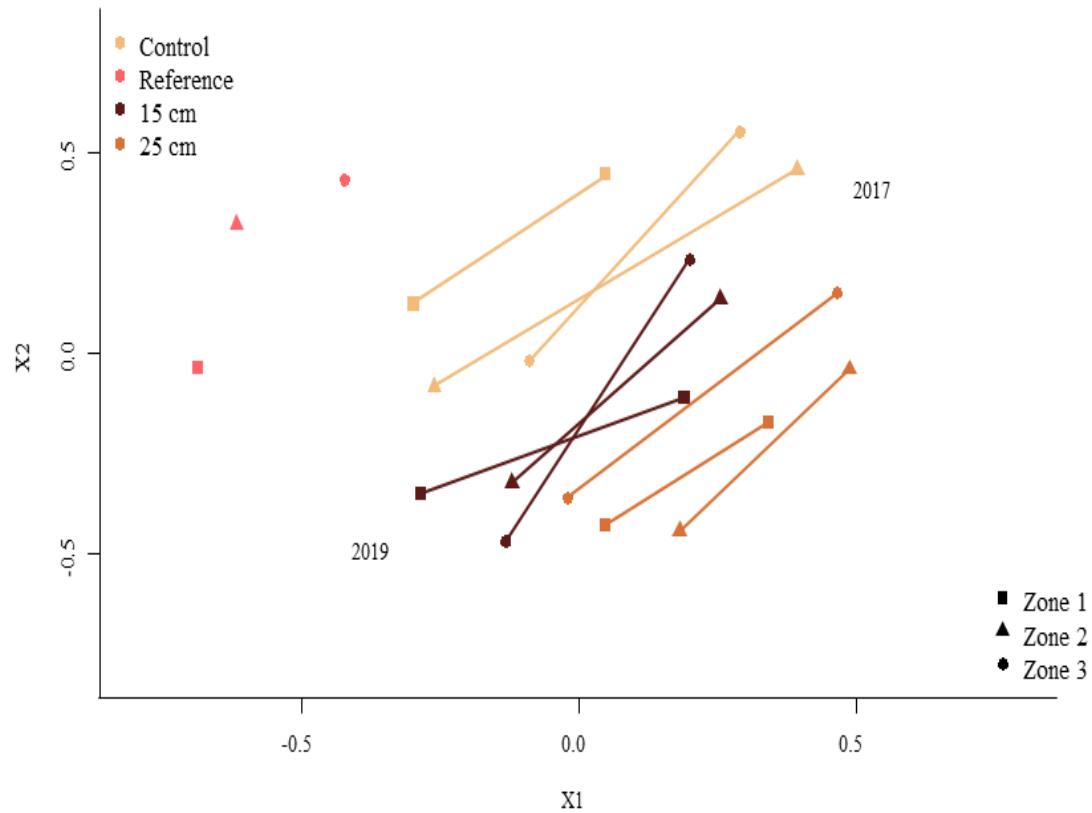
2019 Vegetation Community with Significant Species Vectors





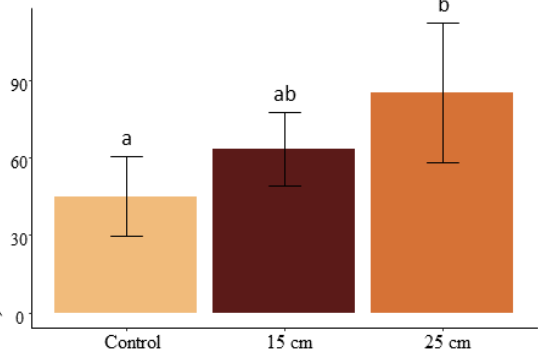
# Results – BP7 Community Structure

Vegetation Community Trajectory (2017-2019)

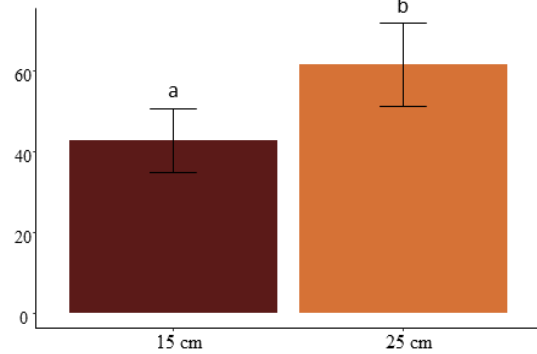


# Results – BP7 Tree Height & RCD

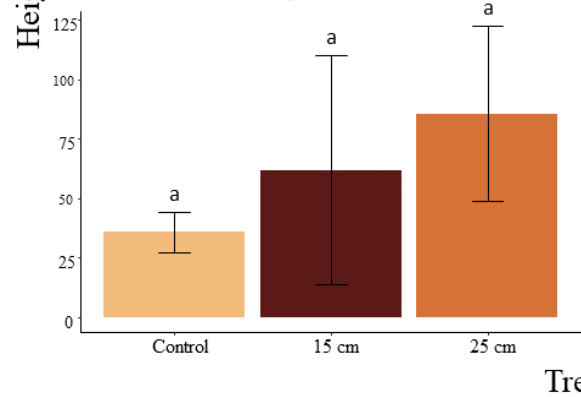
a) Jack Pine Height



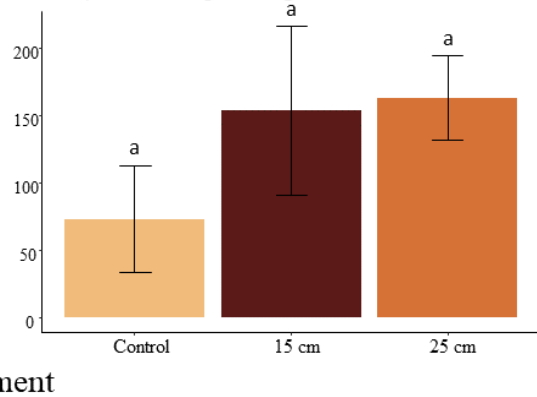
b) Black Spruce Height



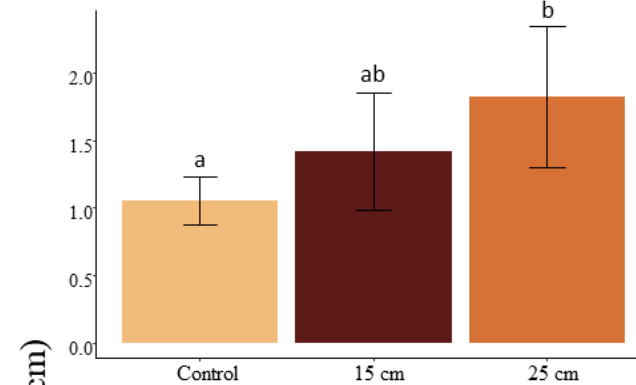
c) Tamarack Height



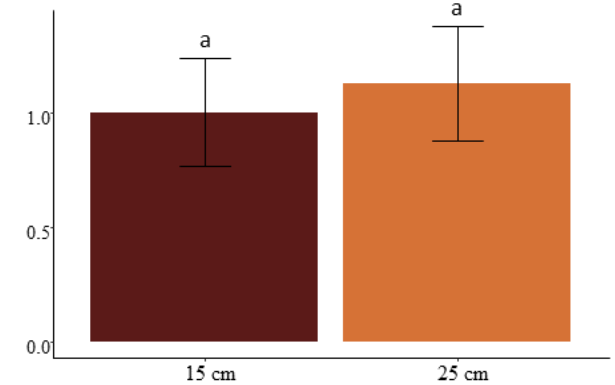
d) Balsam Poplar Height



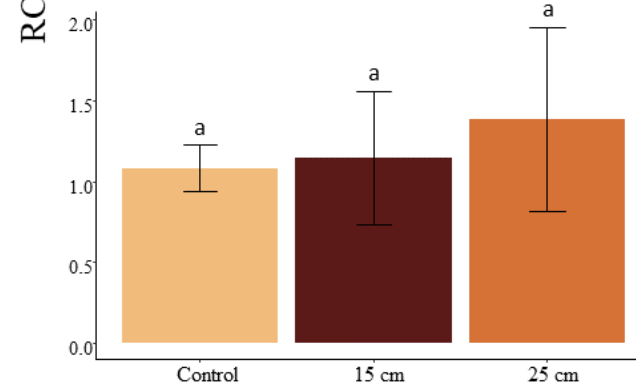
a) Jack Pine Root Collar Diameter



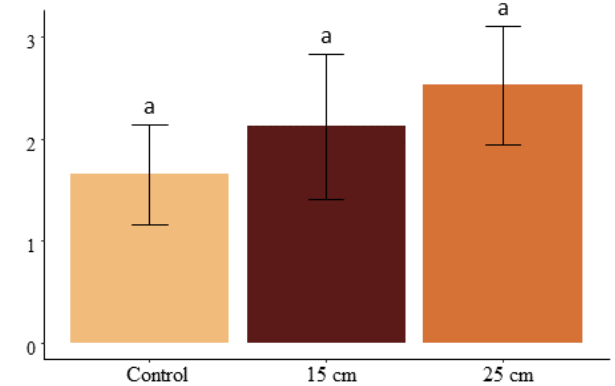
b) Black Spruce Root Collar Diameter



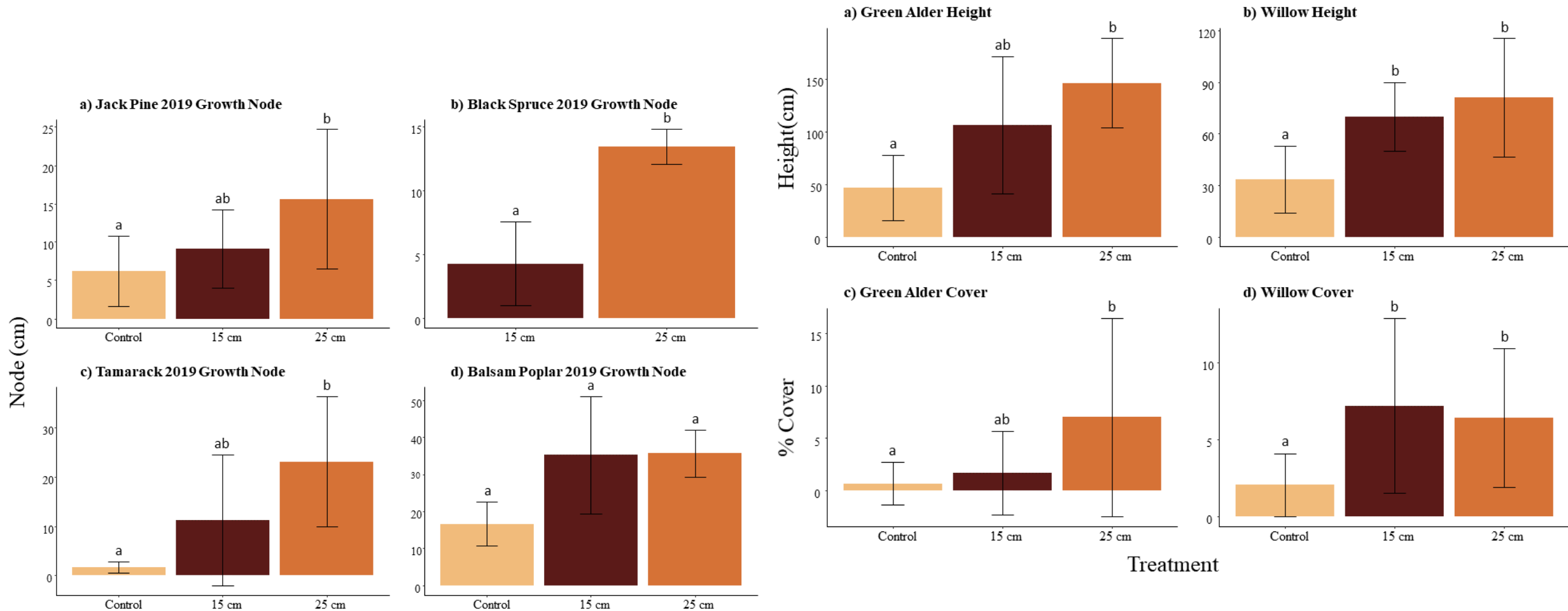
c) Tamarack Root Collar Diameter



d) Balsam Poplar Root Collar Diameter



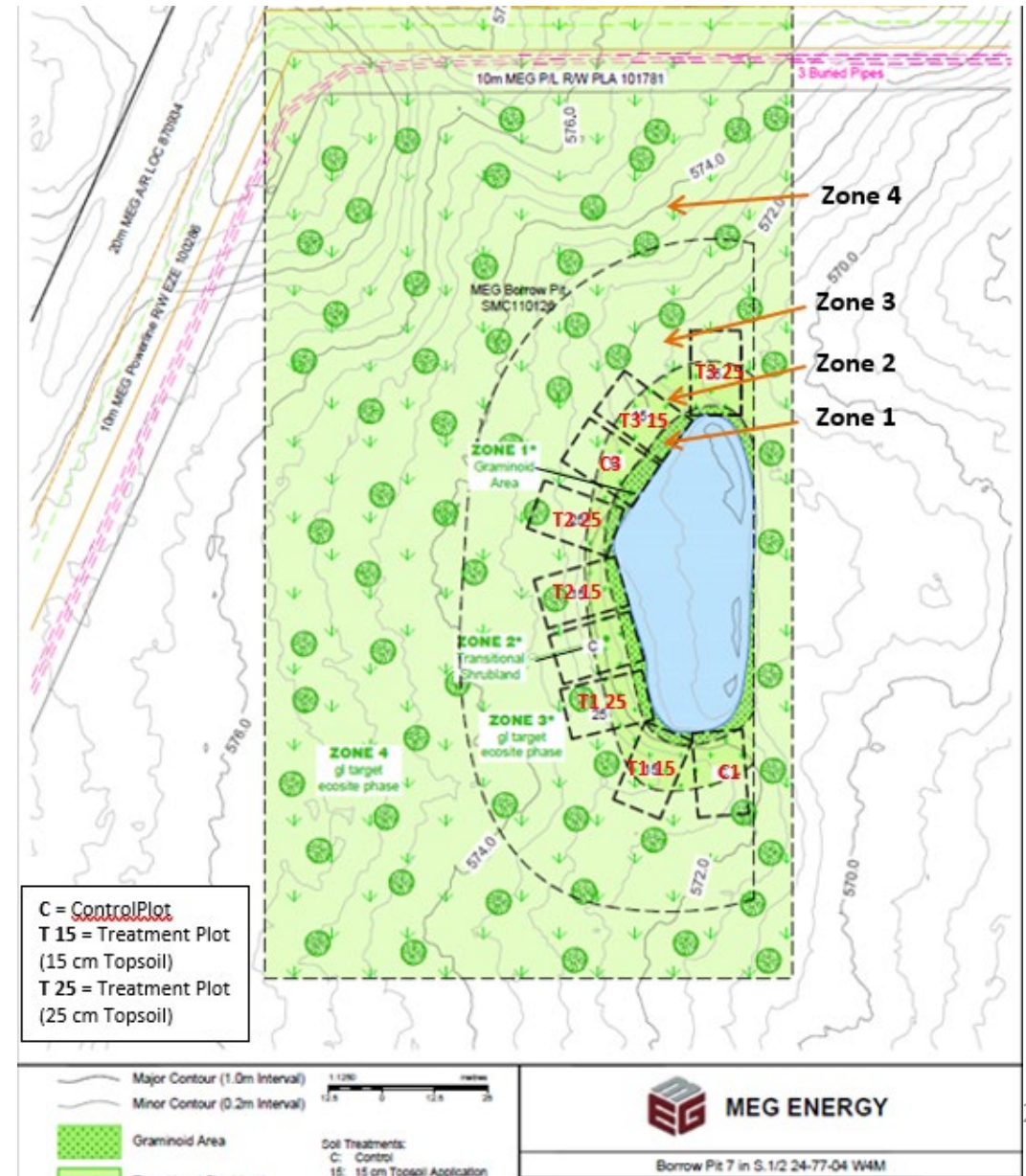
# Results – BP7 Tree and Shrub Growth



Treatment

# BP7 – Quick Results Summary

- Plant communities appeared to cluster by treatment, and not by zone
  - Did not support assumption that theoretical depth to water table that would have the influence over community development.
- The T25 and T15 treatments did not facilitate major differences in litter development
- Treatment type impacted Species Richness ( $p=0.0060$ ), but treatment differences were not strong enough at this point for significant differences to appear
- No significant differences in total vegetation cover, bare ground cover, mean relative cover of all veg strata, species richness, cover of litter, or moss/lichen/mushroom between the T15 and T25 treatments
  - Concluded that 15 cm of topsoil was sufficient for the development of many relevant vegetation growth endpoints in the study area



# But How Do We Best Evaluate Riparian Zones for Certification?

- Which Certification Criteria are most appropriate?

Forested Land?

Peatland?

(Neither?)

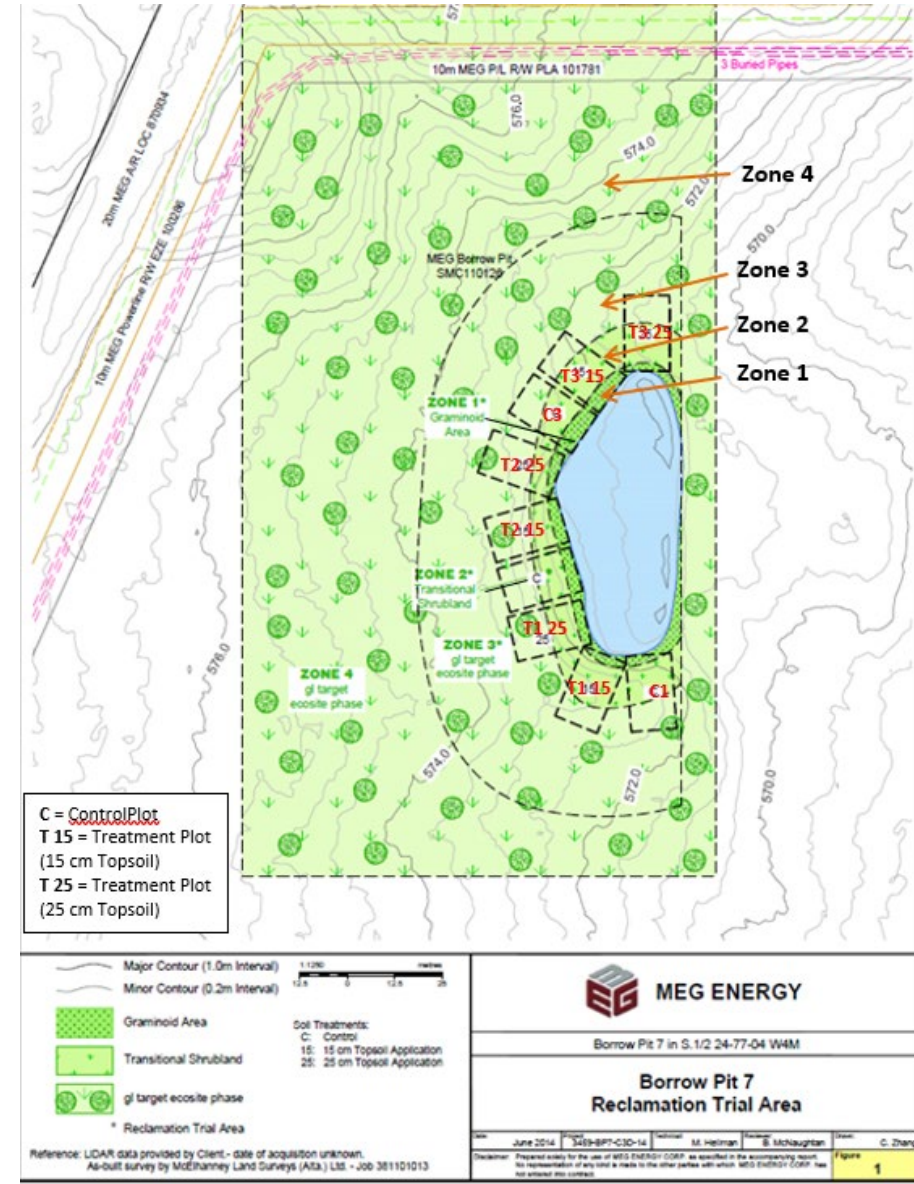
# The Problem with Forested Land Criteria

- Directed to use Forested Criteria if site was upland pre-disturbance
  - Peatland Criteria also directs user toward Forested Criteria for both forested and forested riparian areas
- Forested Criteria may not be most appropriate to communicate and leverage important riparian zone community structure
  - E.g., Zones 2 and 3 in BP7 would be evaluated as Forested Lands, although they are colonized by both upland and riparian species



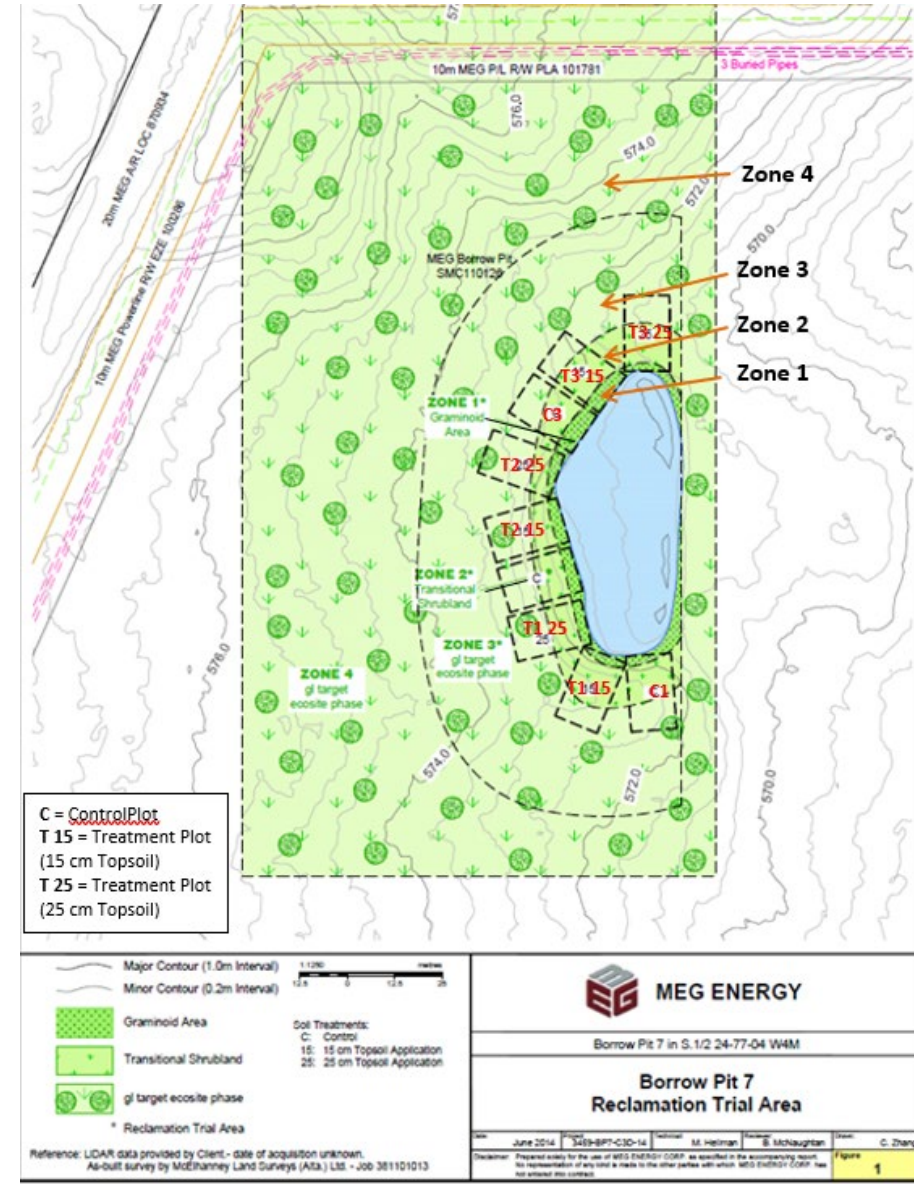
# The Problem with Peatland Criteria

- Open water and upland species are problematic for of Peatland Criteria
  - Open water and upland species not conducive to peat-forming processes
  - Limits to how much open water can be present at site
  - Limits to how much of site can be reclaimed to upland ecosites
    - BUT, riparian areas considered uplands!



# The Problem with Peatland Criteria

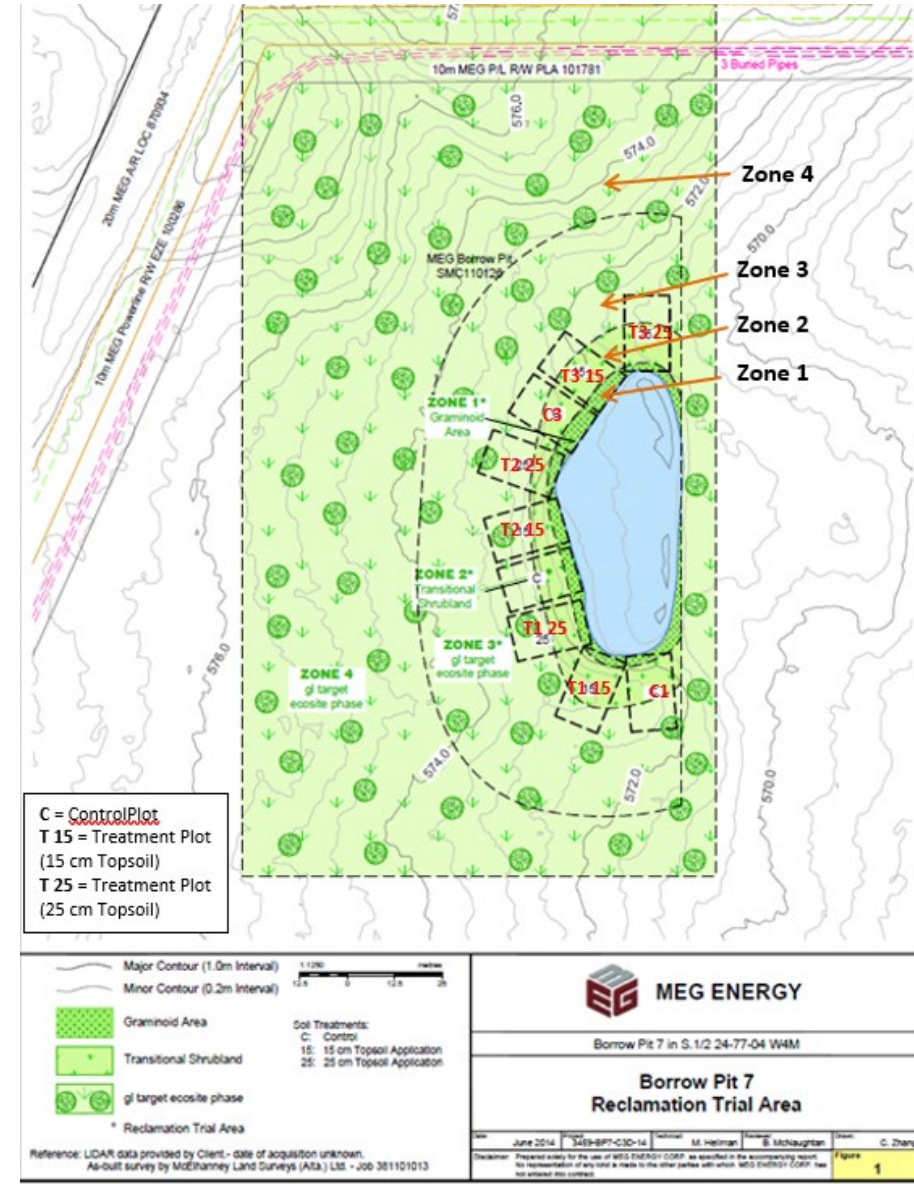
- Open water may only occupy a maximum of 15% of the total study area in the disturbance assessment
  - (max 15 m x 15 m area within each 40 m x 40 m grid space)
- Open water = permanently water-filled areas with no living, peat-forming vegetation
  - Any non-peat forming vegetation (including submerged vegetation)
  - Surrounding emergent vegetation, “marsh” vegetation
- So, ALL of zone 1, and parts of zone 2 would be classified as Open Water
- Zone 1 – OW, Zone 2 – OW/Uplands, Zone 3 –Uplands
  - What happened to our Riparian Zone that we worked so hard on?





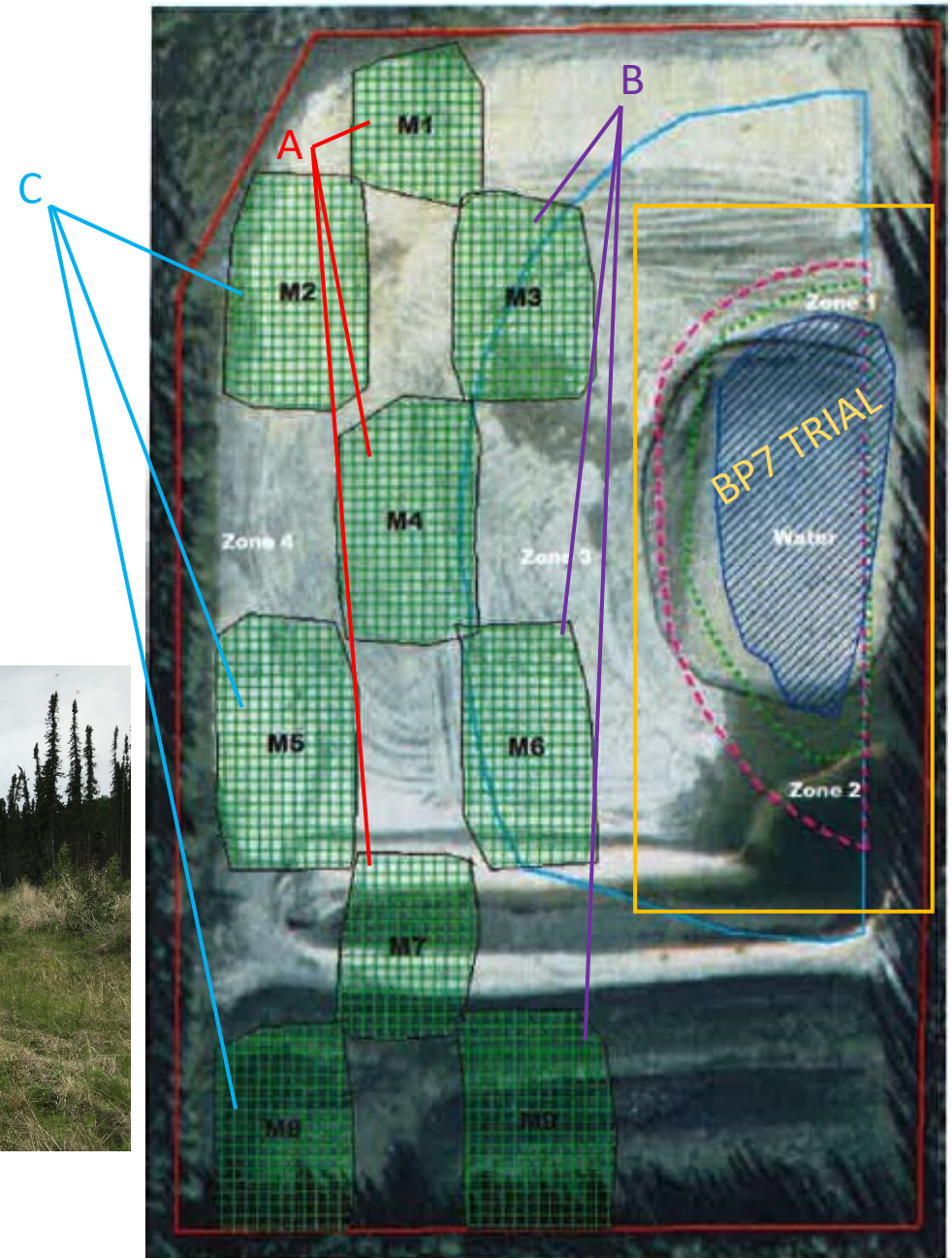
# How to Leverage Riparian Zones?

- Could use published species lists and tools to better ascertain growth and development of riparian species and community
  - Wetland Indicator Statuses (Ob Wet, Fac Wet, Fac, Fac Up, Up)
    - Level of granularity that is particularly helpful for riparian zones
  - Floristic Quality Assessment (Coefficients of Conservatism)
    - Lower scoring species have higher tolerance to disturbance
    - Higher scoring species tend to occupy undisturbed, remnant habitats
    - Could be helpful to understand if reclamation has been successful in developing stable communities that are supported by inherent redundancies
- BP7 results showed that preliminary zonal delineation was not successful at predicting dynamic plant community boundaries
  - Assessments should be able to capture the dynamism of riparian communities to better delineate them

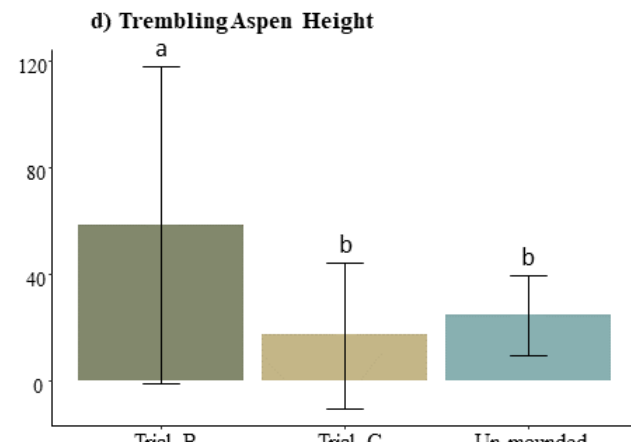
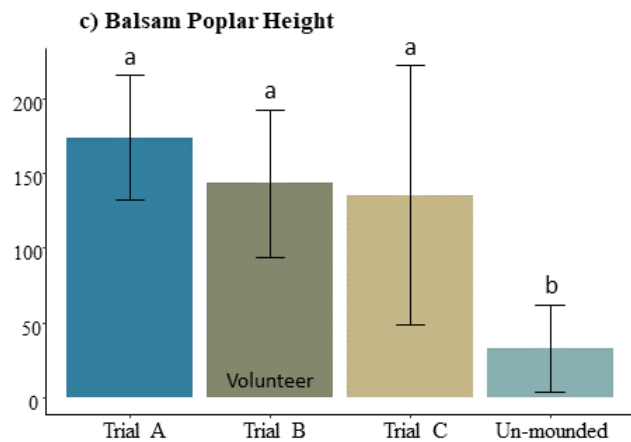
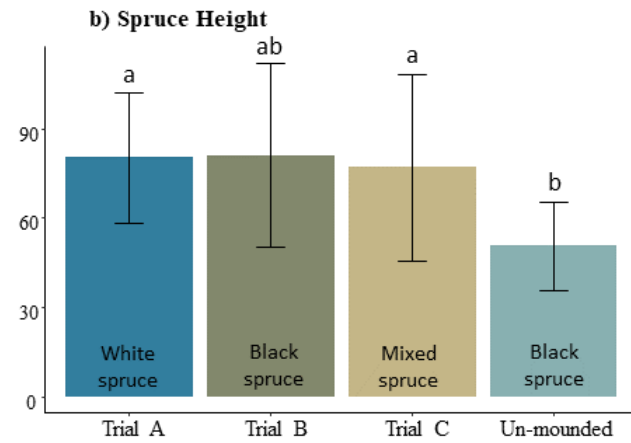
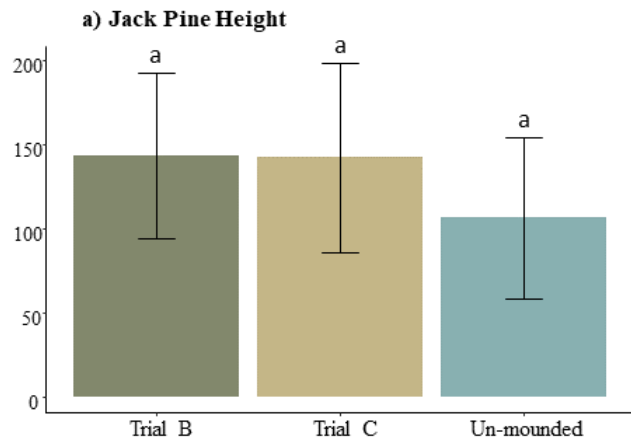
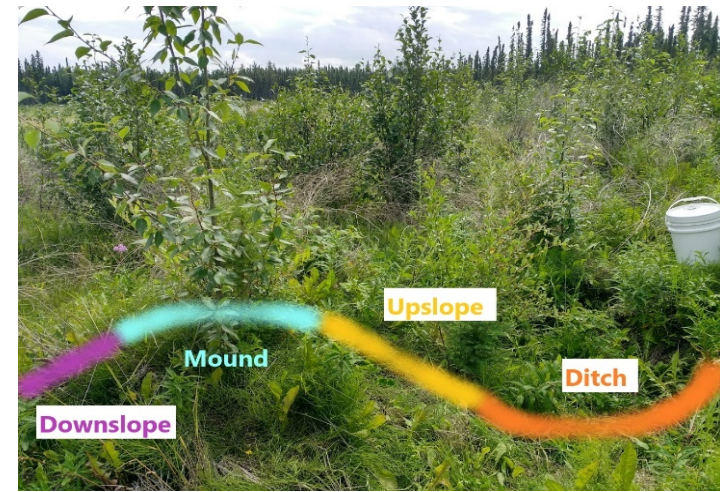


# Mounding Trial

| Trial | Area IDs   | Species   | Area (ha) | # of Mounds | Qty. Seedlings |
|-------|------------|---|-----------|-------------|----------------|
| A     | M1, M4, M7 | <i>Populus balsamifera</i> ,<br><i>Picea glauca</i> , <i>Salix spp.</i> ,<br><i>Betula glandulosa</i> | 0.2169    | 151         | 1812           |
| B     | M3, M6, M9 | <i>Pinus banksiana</i> , <i>Picea mariana</i> , <i>Salix spp.</i> ,<br><i>Betula glandulosa</i>       | 0.2632    | 177         | 2124           |
| C     | M2, M5, M8 | <i>Populus balsamifera</i> ,<br><i>Picea glauca</i> , <i>Pinus banksiana</i> , <i>Picea mariana</i>   | 0.271     | 201         | 2412           |
|       |            | Total   | 0.7511    | 529         | 6348           |



# Mounding Trial - Tree Heights



| Position   | Jack Pine        | Spruce | Balsam Poplar | Trembling Aspen |
|------------|------------------|--------|---------------|-----------------|
|            | Mean Height (cm) |        |               |                 |
| Ditch      | 56*              | N/A    | 32.7          | 34.0            |
| Upslope    | 136.4            | 62.8   | 148.4         | 23.1            |
| Mound      | 152.3            | 89.5   | 173.6         | 147.5           |
| Downslope  | N/A              | N/A    | N/A           | 57.7            |
| Un-mounded | 106.4            | 50.5   | 32.6          | 24.4            |

| Comparison               | Holm-adjusted p-value |                                 |                                 |                             |
|--------------------------|-----------------------|---------------------------------|---------------------------------|-----------------------------|
|                          | Jack Pine             | Spruce                          | Balsam Poplar                   | Trembling Aspen             |
| Ditch to up slope        | 1                     | N/A                             | <b>0.0005</b>                   | 1                           |
| Ditch to mound           | 1                     | N/A                             | <b>1.23*10<sup>-5</sup></b>     | <b>0.0124</b>               |
| Ditch to down slope      | N/A                   | N/A                             | N/A                             | 1                           |
| Ditch to un-mounded      | 1                     | N/A                             | 1                               | 1                           |
| Up slope to mound        | 1                     | <b>0.0014</b>                   | 0.5646                          | <b>1.80*10<sup>-5</sup></b> |
| Up slope to down slope   | N/A                   | N/A                             | N/A                             | 1                           |
| Up slope to un-mounded   | 1                     | 0.2020                          | <b>&lt;2.2*10<sup>-16</sup></b> | 1                           |
| Mound to down slope      | N/A                   | N/A                             | N/A                             | 0.0556                      |
| Mound to un-mounded      | 0.2900                | <b>8.64*10<sup>-7</sup></b>     | <b>&lt;2.2*10<sup>-16</sup></b> | <b>1.80*10<sup>-5</sup></b> |
| Down slope to un-mounded | N/A                   | N/A                             | N/A                             | 1                           |
| Overall Test p-value     | <b>0.0036</b>         | <b>&lt;2.2*10<sup>-16</sup></b> | <b>&lt;2.2*10<sup>-16</sup></b> | <b>0.0152</b>               |

Treatment



Questions?

Thank you to

