SASKATCHEWAN RESEARCH COUNCIL

Assessment of Contaminated Soil in the Canadian Boreal Forest using Standardized Toxicity tests

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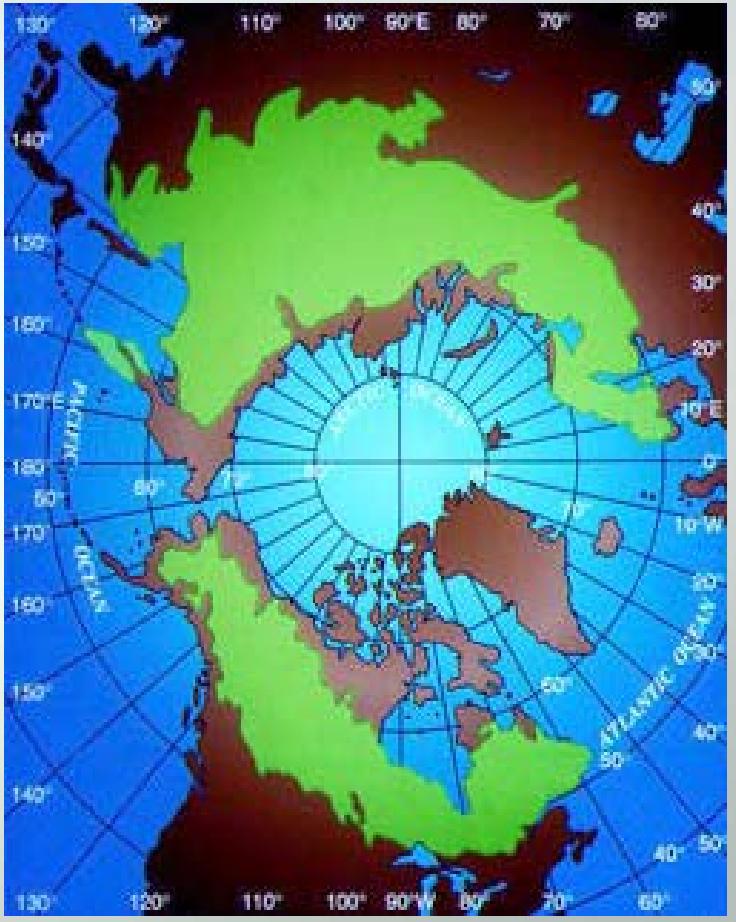
Outline

1. Methods
   - Plants
   - Invertebrates
   - Soil collection and handling
2. Performance tests
3. Case study of hydrocarbon impacted site



http://www.borealforest.org/world/world_overview.htm

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Project Objectives

- Develop standardized biological test methods to measure effects of contaminants (e.g., brine, PHC) in Canadian boreal and northern (taiga) soils and wetlands
  - Use ecologically-relevant terrestrial and wetland species (single-species and microbial)
  - Test a variety of soils of the boreal and taiga eco-zones
- Develop technical guidance on the collection, handling, and preparation of contaminated soils for biological testing in support of site-specific risk assessments
- Develop tools useful for contaminated land risk assessment and management

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Method development process

- Create list of potential species that are ecologically relevant to the boreal
- Acquire or collect seeds or invertebrates, bring to germination or into culture in the lab
- Perform tests of growth, survival or reproduction in a wide variety of soils – “performance testing”
- Test impacted soils diluted in a matching reference soil
- Environment Canada validates the method, publishes

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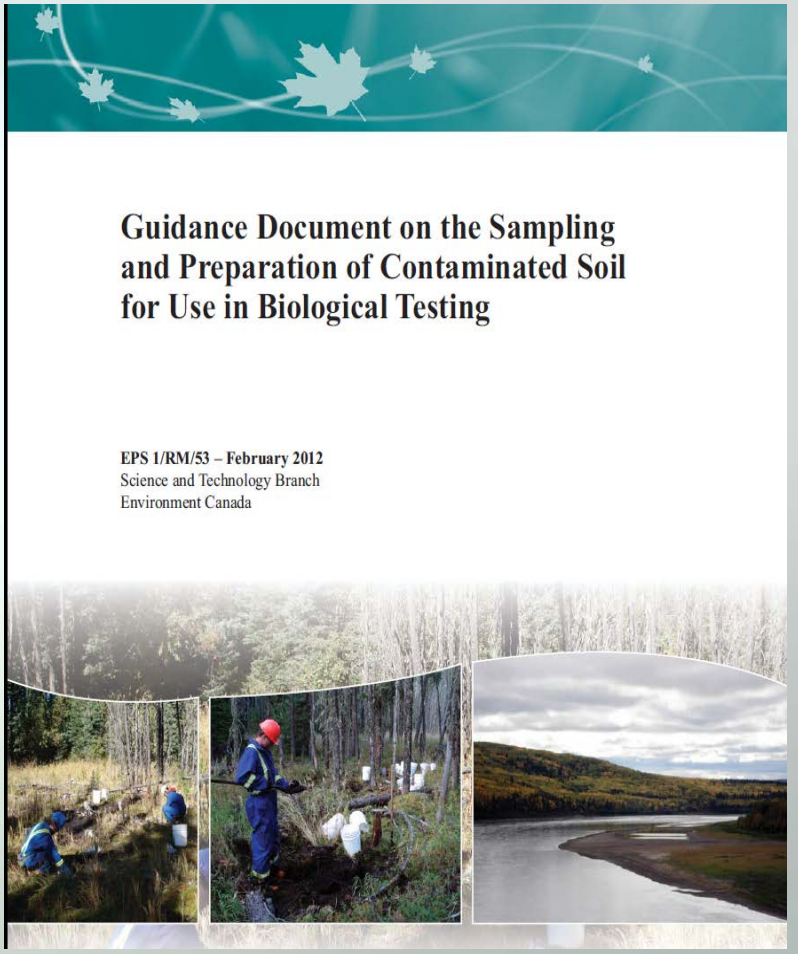
Contaminated Soil Sampling Guidance

Environment Canada EPS 1/RM/53

- Supportive of site-specific risk assessments and soil remediation
  - Single-species and microbial assessments
  - Universal procedures and statistically derived sampling procedures
  - Specific procedures for problematic contamination (e.g., unstable compounds, volatiles)
  - Broad-range of Canada's eco-zones (e.g., forests, cryosols, stoney soils, wetlands)



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Boreal Test Species

Species		Source
Plants	Black spruce (*Picea mariana*)	Commercial seed suppliers or locally collected
	White spruce (*Picea glauca*)	
	Paper birch (*Betula papyrifera)*	
	Jack pine (*Pinus banksiana*)	
	Trembling aspen (*Populus tremuloides*)	
	Bluejoint reedgrass (*Calamagrostis canadensis*)	
	Canada goldenrod (*Solidago canadensis*)	
Earthworm	*Dendrodrilus rubidis*	Alberta
	Dendrobaena octaedra	
Springtail	*Proisotoma minuta*	Sask.
Mite	*Oppia nitens*	Ontario

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Wetland Plant Test Species

Habitat	Species	Source
Marsh	Bebb's willow (*Salix bebbiana*)	Commercial seed suppliers or locally collected
	Cattail (*Typha latifolia*)	
	Bluejoint reedgrass (*Calamagrostis canadensis*)	
	Bebb's willow (*Salix bebbiana*)	
	Aquatic sedge (*Carex aquatilis*)	
Fen	Aquatic sedge (*Carex aquatilis*)	
	Tamarack (*Larix laricina*)	
	Sweet gale (*Myrica gale*)	
	Black spruce (*Picea mariana*)	
	Bluejoint reedgrass (*Calamagrostis canadensis*)	
Bog	Bog cranberry (*Vaccinium vitis-idaea*)	
	Black spruce (*Picea mariana*)	

Establish Invertebrate Species

- Derived from heat extractions of reference soil
- Ongoing culture in the lab on artificial substrate

Hand-collection and sorting

Culturing

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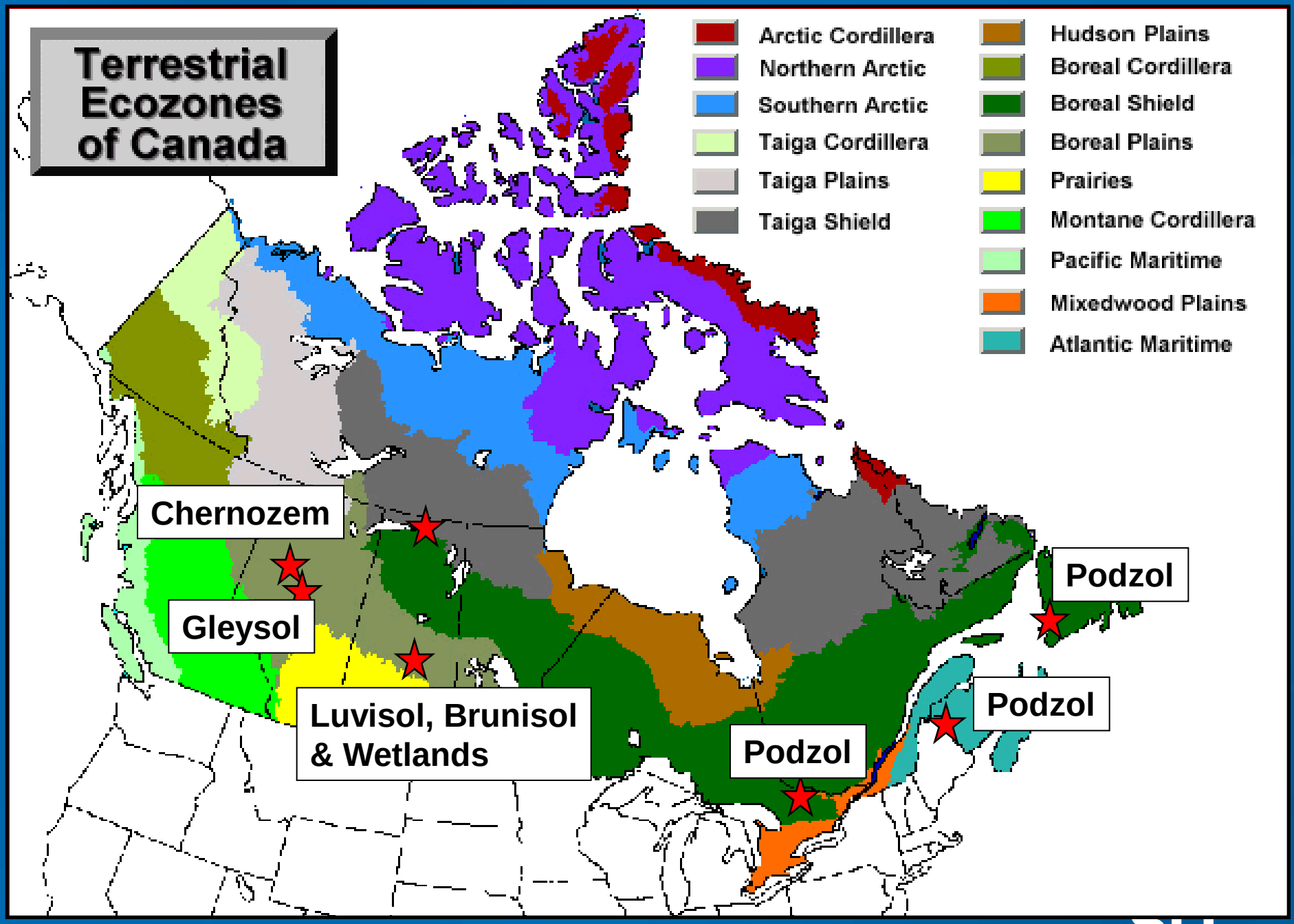

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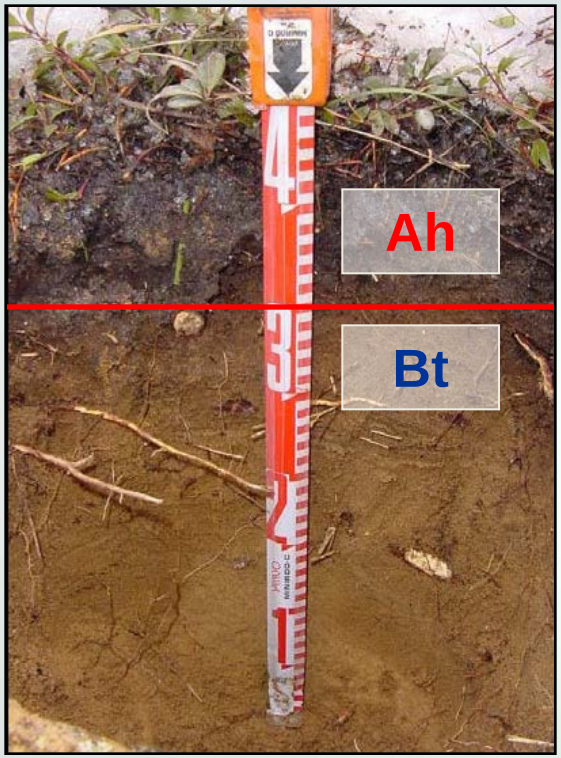
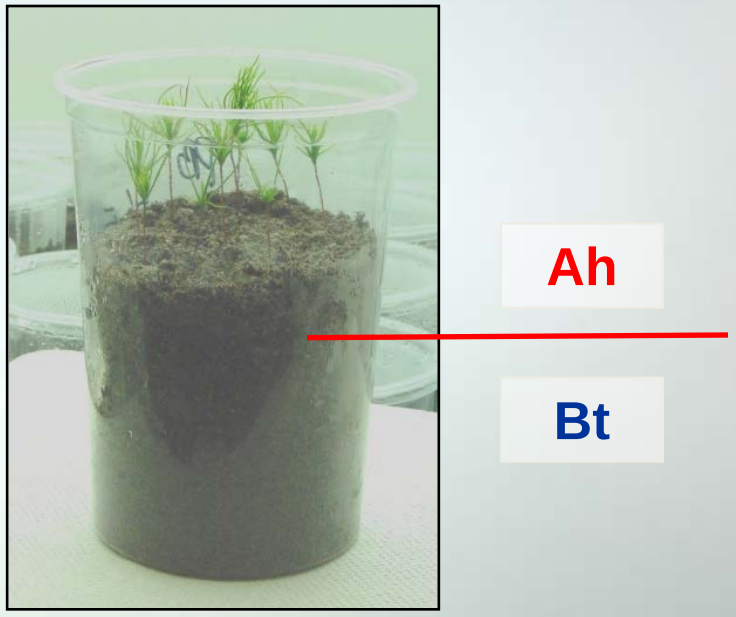
Collection of bulk soils
- aim to retain soil horizons



Field horizons



Plant test setup

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Effects of salt-contaminated soil

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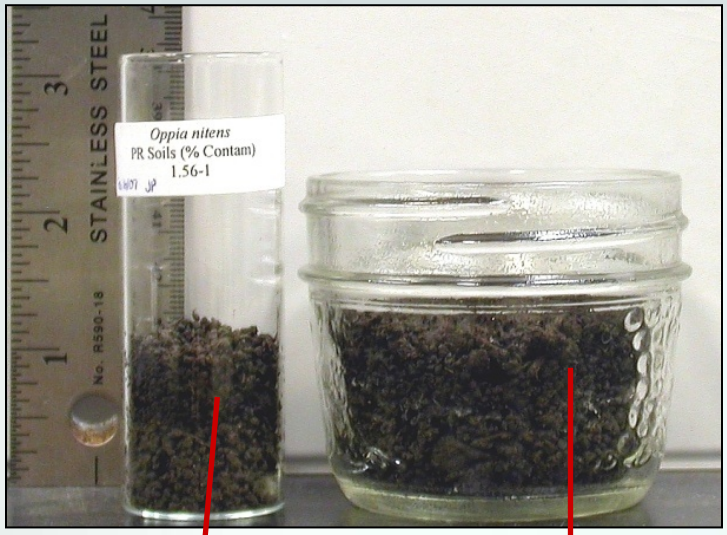
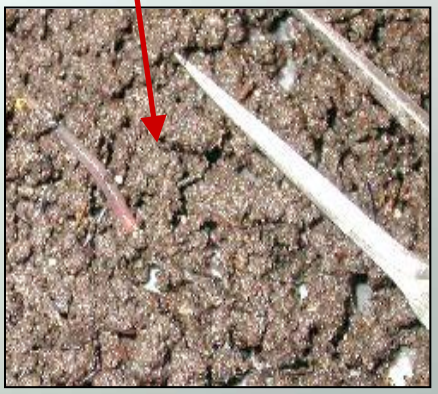
Invertebrate Tests Systems

Testing of Individual Horizons



mite

Collembolan



Earthworm

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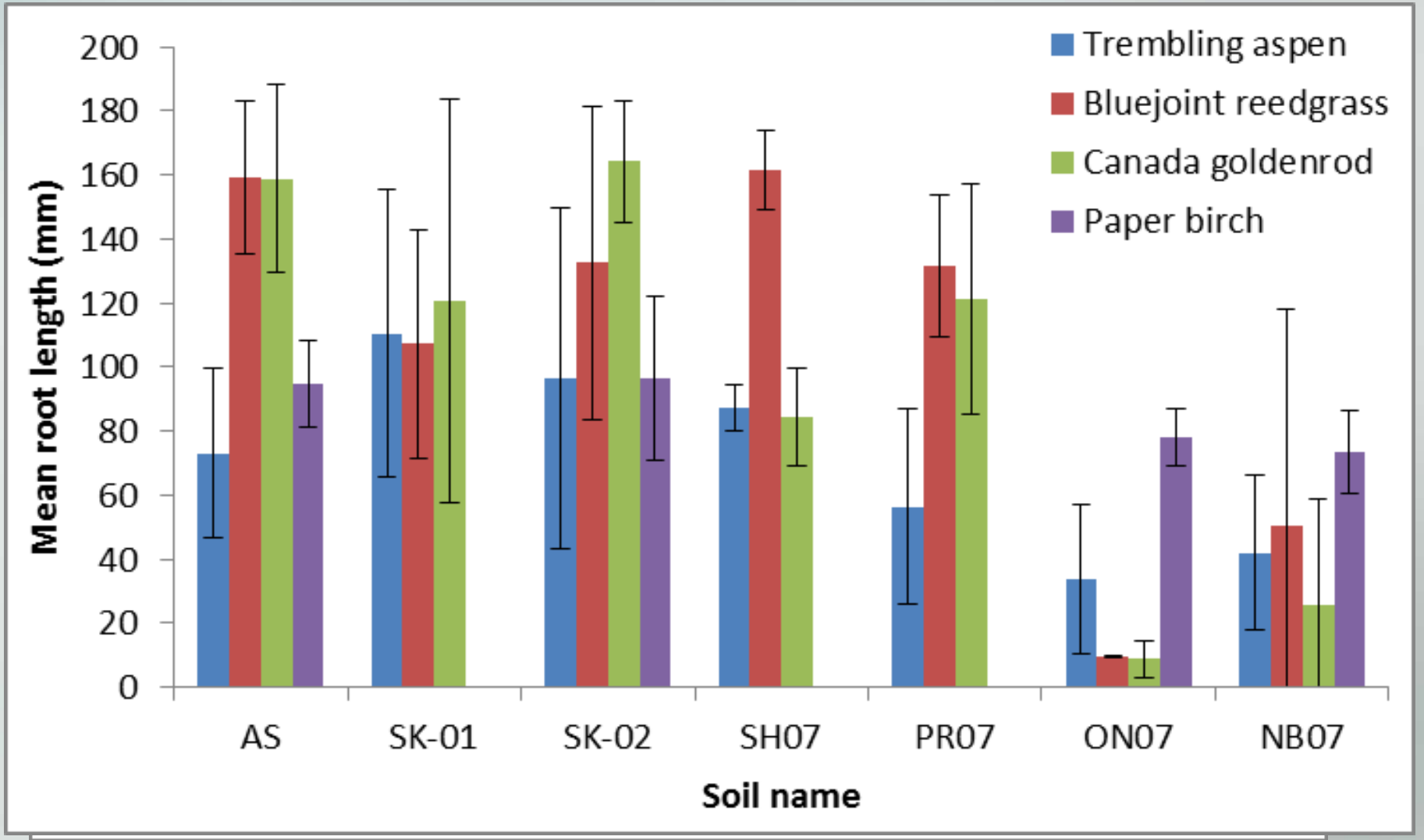
Performance of plants (root length)



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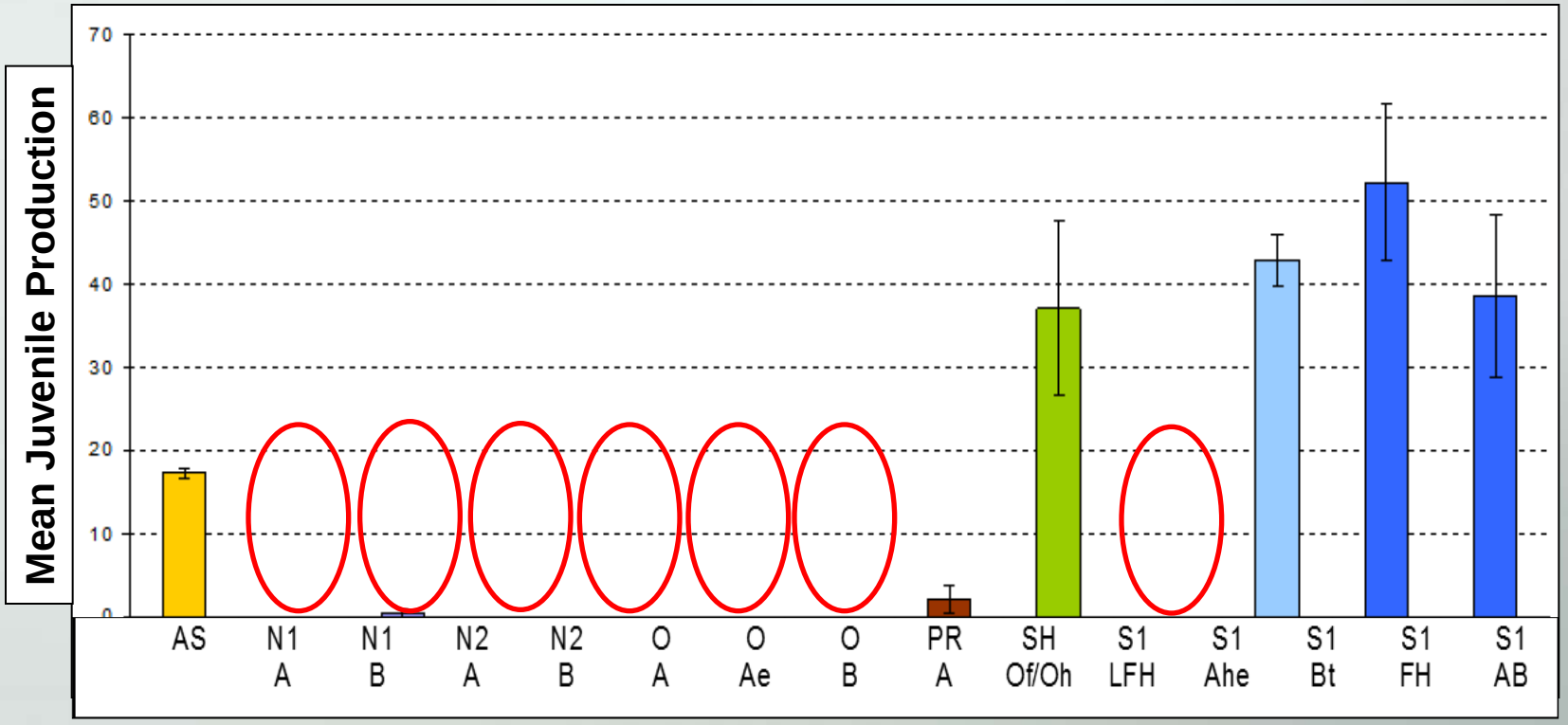
Performance of *Dd. rubidus* in 14 boreal soils

- Juvenile production varies with soil type but adult survival not affected
- Reduced reproduction in acidic soil (pH <4.5)



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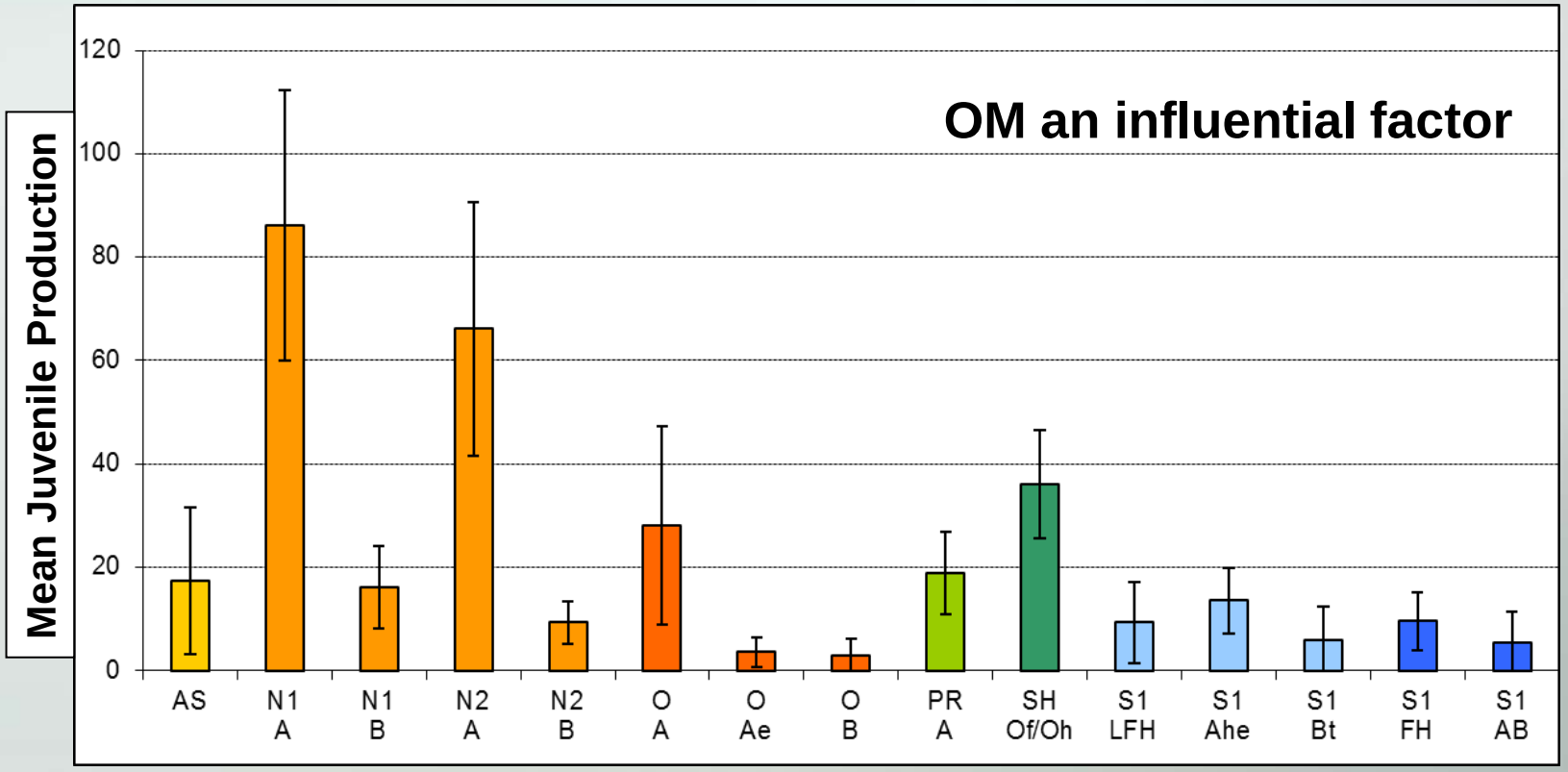
Performance of *Oppia nitens* in 14 boreal soils

- Evaluate survival and reproduction in boreal soils
- Develop performance data to help establish validity criteria



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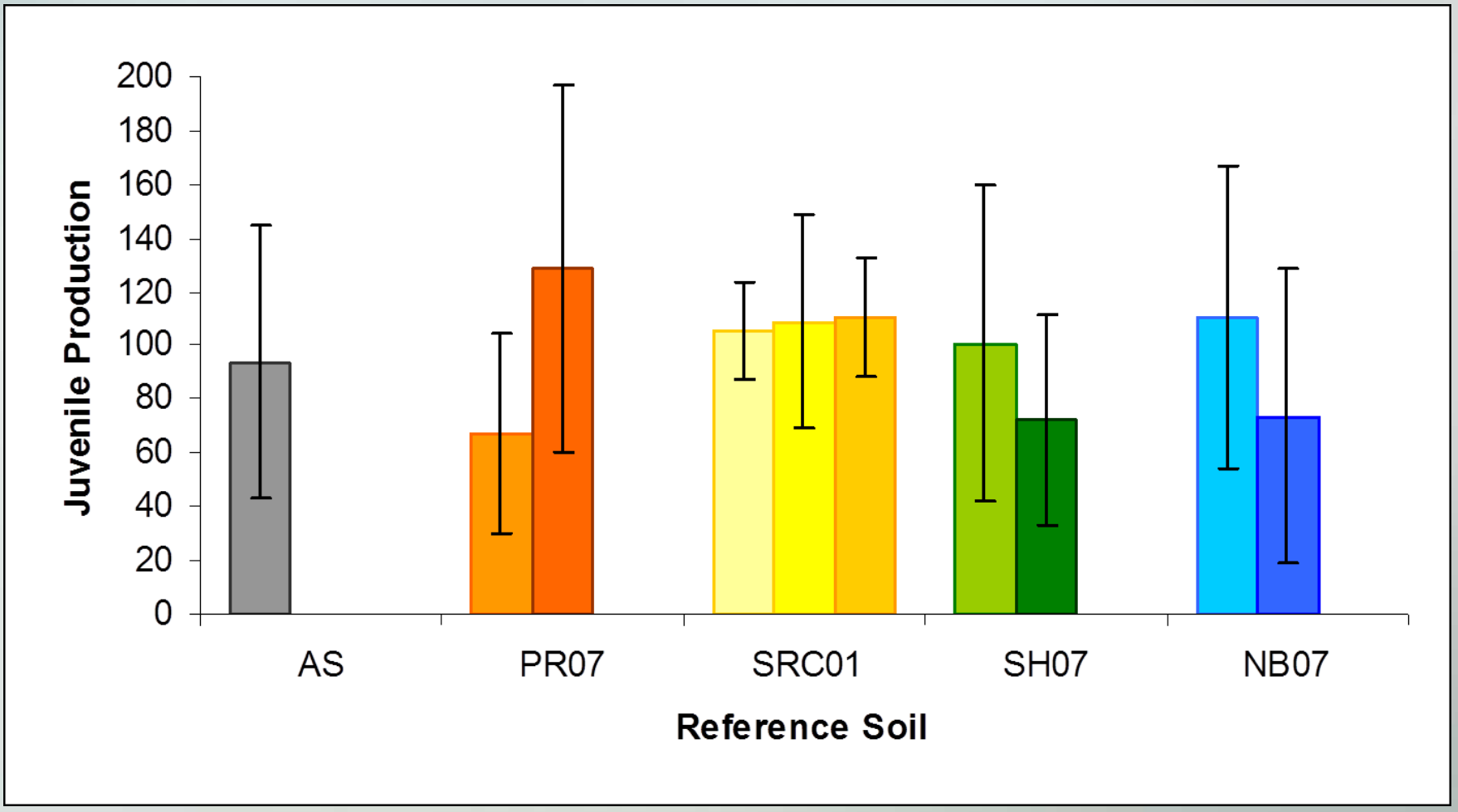
Performance of *P. minuta* in 14 boreal soils



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Site of crude oil spill in 1989

Swan Hills bog in Northern Alberta

- water table of 5-15 cm
- pH 4.6
- 20-30 cm peat layer over
  10-20 cm Ahg horizon
- trees removed and straw spread to remediate
- 35% of surface not vegetated
- hydrocarbons high in F3:
  >C16-C34: 190,000 mg/kg
- **Test species present**:
  black spruce, bluejoint,
  paper birch, trembling aspen

2006

Collected two horizons Of/Oh and Ahg at reference and contaminated locations

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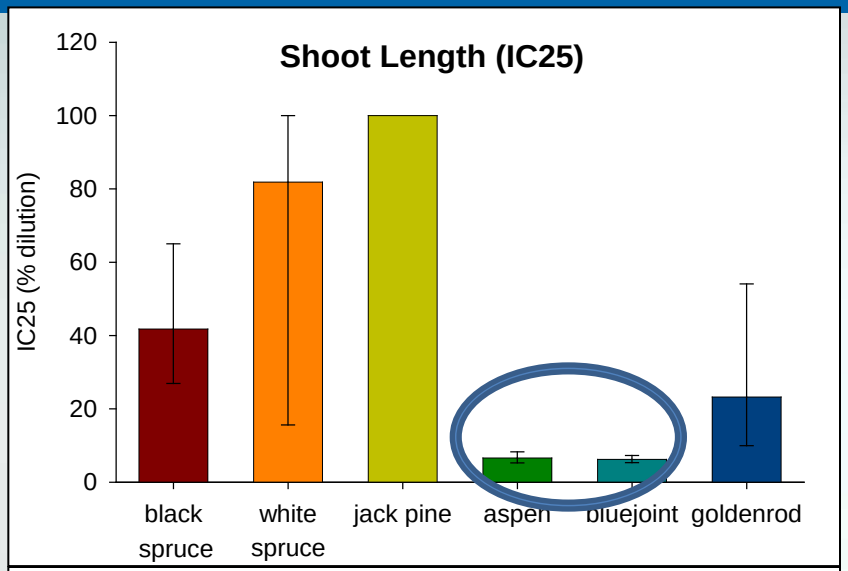
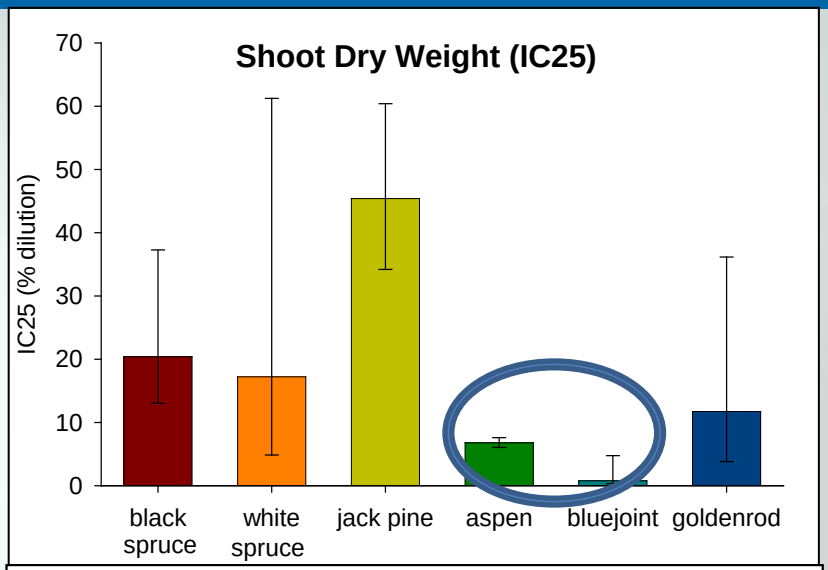
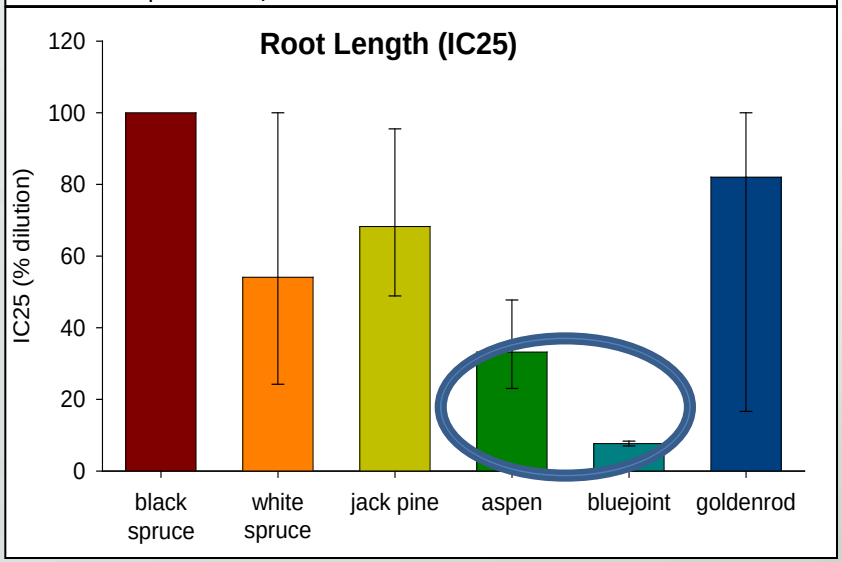
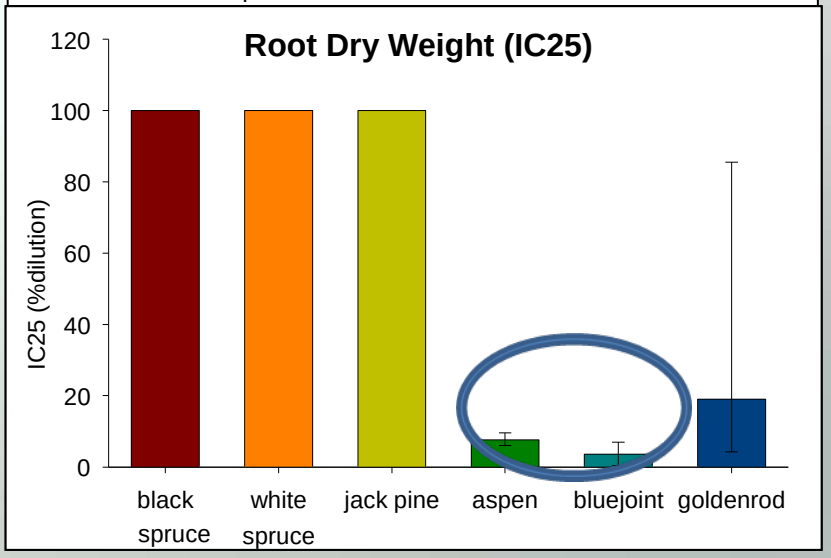
Plant shoot and root endpoints (IC25)









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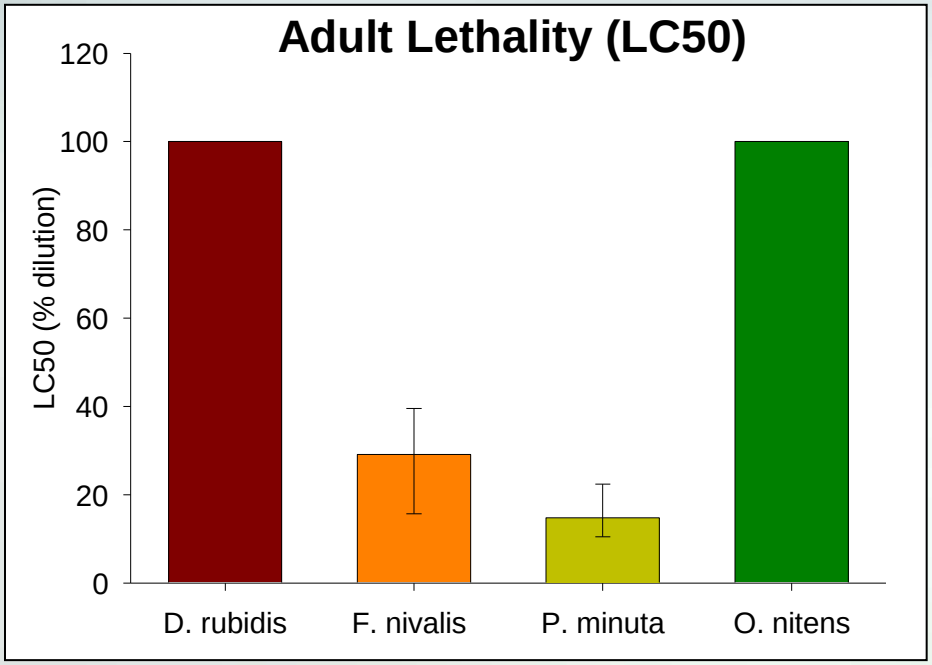
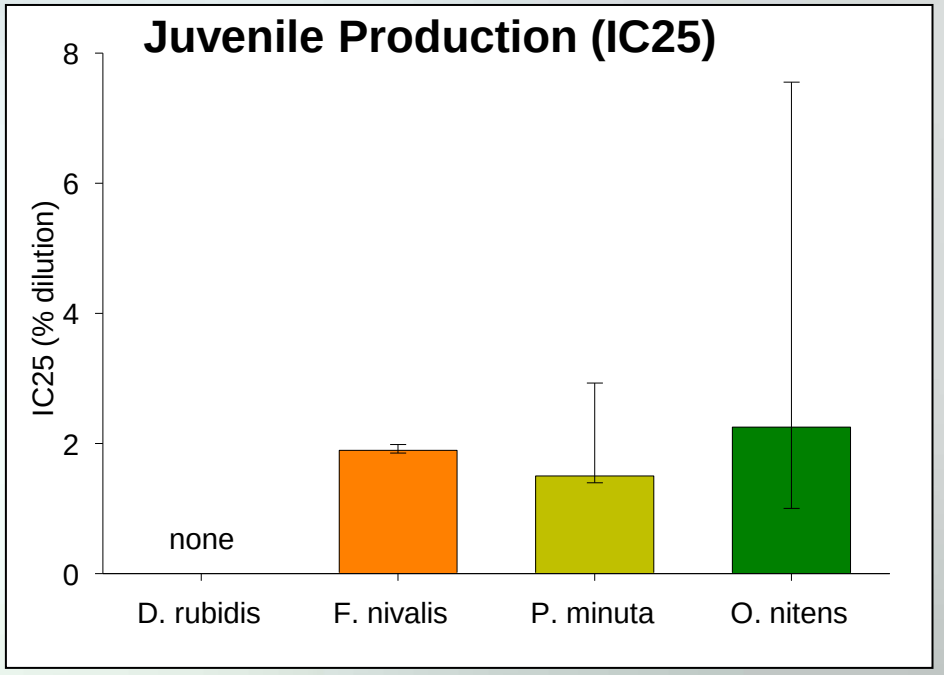
Boreal invertebrate survival and juvenile production (IC25)





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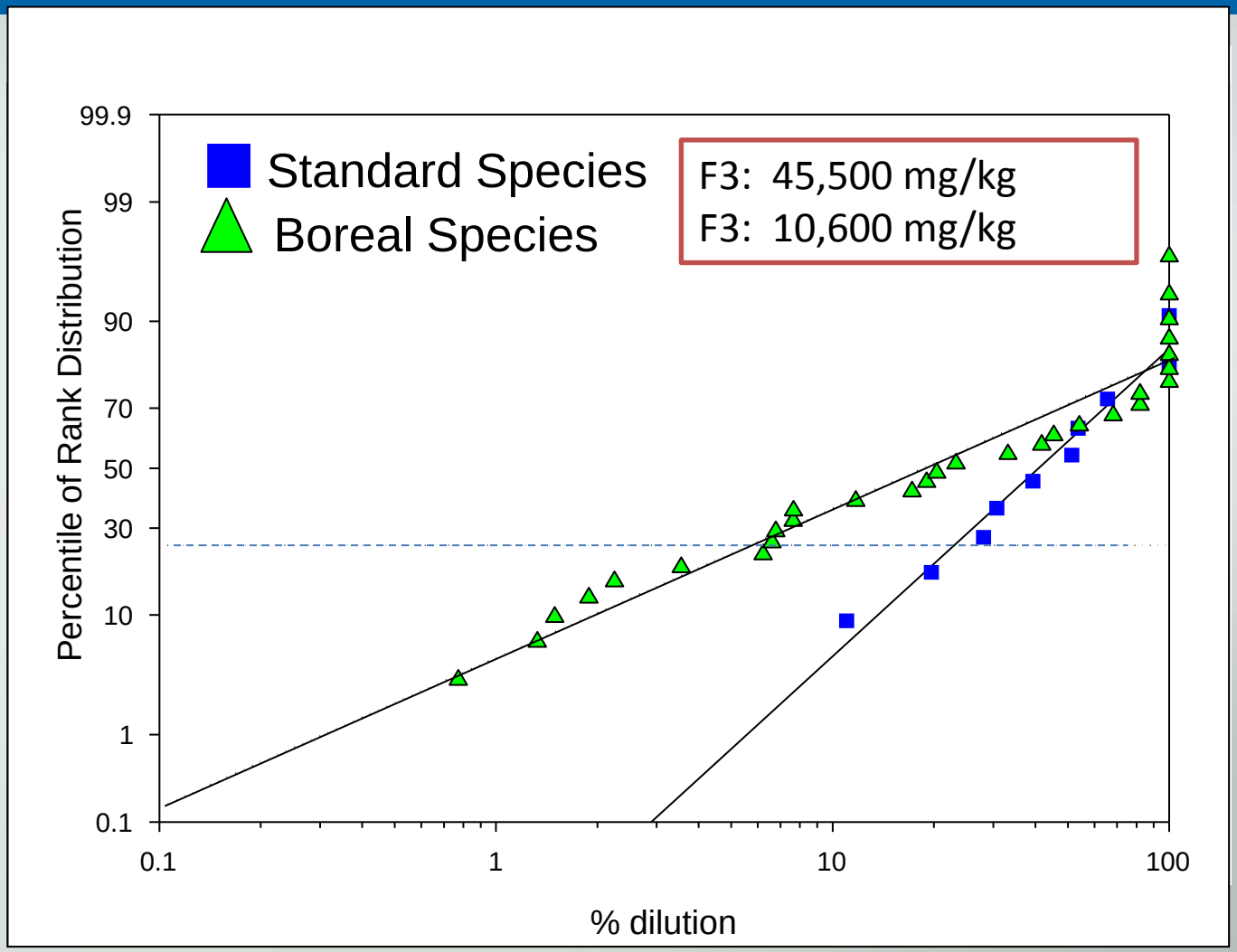
Species sensitivity distribution



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Research Goal – Soil Test Method Development (ecological-relevance & applicability)

- ☑ Collected reference and contaminated soils representative of Canadian boreal, northern and wetland regions
- ☑ Established cultures of candidate soil invertebrate species and seed sources
  - Taxonomic verification – traditional and genetic sequencing methods
  - Initiated soil toxicity test method development using reference soils
  - Discovered that some species performance is limited in some soil types; we need to define limits of non-contaminant factors so that appropriate test batteries can be developed for soil-species scenarios
- ☑ Ongoing development of test method using established wetland plant species
- ☑ Completed guidance document on collection of contaminated soils for site-specific risk assessments using biological tests

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Future Goals:

Complete development of ecologically-relevant tools for site assessments and evaluation of remedial techniques

- Boreal and taiga terrestrial plant species (published 2013); wetland plant species (2014)
- Soil invertebrate species in 2013 (collembolan) and in 2014 (earthworm and mite)
- Soil microbial tests (2014)
  - Evaluation of effects on biomass, activity, diversity and community structure in natural consortium

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Questions?

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