Exploiting the benefits of plant-microbe interactions for remediation, revegetation and land reclamation

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National Research Council Canada
Conseil national de recherches Canada
Canada

Mining in Canada

- Canada is a global leader mining
- contribution of $35.6B to GDP in 2011
- represents 22.5% of Canadian exports
- major employer in Canada: 320,000 jobs in 2011, more than 6,000 in R&D
- continued exploration spending of up to 18% in 2012
- legacy of contaminated sites, many orphan sites

Plant-Microbe Tripartite Associations
plant – fungi - bacteria

- chemical signaling (beneficial and harmful)
- exchange of nutrients (e.g. nitrogen, phosphorus)
- water capturing capability
- plant growth promoting activity
- plant stress reduction
- plant disease suppression or enhancement
- increased plant growth ranges
- increased plant biomass

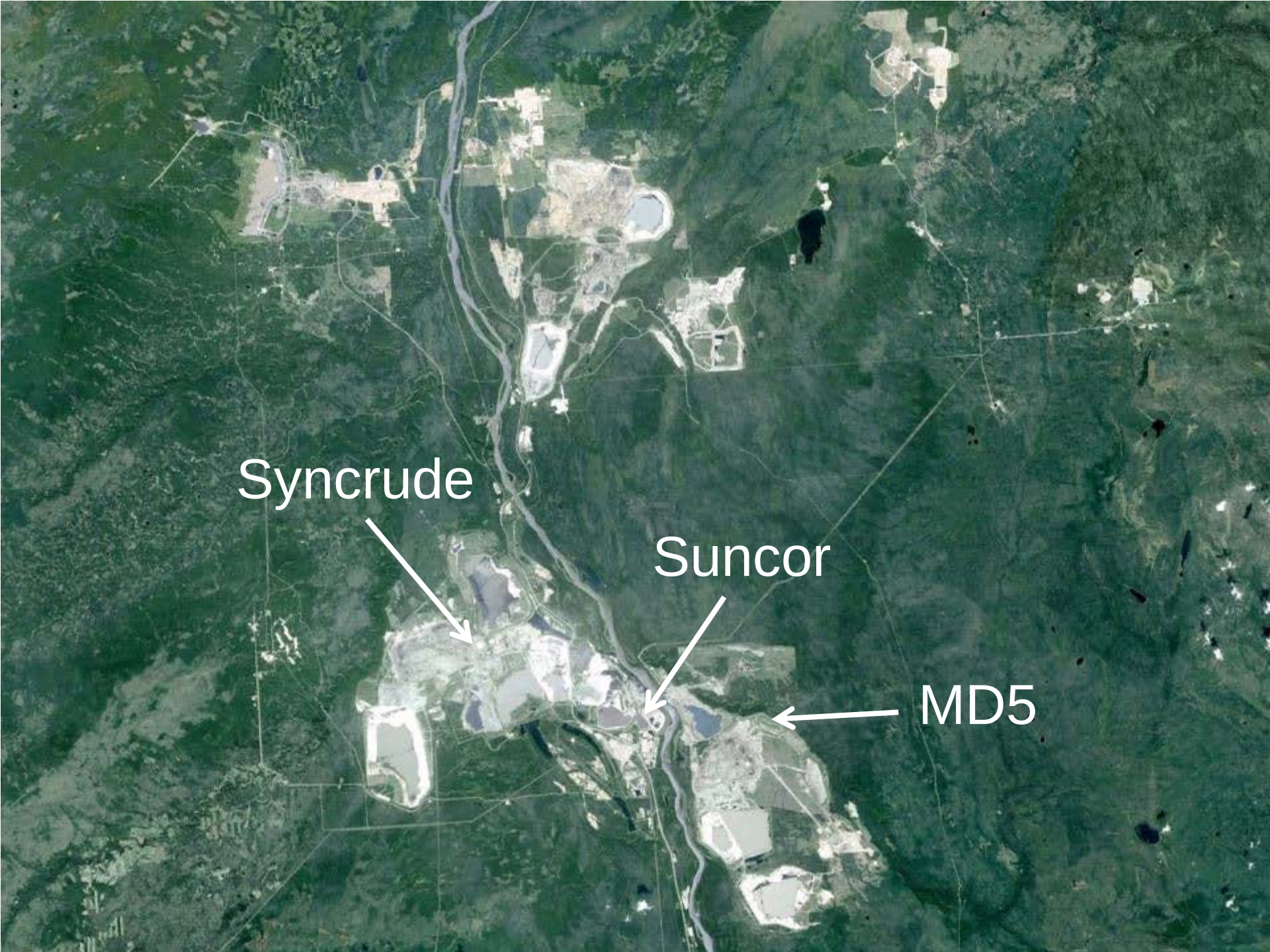
Objectives

- Evaluation of field performance of greenhouse inoculated plants on an oil sands site

- Evaluate performance of inoculated alders for reclamation and revegetation of waste rock on a mining site

- Use ‘omics’ technologies to explore the tripartite association between plants, fungi and bacteria on mining and hydrocarbon contaminated sites

Evaluation of field performance of greenhouse inoculated plants on an oil sands site


Syncrude
Suncor
MD5

Alders

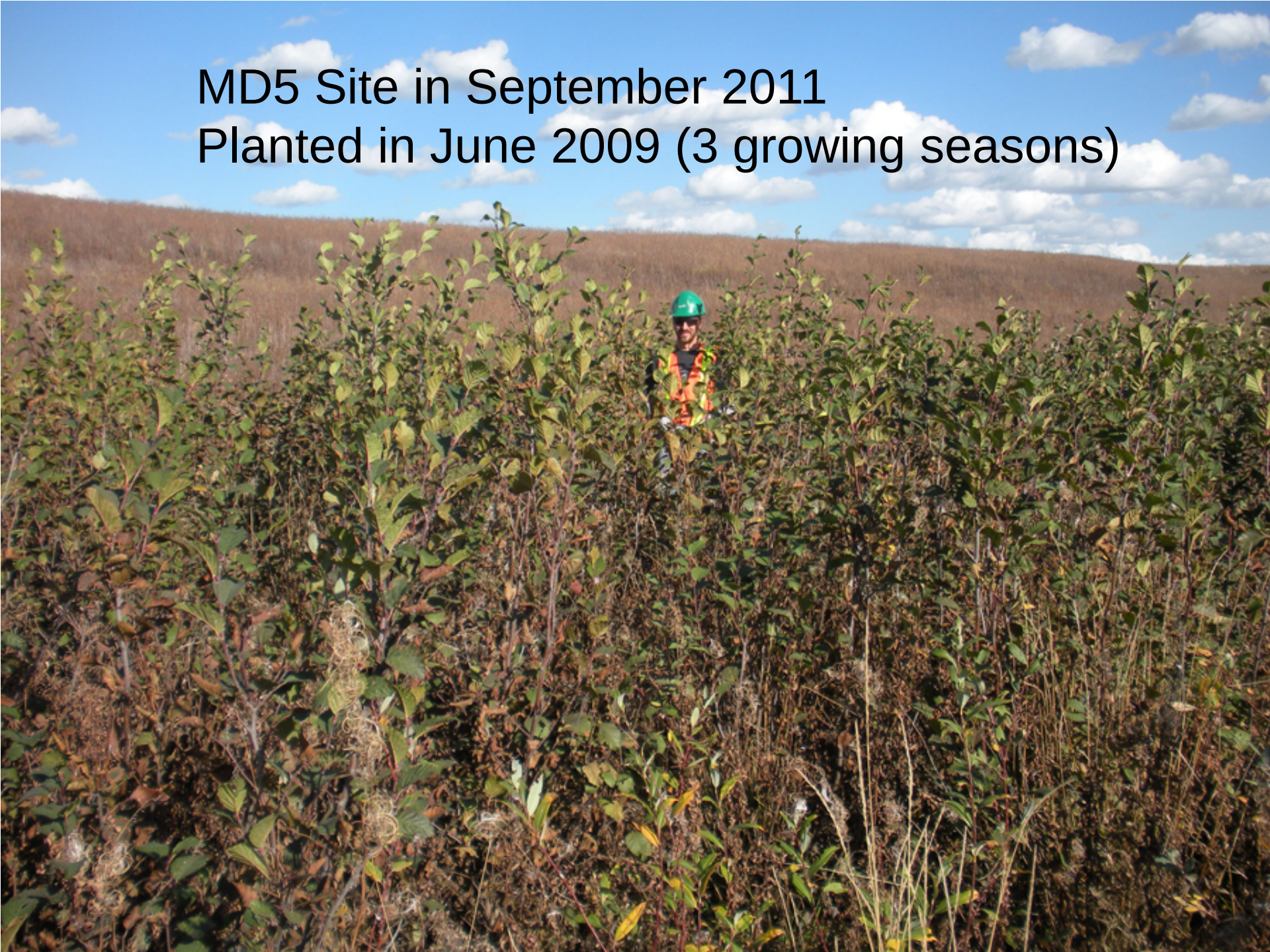
Pioneer species

Frankia sp.

N-fixing bacteria

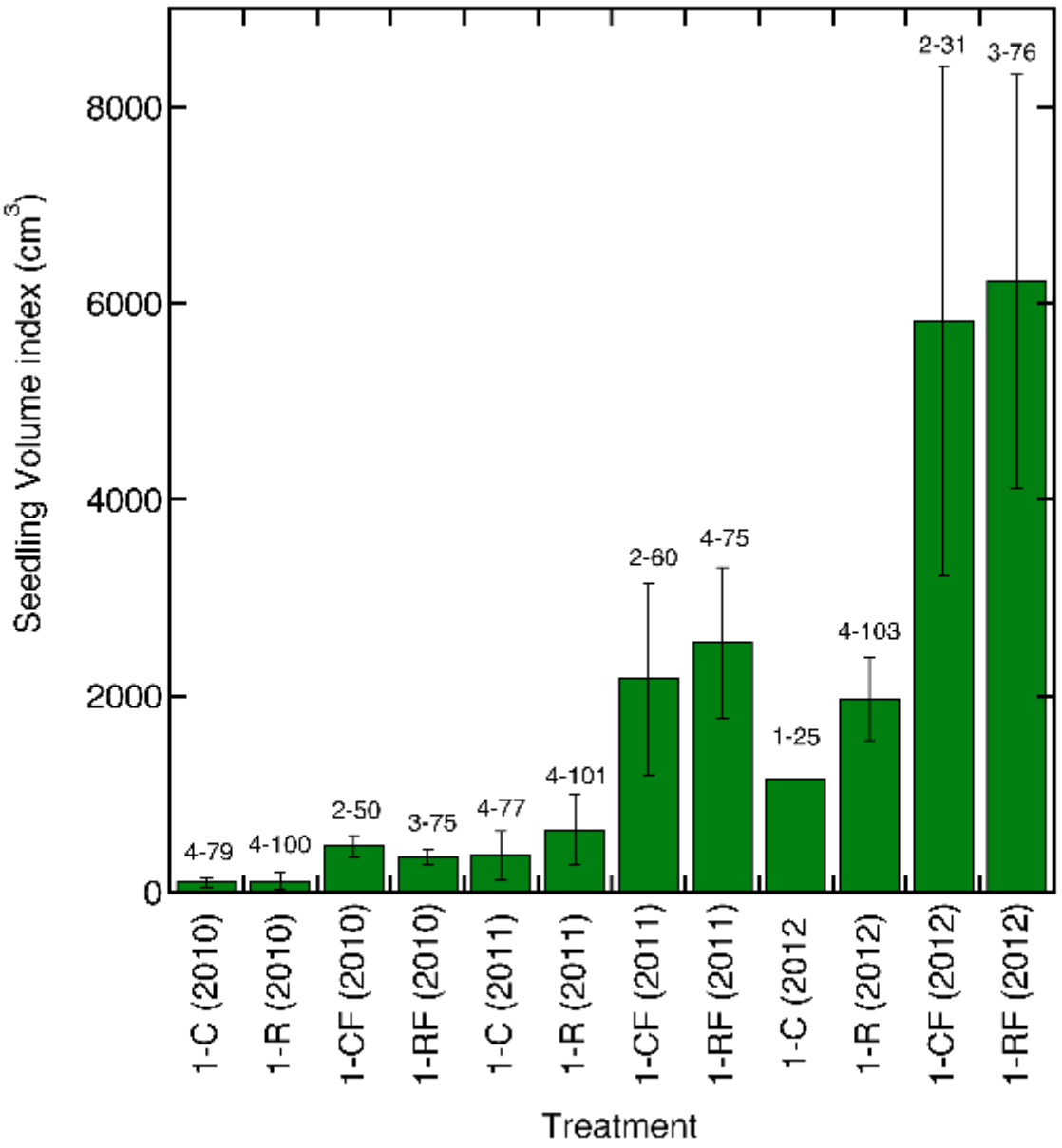
Alders on MD5 Site in September 2009
Planted in June 2009 (1 growing season)


MD5 Site in September 2010
Planted in June 2009 (2 growing seasons)

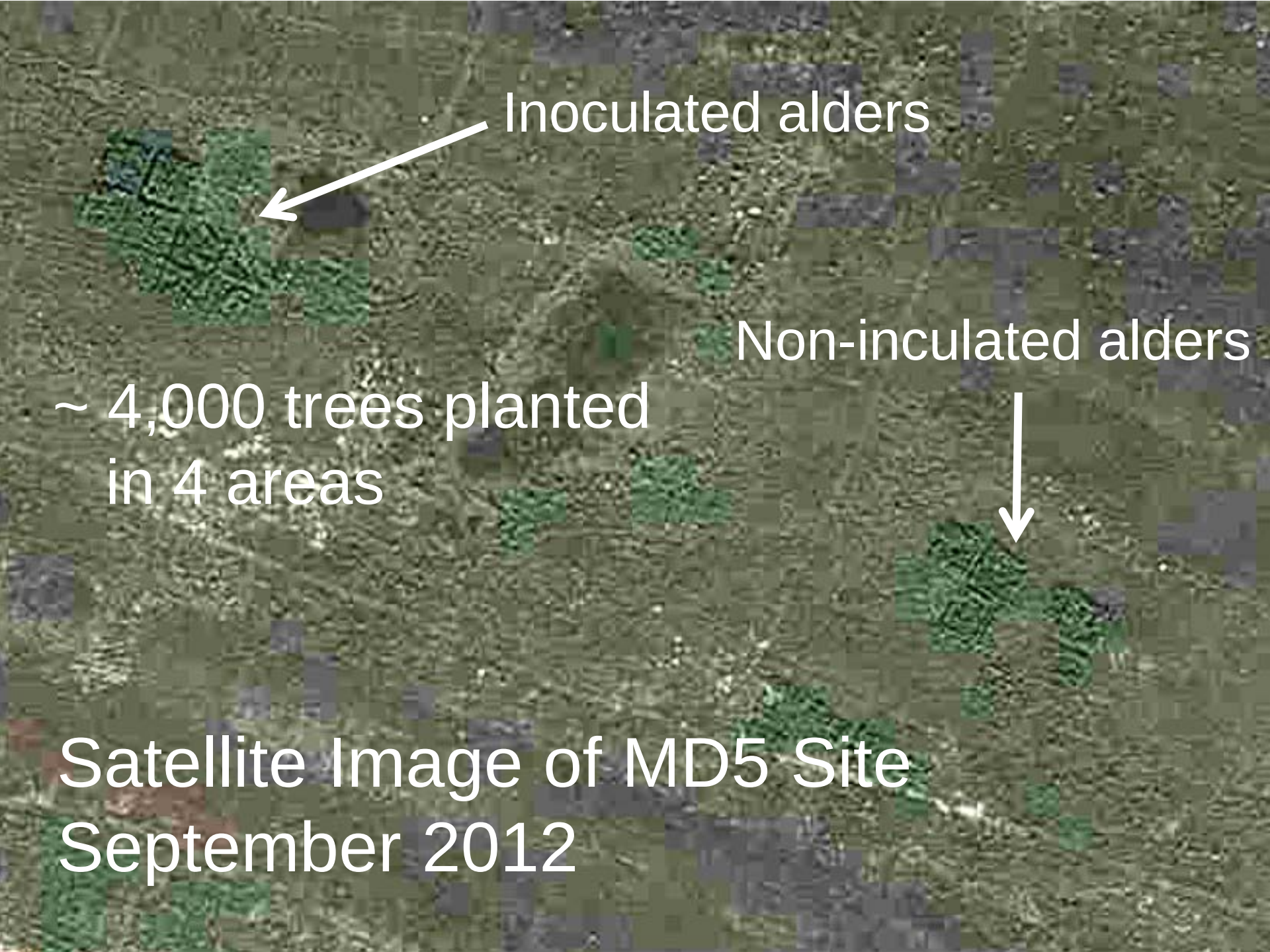

MD5 Site in September 2011
Planted in June 2009 (3 growing seasons)


MD5 Site in September 2012
Planted in June 2009 (4 growing seasons)

Alder Growth at Suncor MD5 Site (4 Growth Seasons)

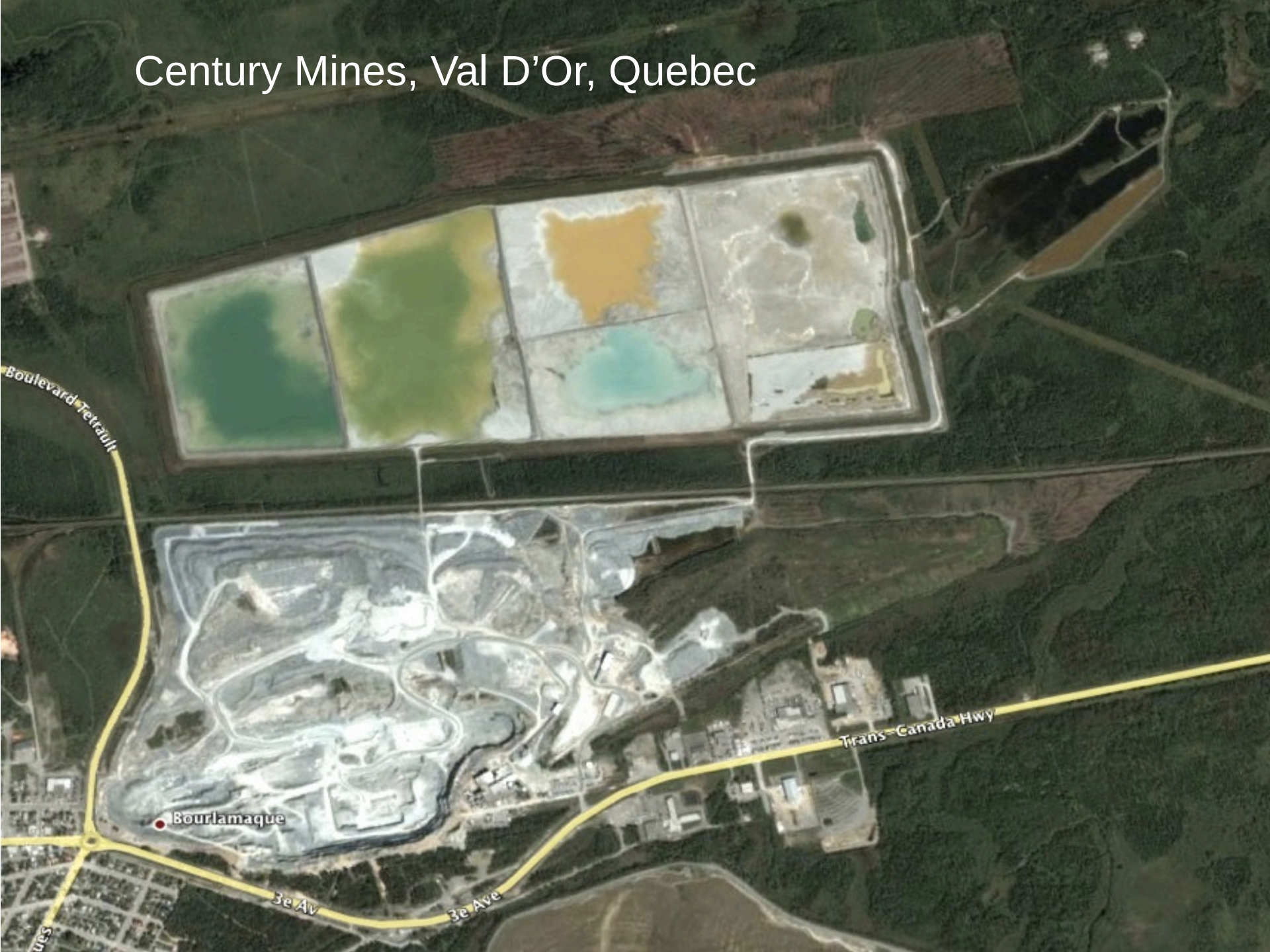


- For the last two growing seasons, SVI for inoculated alders 3-4 times that for uninoculated alders


Inoculated alders
Non-inculated alders
~ 4,000 trees planted
in 4 areas
Satellite Image of MD5 Site
September 2012

Reclamation of waste rock at a former gold mine site

Century Mines, Val D'Or, Quebec

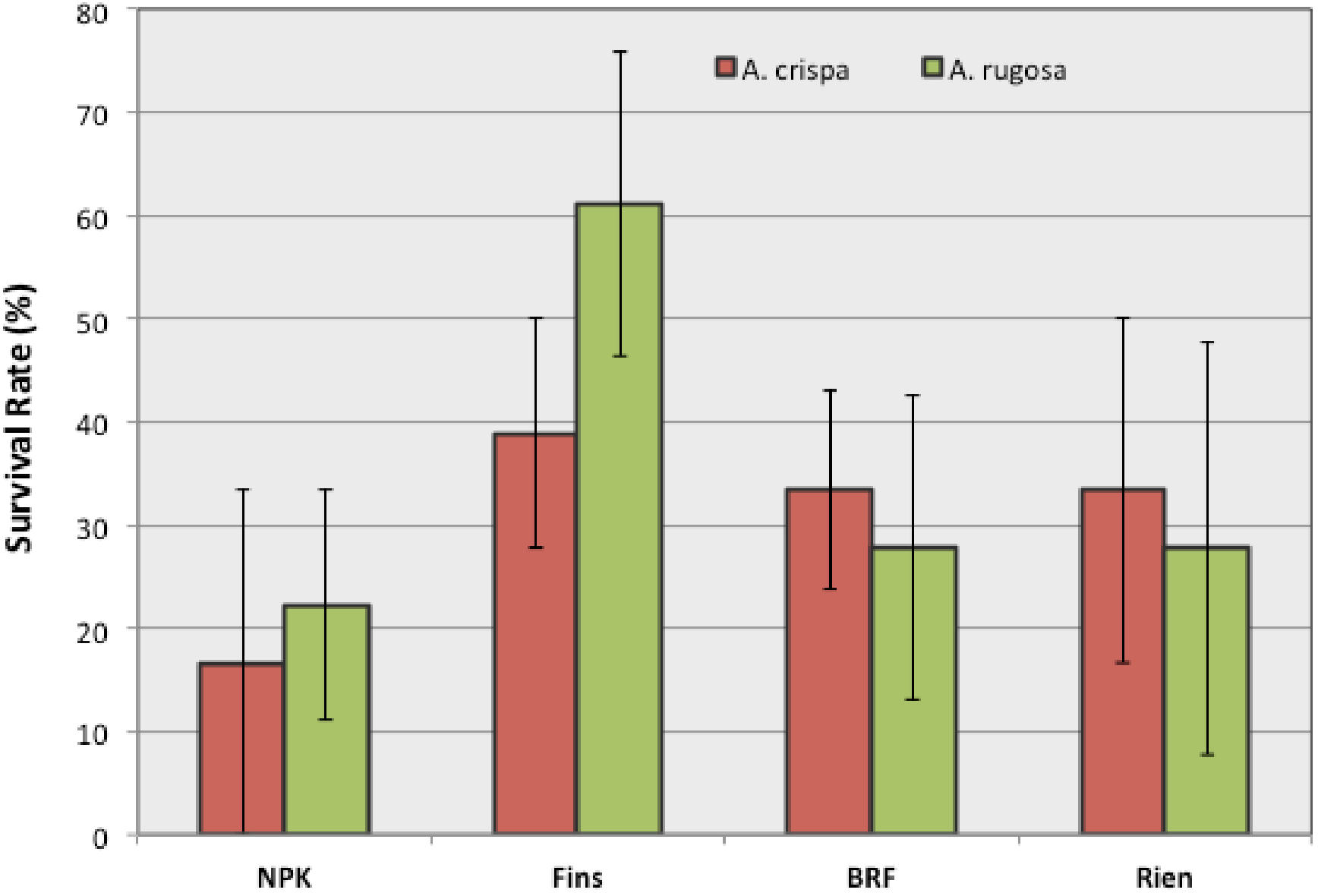


Waste Rock Site

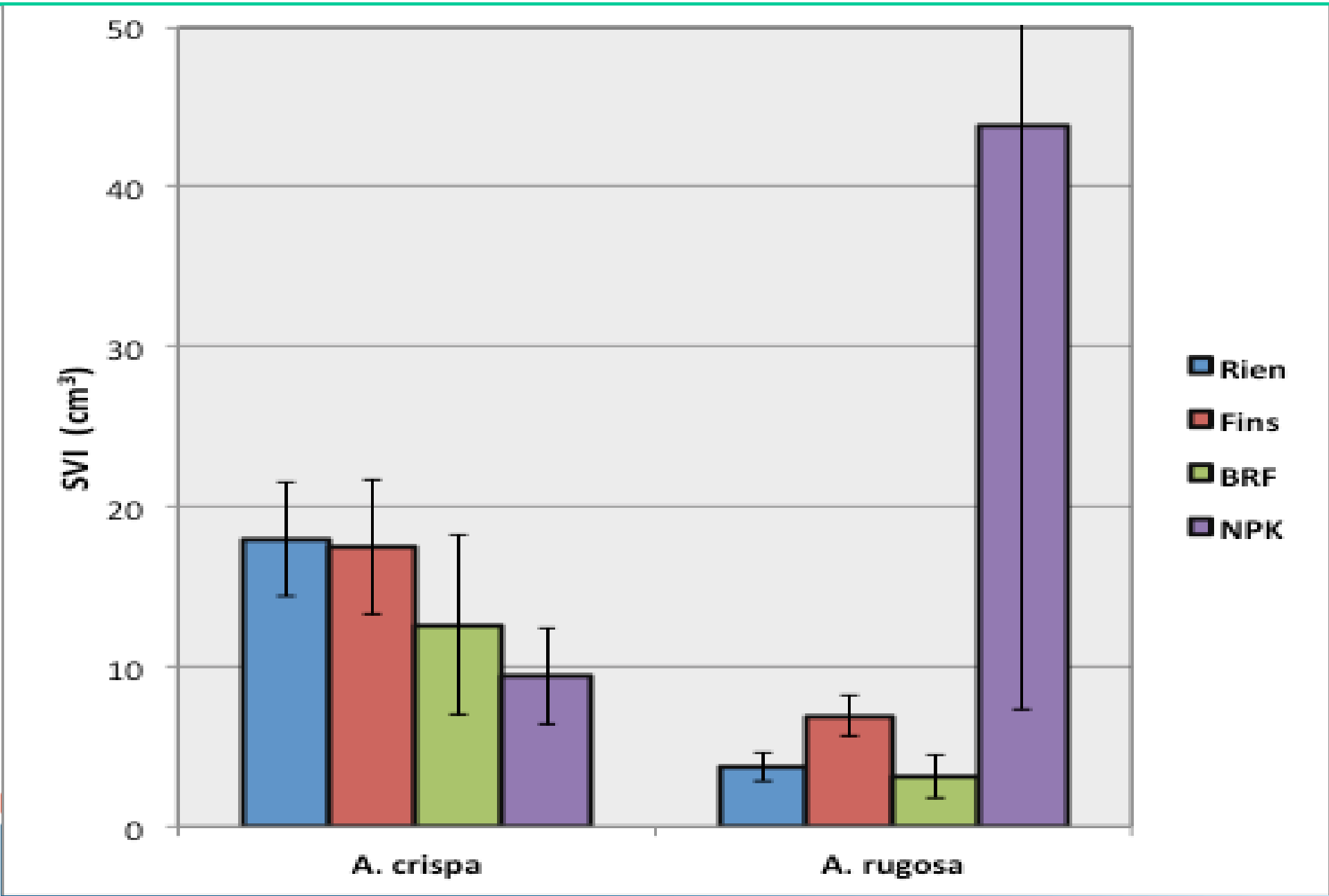
Val D’Or, Quebec

Preparation of experimental plots on the waste rock site

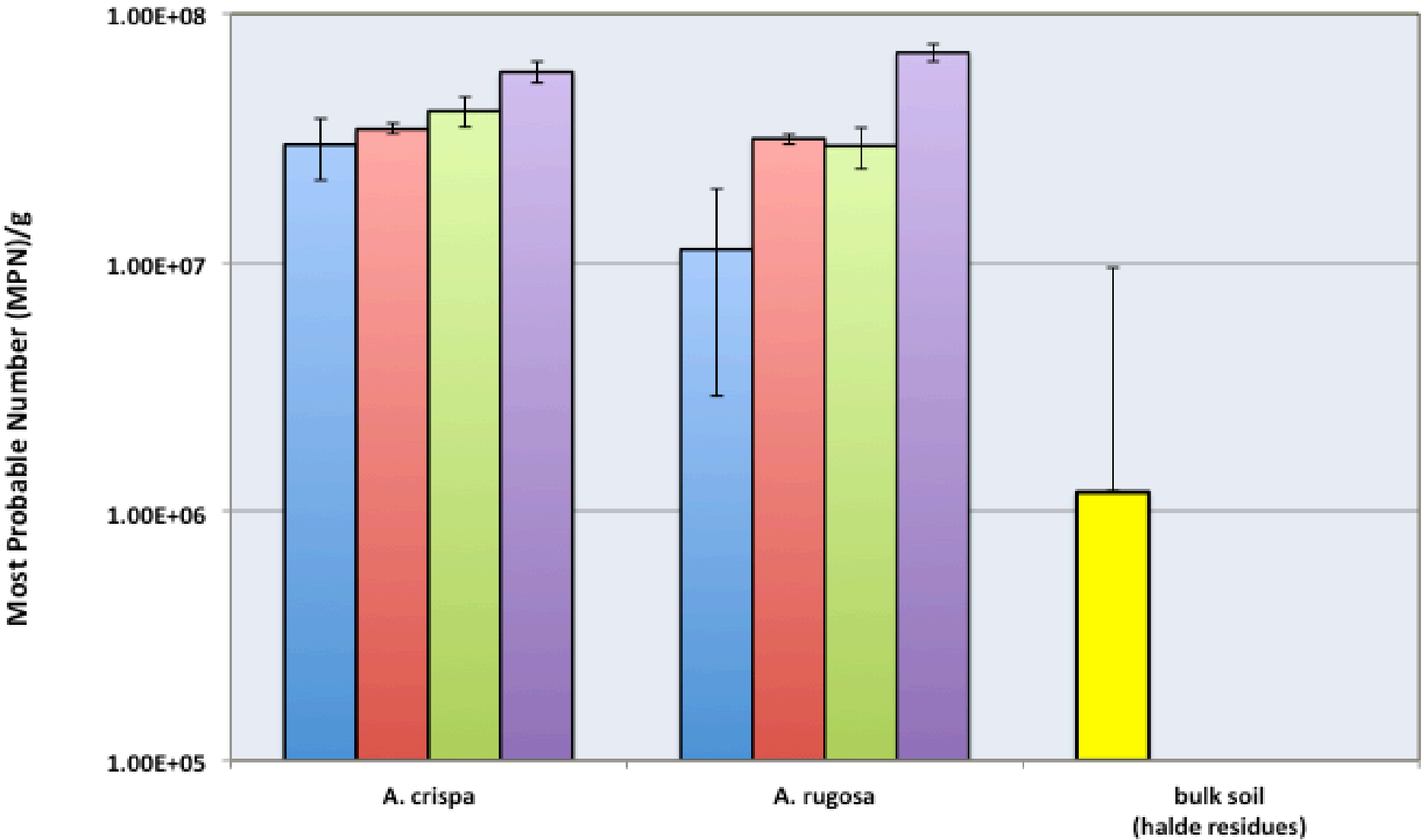
Alder Survival after two (2) years



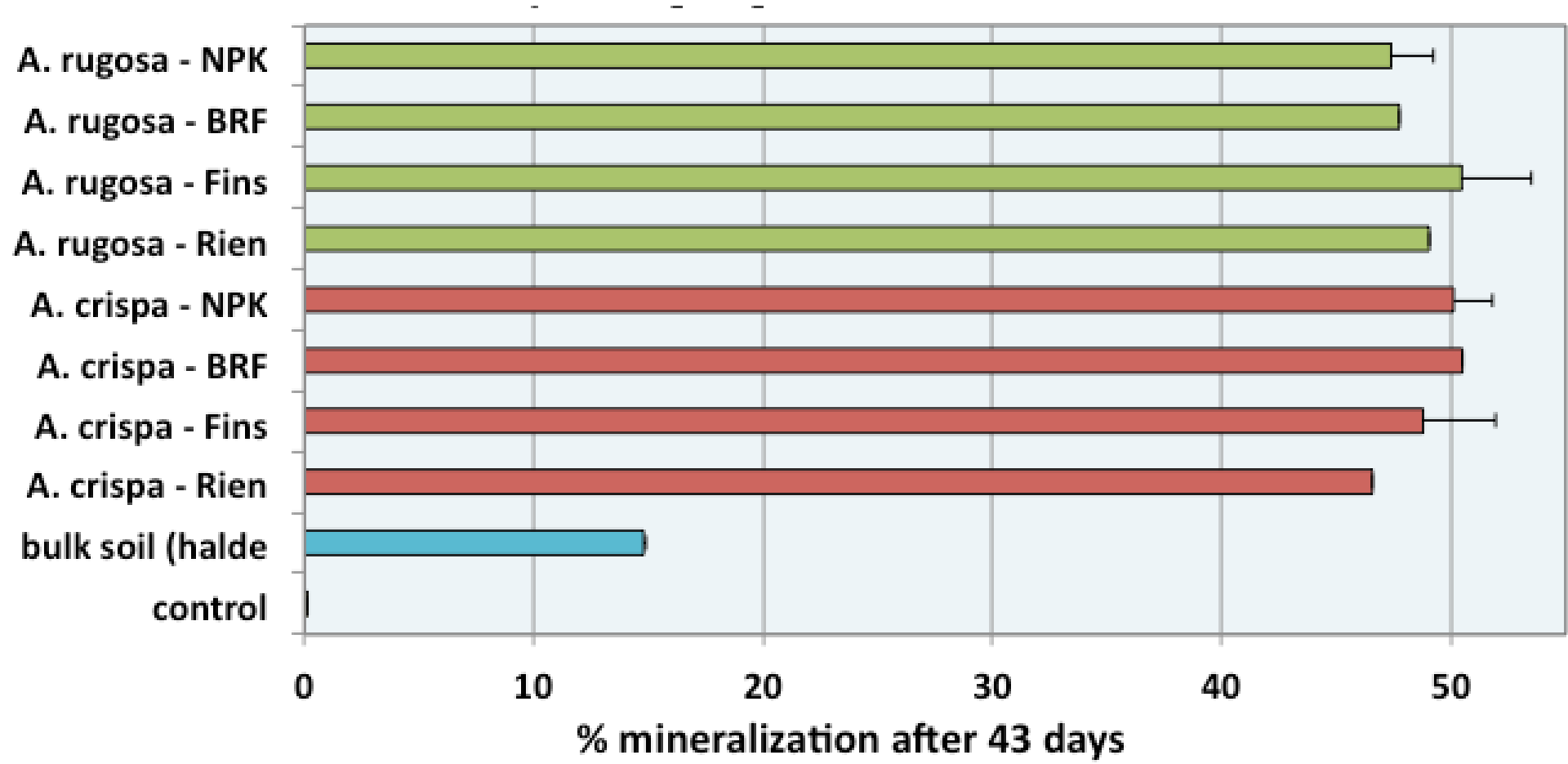
Growth of Alders (after 2 growth seasons)



Microbial Viable Counts (MPN/g)

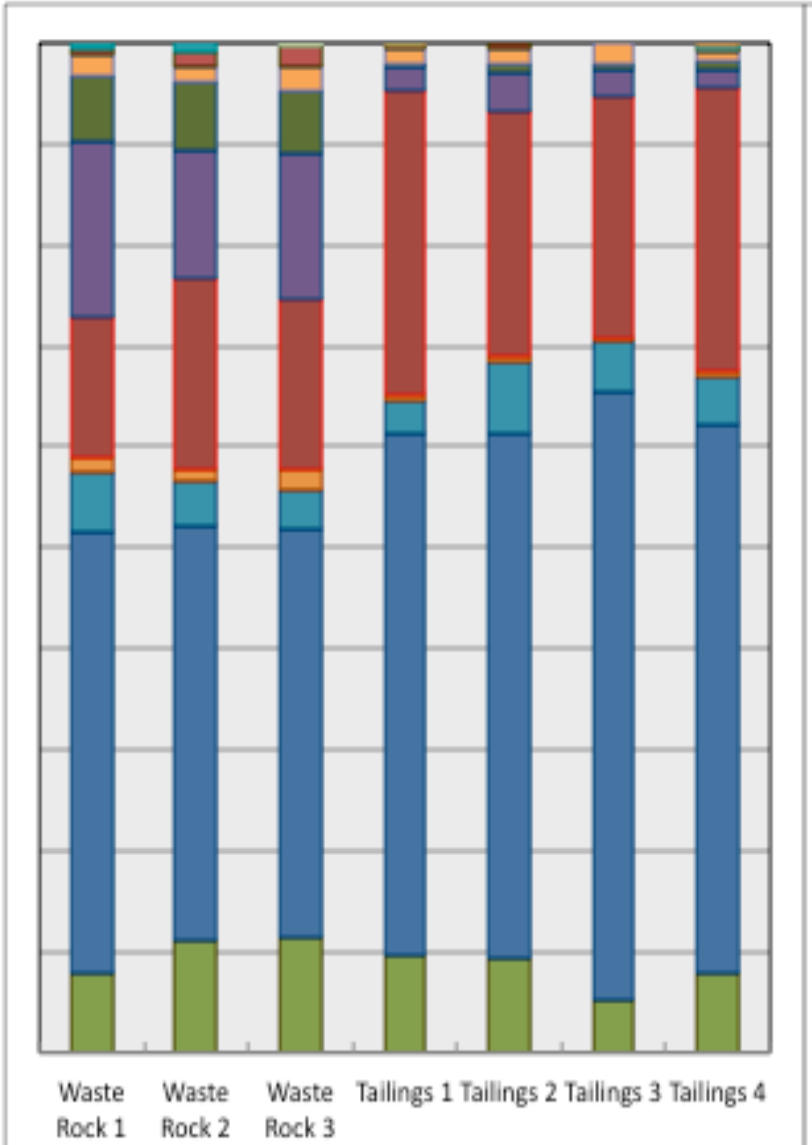


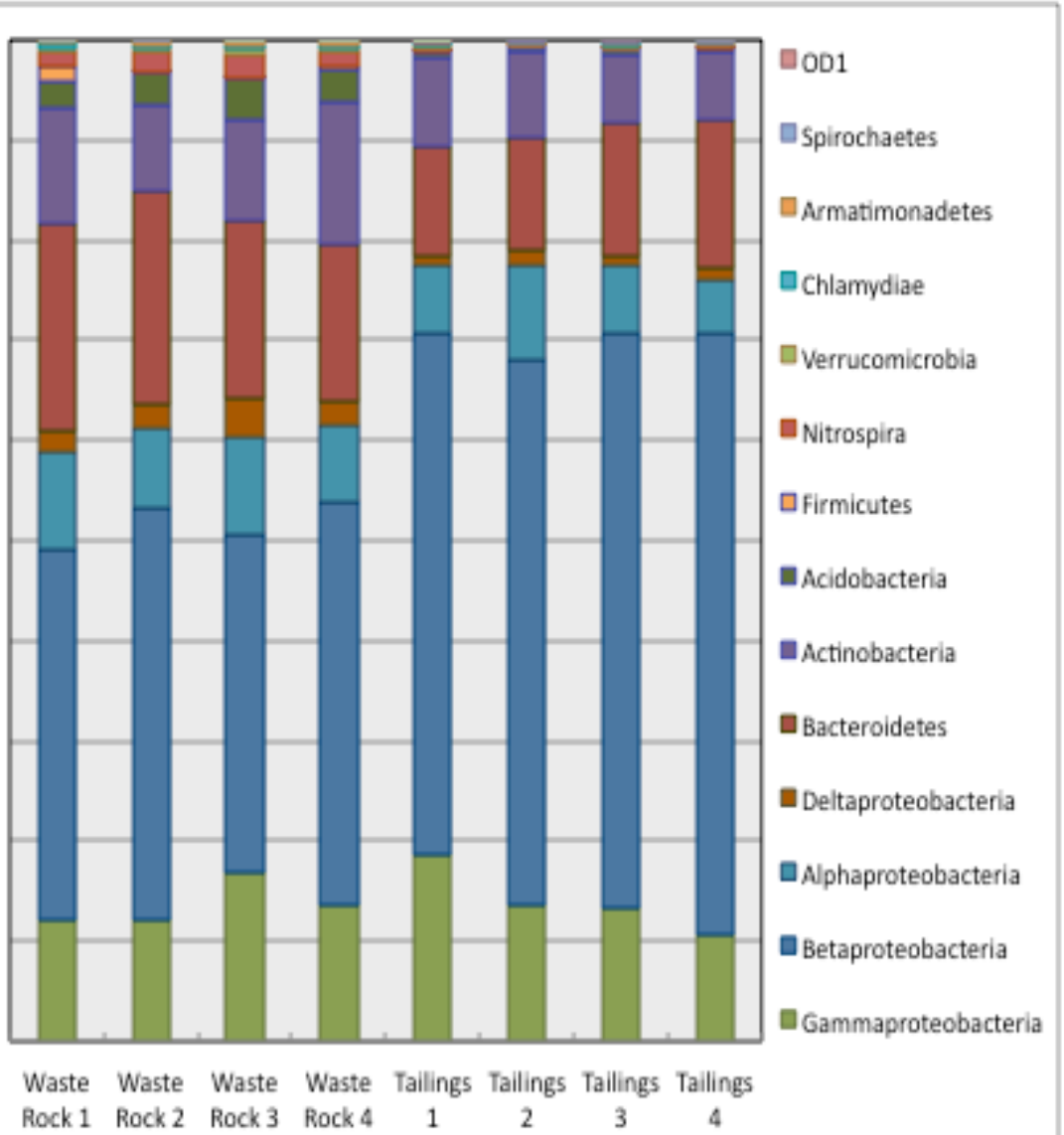
Mineralization of ^{14}C-Acetate in the Rhizosphere



Initial (t=0) phylum-level bacterial diversity

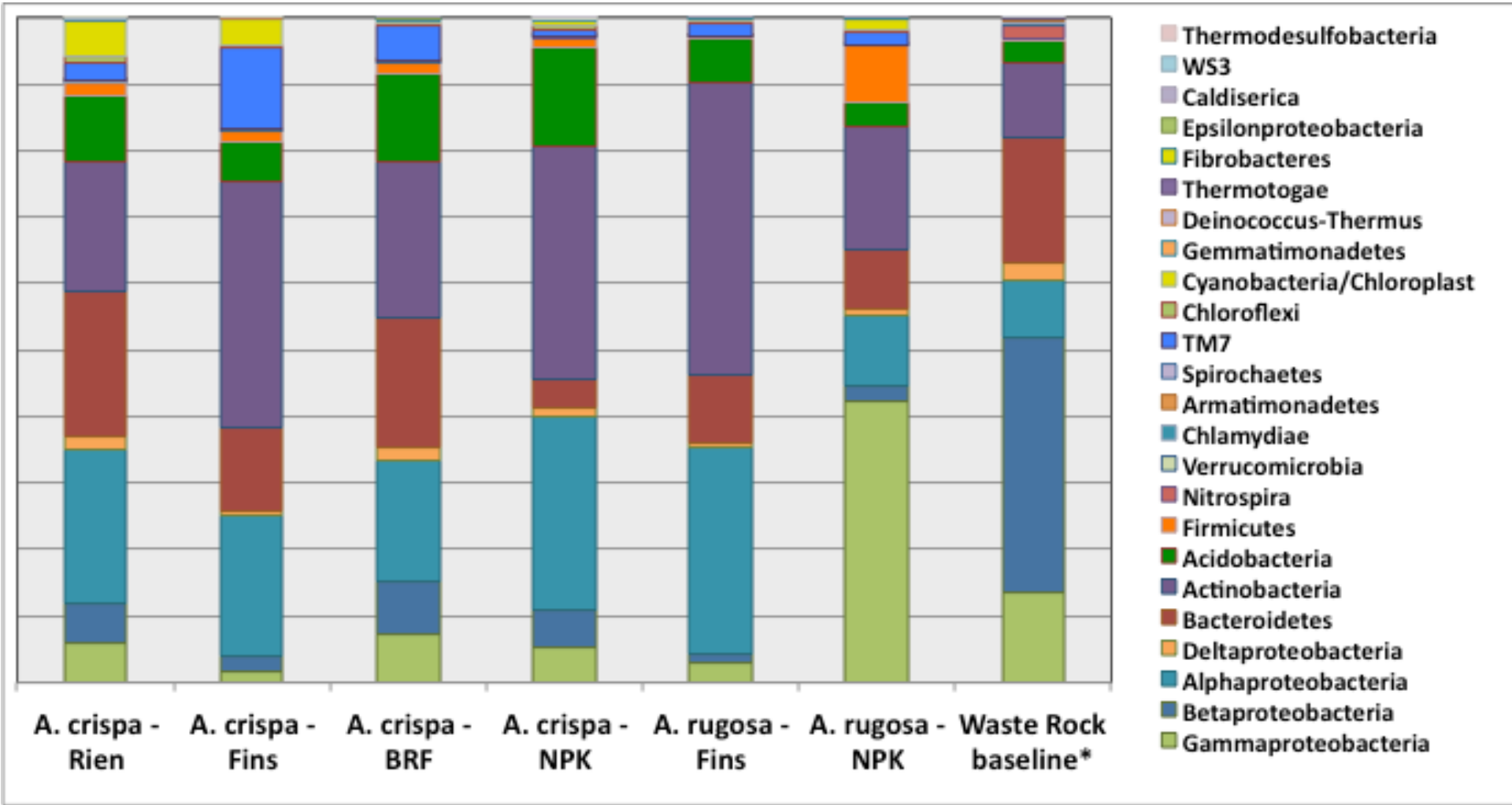
- July 2011 Sampling
- September 2011 Sampling





Rhizosphere phylum-level bacterial diversity

June 2013: Two growing seasons in the field



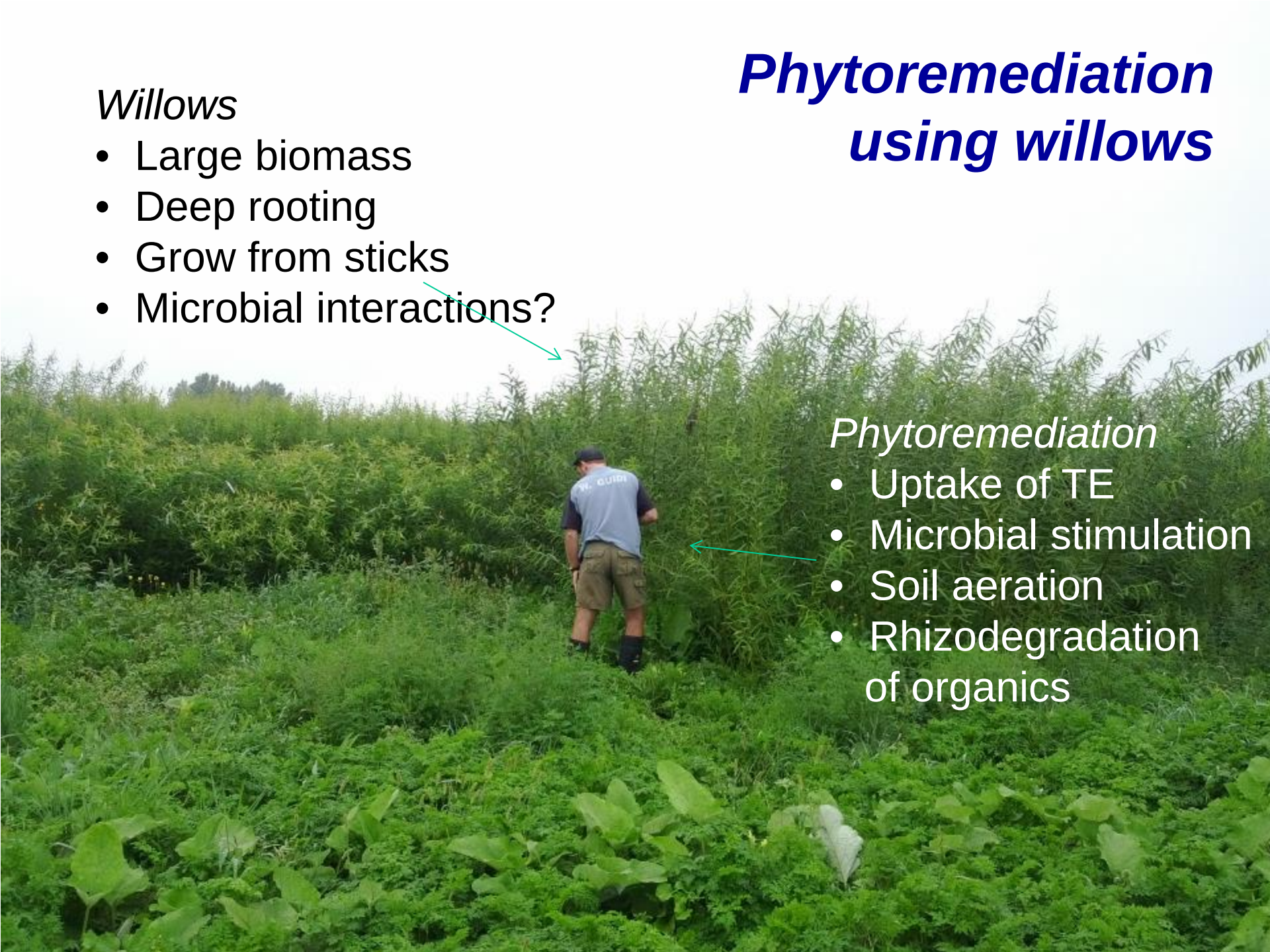
Alders in the field after
Two growing seasons

Explore the tripartite association between willows, fungi and bacteria on a hydrocarbon contaminated site

Phytoremediation using willows

Willows

- Large biomass
- Deep rooting
- Grow from sticks
- Microbial interactions?

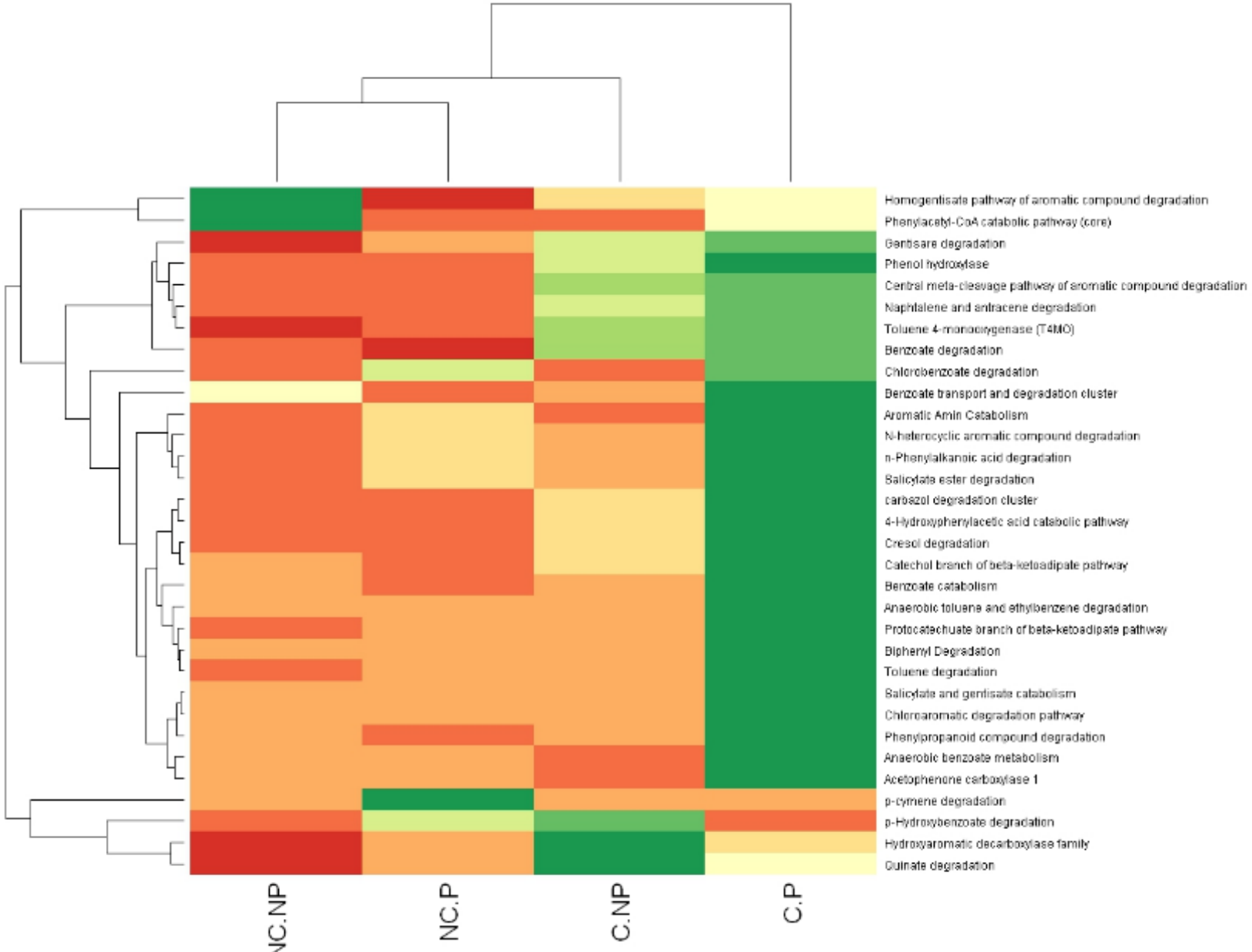


Phytoremediation

- Uptake of TE
- Microbial stimulation
- Soil aeration
- Rhizodegradation of organics

Petroleum contaminated lagoon site

Expression of Hydrocarbon Degradation Genes During Phytoremediation of a Petroleum Contaminated Site



Summary

- Field trials on an oil sands site showed that *Frankia*-inoculated alders grew better than uninoculated plants (biomass, root development), and had a positive impact on indigenous soil microorganisms (population density, diversity, activity)
- Inoculated alders were able to establish and grow on waste rock at a mining site, having a positive effect on the microbial community structure and function in the rhizosphere
- Application of genomics technologies demonstrated the positive interactions between plants and microbes on mining and hydrocarbon contaminated sites

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