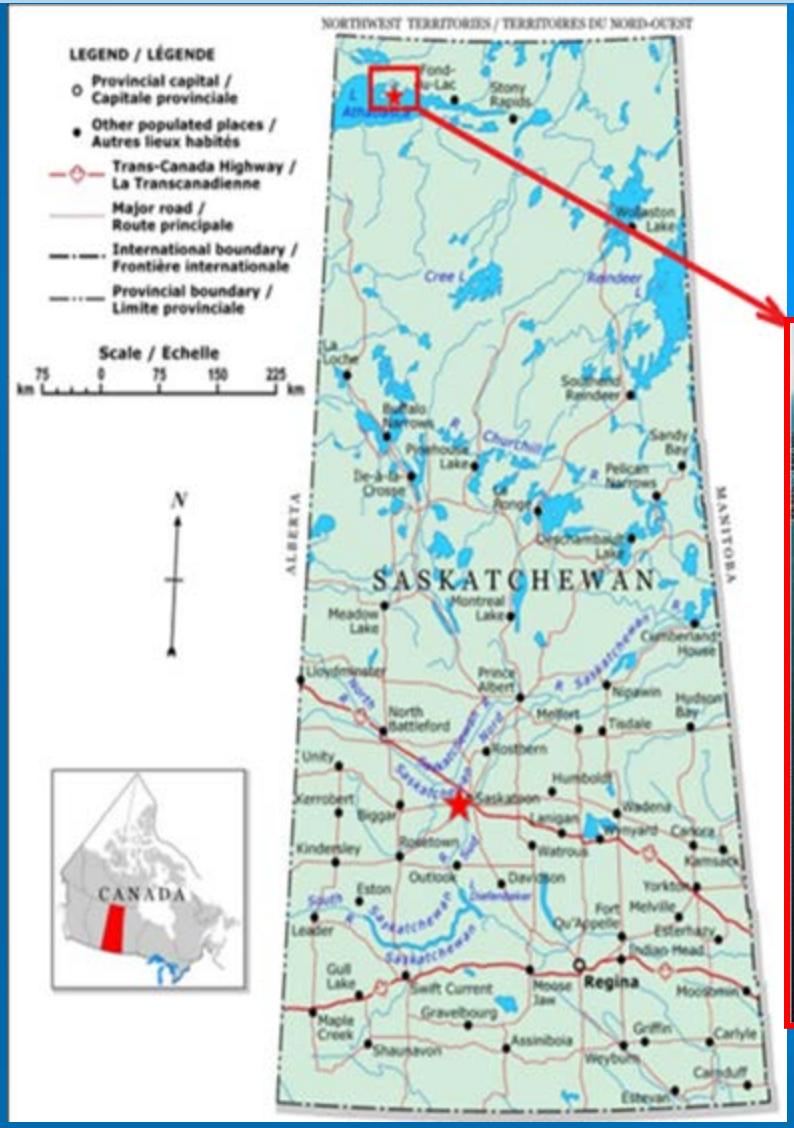
BIOCHAR APPLICATION FOR REVEGETATION PURPOSES IN NORTHERN SASKATCHEWAN

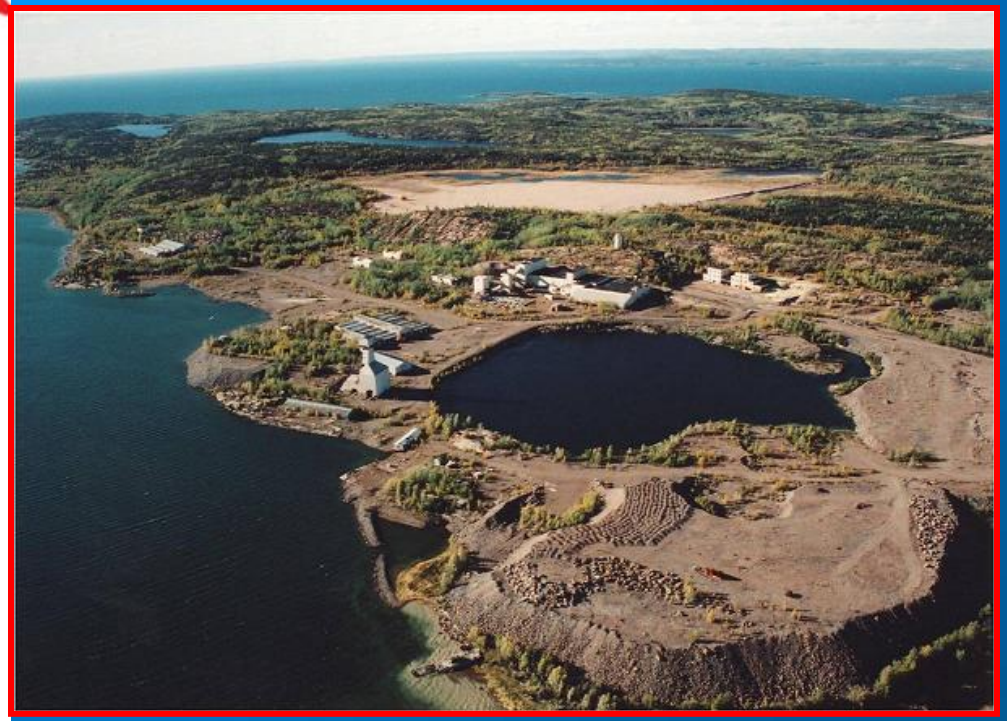
Skye Ketilson, M.Sc
Elizaveta Petelina, M.Sc, MSEM
Alexey Klyashtorin, Ph.D
Tamara Yankovich, Ph.D

Remediation Technologies Symposium 2014, Oct 15-17, 2014

Gunnar Uranium Mine Site



- ✓ uranium mines and mills
- ✓ established in 1953
- ✓ ceased in 1964



Gunnar Site Remediation Project

- SRC has been contracted by the Saskatchewan government to manage decommission and rehabilitation activities at the site
- 82 ha of unconfined tailings in 3 locations
- to be capped by ~1 m engineered cover
- native plant communities are to be established on the cover

Gunnar Revegetation Research

- Greenhouse & Field trials
- Soil source:
  - Borrow Material proposed for the tailing cover (mainly sand-gravel, poor in organic matter and nutrients)
- Organic amendments:
  - Peat and Biochar
- Nutrient Source:
  - Mineral Fertilizer NPK(S)
- Native plant species

Greenhouse trials

- Sphagnum peat
- Willow dust biochar (slow pyrolysis)
- Organic Matter - 2%
  - Peat - 80 t/ha
  - Biochar - 95 t/ha
- Mineral Fertilizer
  - 45 N kg/ha
  - 84 P_2O_5 kg /ha
  - 112 K_2O kg/ha
- 4 treatments
- 2 L pots

Greenhouse trials

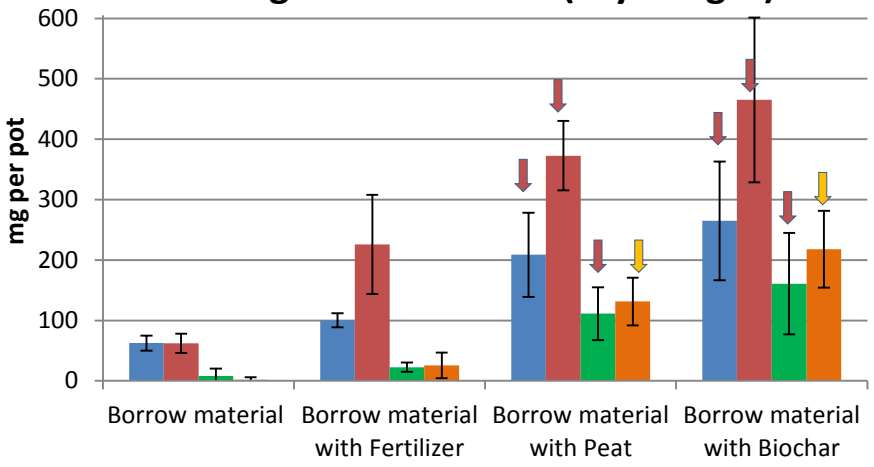
- Native plants
  - Slender Wheatgrass (*Elymus trachycaulus*) – 6 PLS per pot
  - Rocky Mountain Fescue (*Festuca saximontana*) – 22 PLS per pot
  - American Vetch (*Vicia americana*) – 4 PLS per pot
  - Common Yarrow (*Achillea millefolium*) – 11 PLS per pot
- 16 plant-soil combinations

  x 5 replicates
- 12 weeks simulating typical summer conditions at Gunnar
  - Light
  - Temperature
  - Precipitation
- Collected data
  - number of seedlings (weekly)
  - aboveground dry biomass (at the end of the experiment)

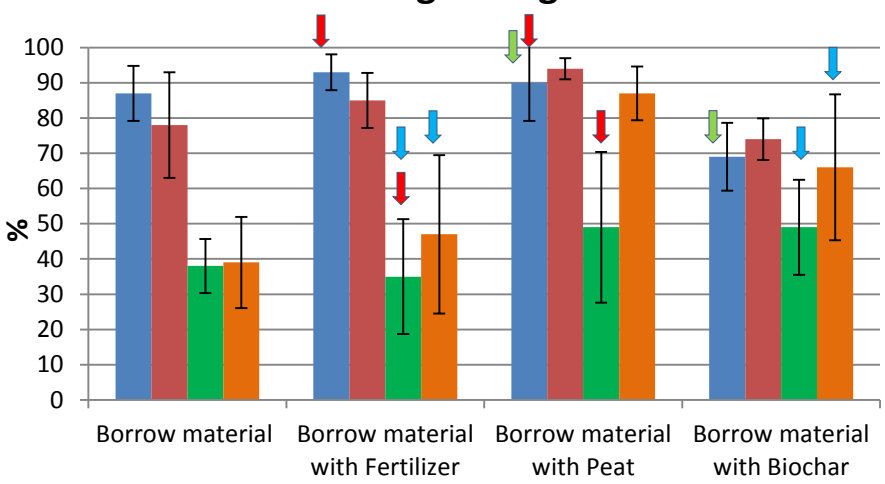
Greenhouse trials

Slender wheatgrass | Rocky mountain fescue | American vetch | Common yarrow

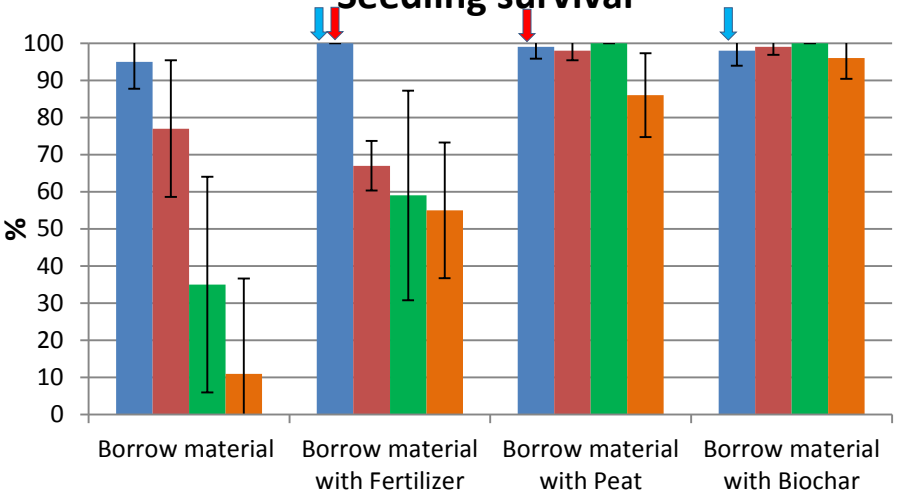
Aboveground biomass (dry weight)



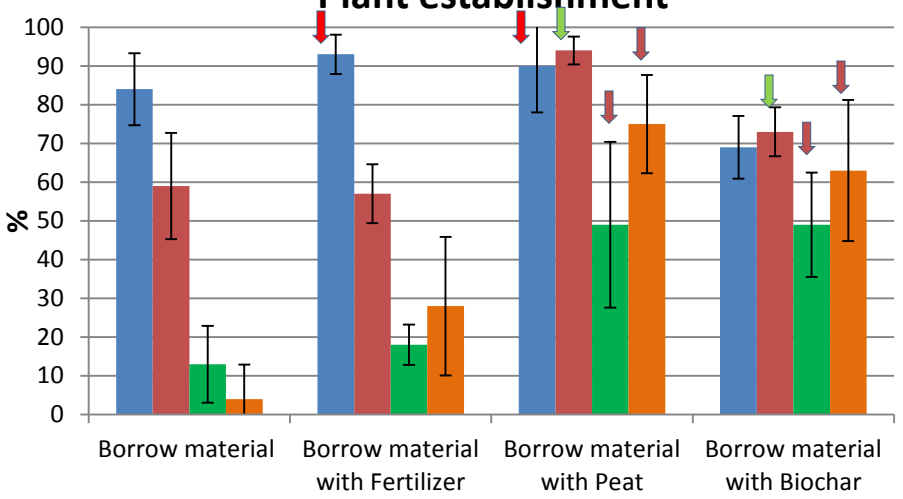
Seedling emergence



Seedling survival



Plant establishment



Peat = Mineral Fertilizer | Peat = Biochar | Biochar > Peat

Biochar = Mineral Fertilizer | Peat > Biochar | Error bar – Standard Deviation

Greenhouse trials

- peat and biochar both boost plant establishment and growth, but plant response can differ depending on a species

- biochar can be a good substitute for peat as a soil amendment

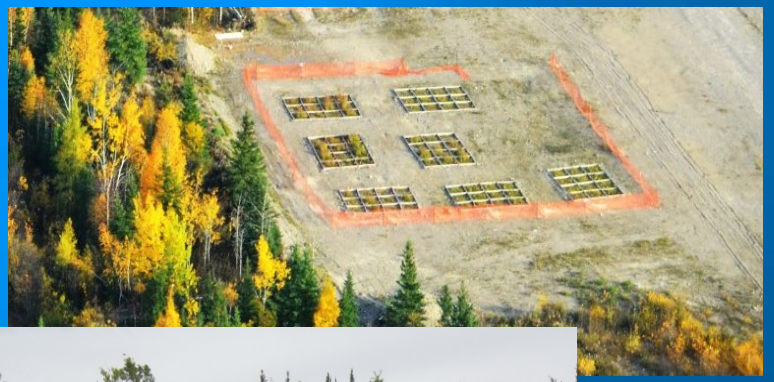
Field trials

- Sphagnum peat
- Pine chunky biochar (slow pyrolysis)
- Organic matter - 2, 4, 6 %

  Peat - 80,160, and 240 t/ha

  Biochar - 90, 190, and 280 t/ha
- 1 m^2 plots

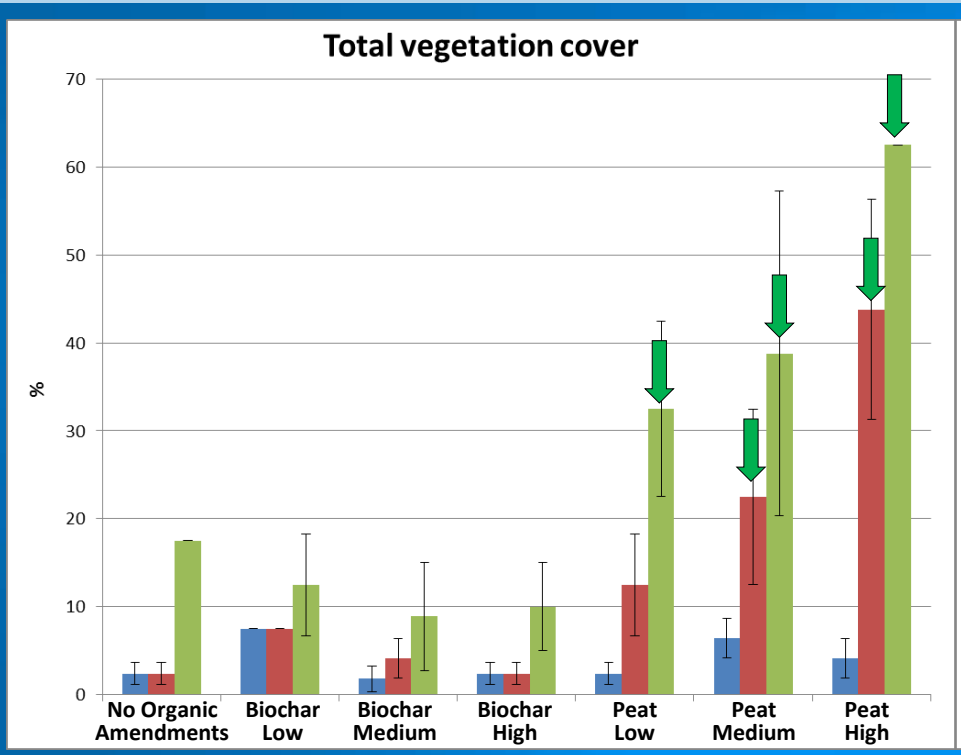
  7 Wooden Boxes (each with 12 cells)
- Mineral Fertilizer
  - Low rate
    - 22 N kg/ha
    - 56 P_2O_5 kg /ha
    - 56 K_2O kg/ha
    - 10 S kg/ha
  - High rate
    - 45 N kg/ha
    - 84 P_2O_5 kg /ha
    - 112 K_2O kg/ha
    - 20 S kg/ha
- 21 combinations x 4 replicates

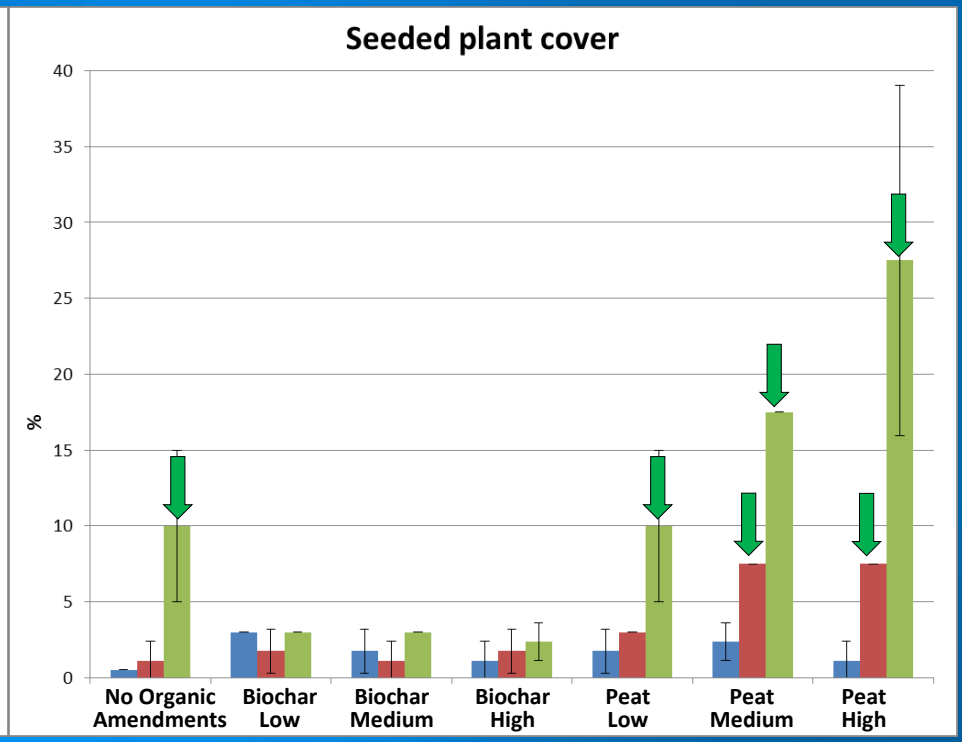


Field trials

- Native plant seed mix
  - 20% Rocky Mountain Fescue (*Festuca saximontana*)
  - 20% American Vetch (*Vicia americana)*
  - 10% Streambank Wheatgrass (*Elymus lanceolatus* ssp. *riparius*)
  - 10% Slender Wheatgrass (*Elymus trachycaulus*)
  - 10% Violet Wheatgrass (*Elymus violaceus*)
  - 7% Tufted Hairgrass (*Deschampsia caespitosa*)
  - 7% Rough Hair Grass (*Agrostis scabra*)
  - 6% Canada Buffaloberry (*Shepherdia canadensis*)
  - 4% Canadian Milkvetch (*Astragalus canadensis*)
  - 3% Marsh Reed Grass (*Calamagrostis canadensis*)
  - 1% White Bluegrass (*Poa glauca*)
  - 1% Alpine Milkvetch (*Astragalus alpinus*)
  - 1% Prairie Crocus (*Anemone patens*)
  - 0.1% Fireweed (*Chamerion angustifolium*)
- 2000 PLS/m^2 seeded in June 2012
- Vegetation survey in August 2012
  - total vegetation cover
  - seeded plant cover
  - cover of dominant invaders
    - rough cinquefoil (*Potentilla norvegica*)
    - strawberry blite (*Chenopodium capitatum*)
- Independent expertise

Field trials



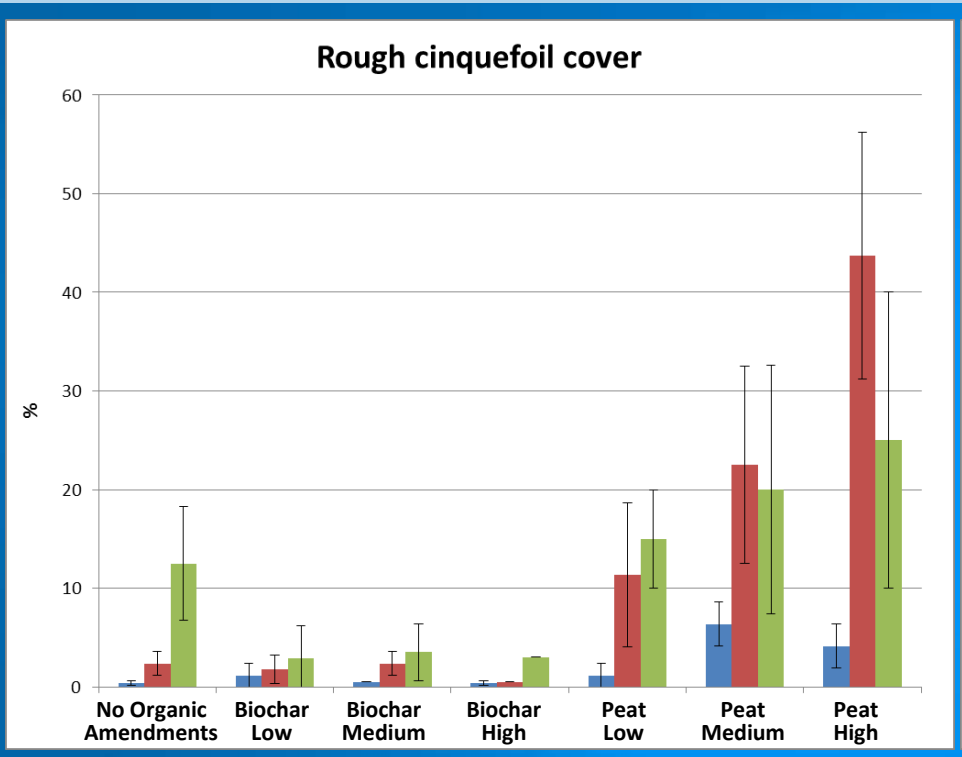


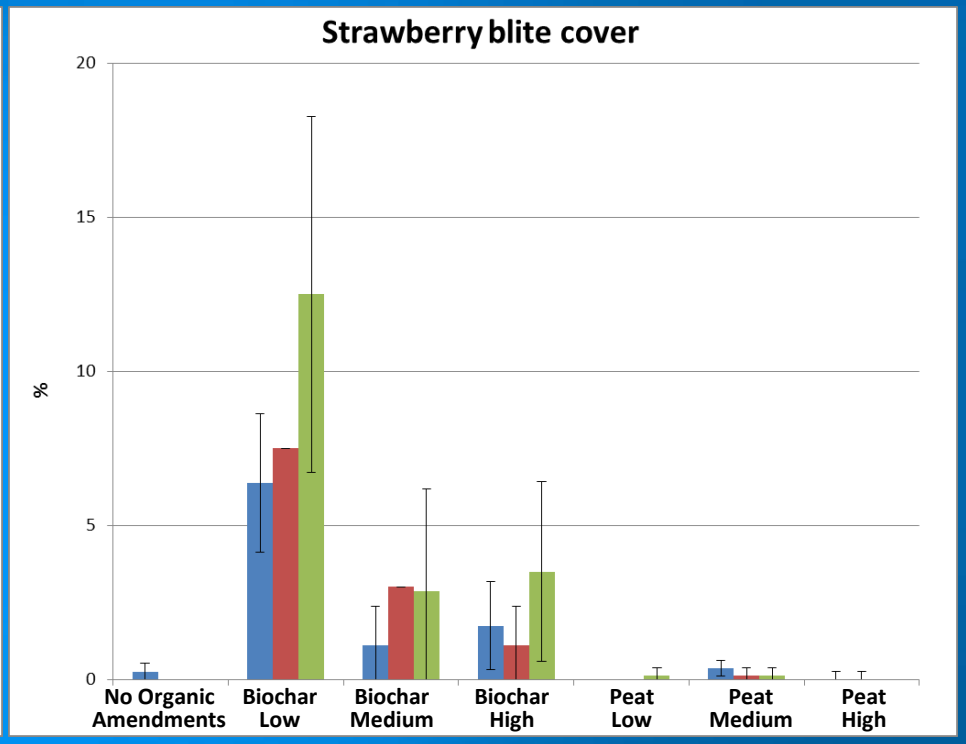
No Fertilizer Fertilizer low rate Fertilizer high rate

Highest indexes
(no statistically significant difference between the treatments)

- Fertilizer alone at the high rate >> Peat/Biochar alone
- Peat/Fertilizer >> Biochar/Fertilizer
- Increased biochar rate decreases the total vegetation cover

Field trials





- Peat promoted rough cinquefoil cover
- Biochar promoted strawberry blite cover

Independent expertise

- Northern leopard frogs (*Lithobates pipiens*)
  - SARA Status: Special Concern
  - SK CDC Rank: S3 (rare to uncommon in Saskatchewan)
- Inhabited peat plots

Greenhouse vs. Field trials

- Greenhouse trials:
  - peat and biochar effects depend on plant species
  - biochar is a good substitute for peat as a soil amendment
- Field trials:
  - peat and biochar effects depend on plant species
  - peat promotes plant establishment and growth to a larger extent than biochar
- Controversial results:
  - May be due to biochar variability, i.e. its water holding capacity

GH Trials	WHC	Field Trials	WHC
Sphagnum peat	509%	Sphagnum peat	523%
Willow Biochar	454%	Pine Biochar	68%

Conclusion

Peat appears to be a more suitable and reliable organic amendment for revegetation projects

Next Step

But

➥Use of biochar may provide a more sustainable approach to land reclamation

So

➥sustainability appraisal has been completed

SASKATCHEWAN RESEARCH COUNCIL

Paper "*Biochar Application for Revegetation Purposes in Northern Saskatchewan*" (*Petelina et al., 2013)* is available in proceedings of the 2013 Northern Latitudes Mining Reclamation Workshop

Back up slide: Field plot set-up

Borrow material screening

Preparation of the soil mixture from borrow material and biochar

Back up slide: Field plot set-up

1m² frame installation

Raking the soil

Fertilizer application

Back up slide: Field plot set-up

Seeding

Soil compaction

Plot mark-up