From Theory to Practice – The Do's and Don'ts of Spill Response and Follow-up Risk Assessment / Risk Management Actions at Saline Water Release Sites in Boreal Peatland Environments

Remtech

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Outline

1. **Background:** Context and Issues – saline water releases to boreal wetland ecosystems
2. **Environmental Context:** Not all boreal wetlands are created the same – hydrology and emergent function
3. **Exposure and Effects:** Salinity thresholds for effects on wetland mosses and plants
4. **Risk Management Implications:** So what? Spill response, pragmatic remediation approaches that advance reclamation goals, and those that don't

1. BACKGROUND

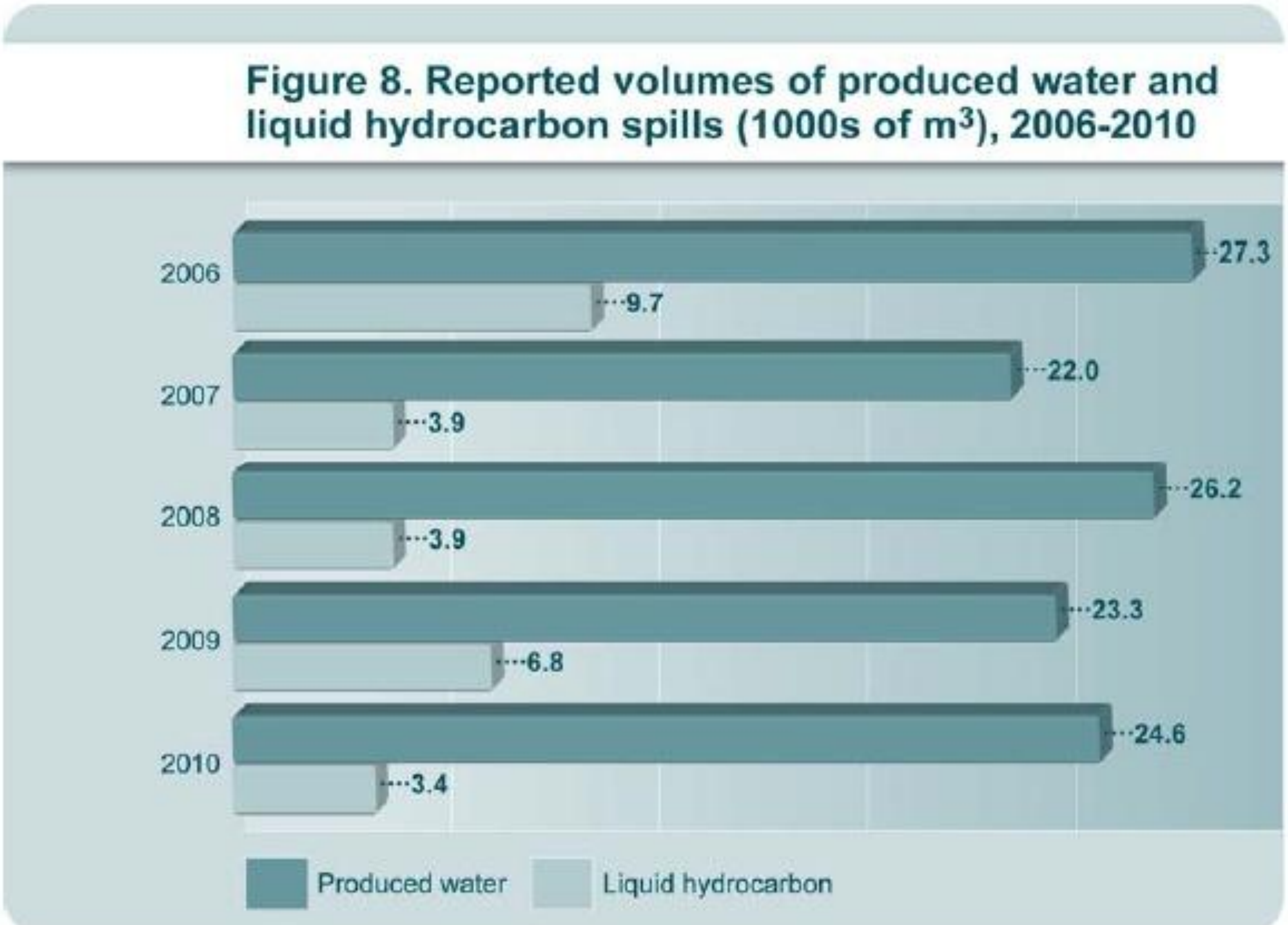
- **Large proportion of N. American oil and gas production fields located within the northern boreal forest;**

- **Peatlands are important component of boreal forest, with ecological features that have similarities and differences from both terrestrial and open aquatic habitats.**

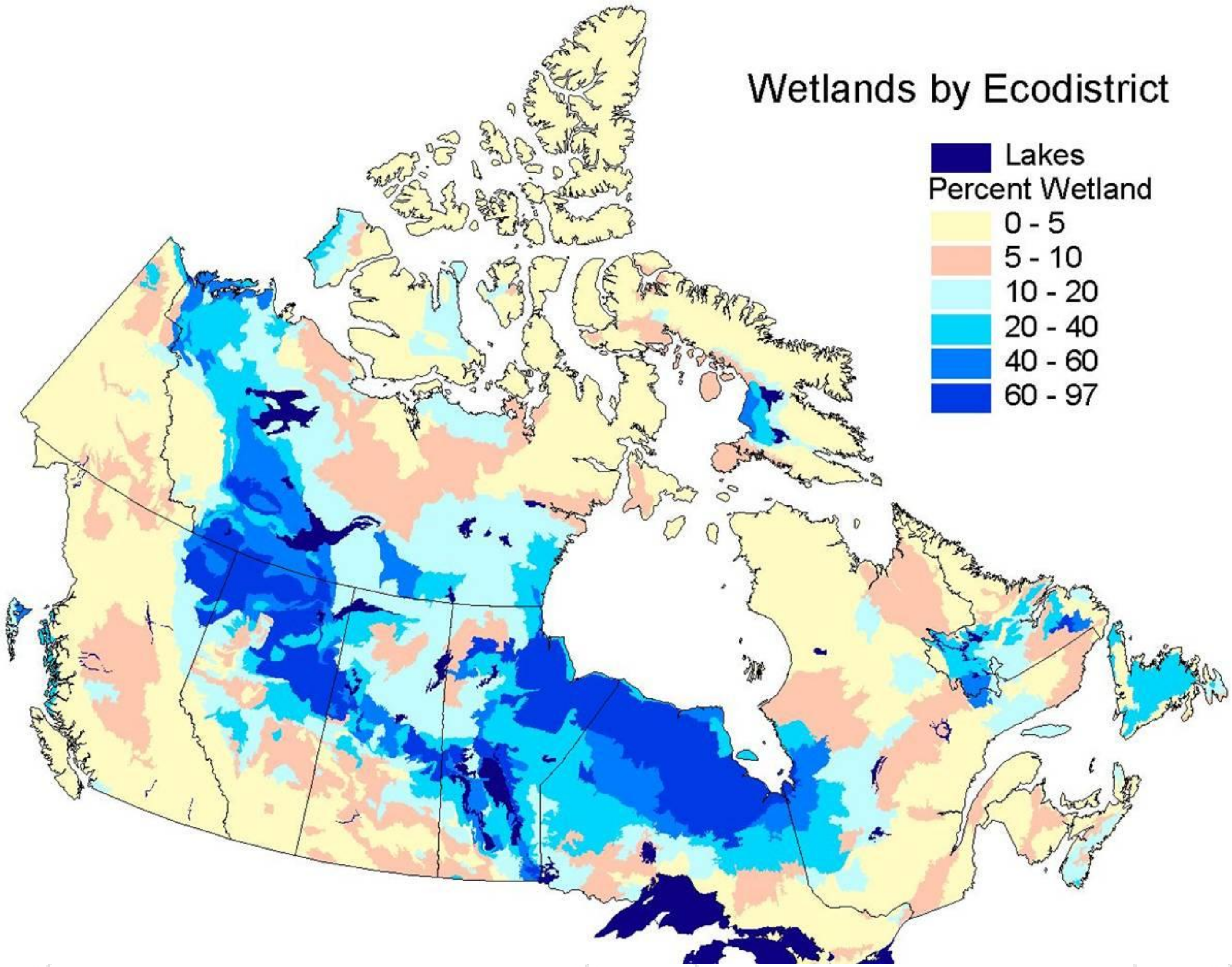
- **Produced water, which can be highly saline, is commonly released in upstream oil and gas areas, especially as a result of breaks in emulsion pipelines, disposal in sumps, and blow-outs.**

The History of Oil Pipeline Spills in Alberta, 2006-2012

(http://www.seankheraj.com/?p=1257)



Julienne Morissette (20060. Living on the Edge: The Effects of Multiple Disturbances On Wetland and Riparian Associated Bird Communities
(http://www.ualberta.ca/~ahamann/teaching/renr690/class2006/Julienne/intro.html)



PTAC/CAPP Wetland Salinity Working Group: Development of environmental risk based guidance for the remediation of salt-affected boreal wetlands.

Phase I:
Literature Review

Key geochemical and ecological characteristics of peatlands

Toxicity of salt ions to peatland flora and fauna

Phase II:
Field Studies –

Vegetative and soil mesofaunal changes at boreal peatland field sites from produced water spills

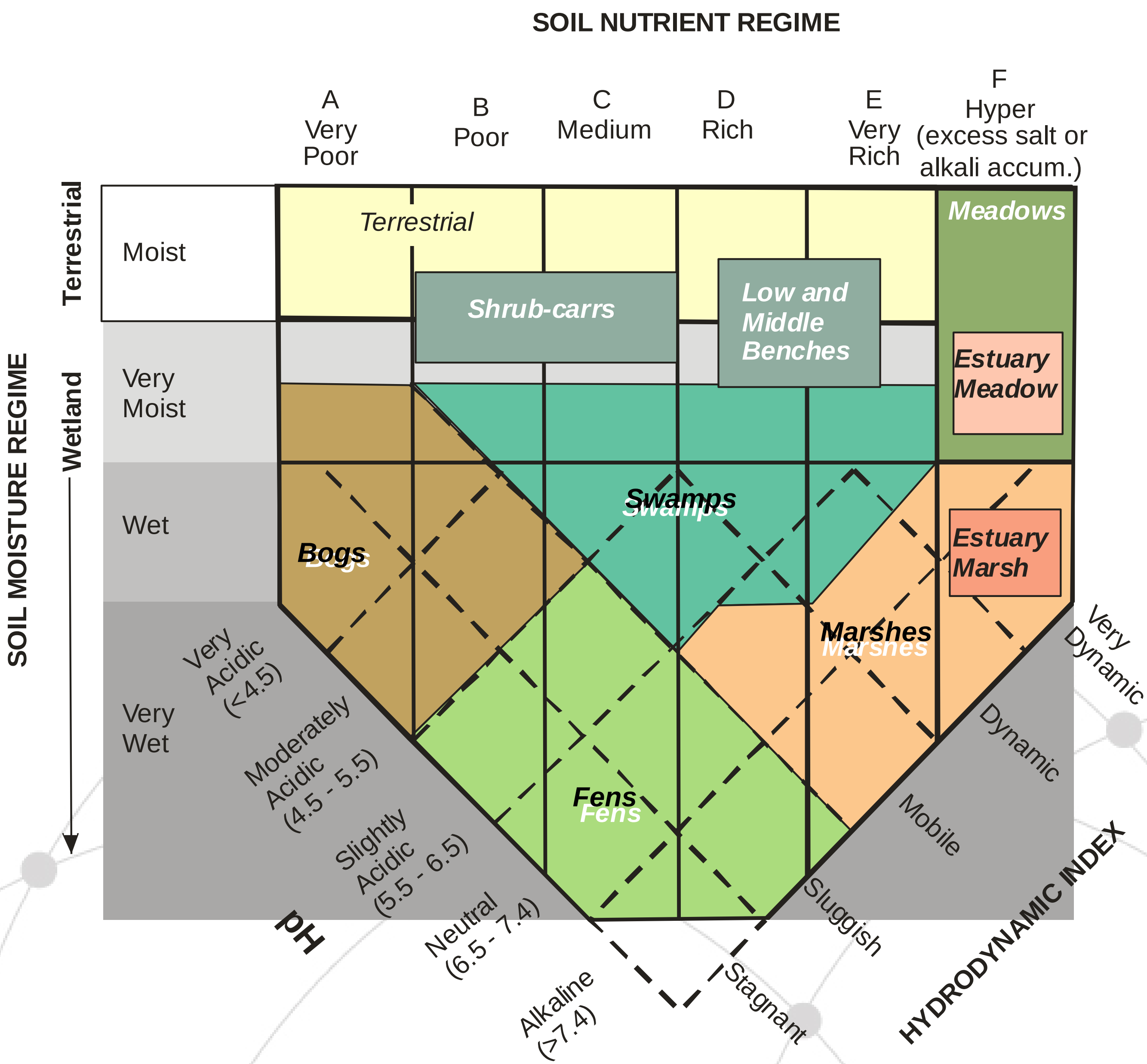
Phase III:
Pragmatic Guidance

Practical guideline for completing ecorisk-based spill response/ site remediation

2007 **2008** **2009** **2010-11**

CAPP, AEnv, AUPRF, PERD funding

2. ENVIRONMENTAL CONTEXT



Water movement:

- Lateral
- Vertical

Geochemistry:

- Mg, Ca resupply
- Ion depletion

Acidification

Peat (detrital organic matter) **accumulation**

Natural fate of major ions is proxy for anthropogenic salt ion inputs

Key Issues

1. **Hydrology -** Peatlands depend on consistent, long-term water supply either from local recharge (ombrogenous), or base flows/groundwater (geogenous)

2. **Chemistry and nutrient supply/flux –** exist along an oligotrophic eutrophic gradient

3. **Diversity** of various floral and faunal groups various across wetland types. Expectations for ecological conditions post-reclamation should also vary

4. **Remediation** should leave sites in a state such that salt ions would not inhibit especially peatland moss and plant colonization and successional processes/sequences that would otherwise be a major structural and functional determinant of the wetland ecosystem type(s) that the site is situated in or near

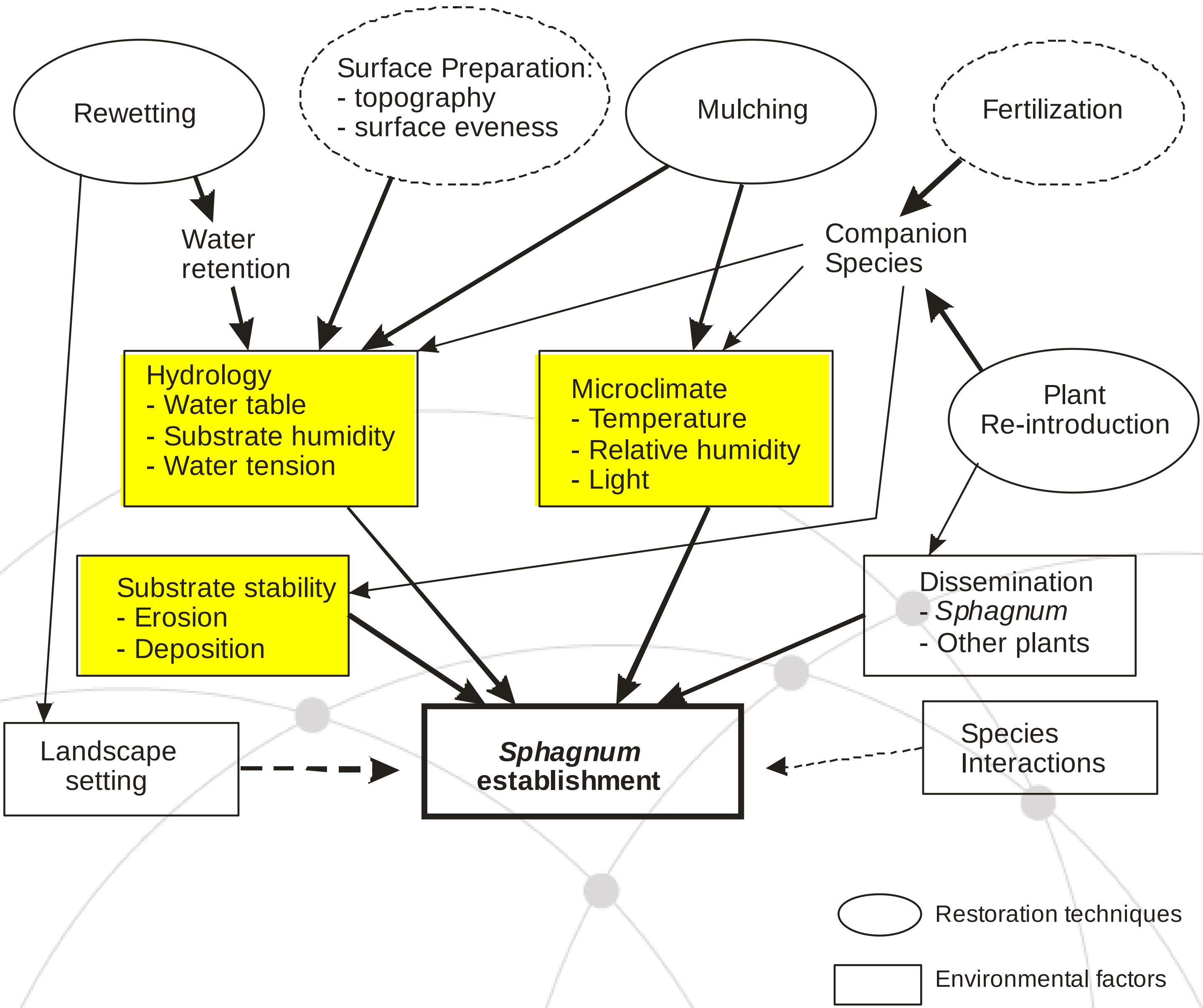
5. **Role that peatland <u>fauna</u> play** in modifying vegetative and hydrogeomorphic form and function is not clear (little scientific research)

- Peatland remediation/restoration should lead to proper ecosystem functioning, and continuation of the natural succession of bog formation, although restoration of complex wetland ecosystems to their former patterns is almost impossible

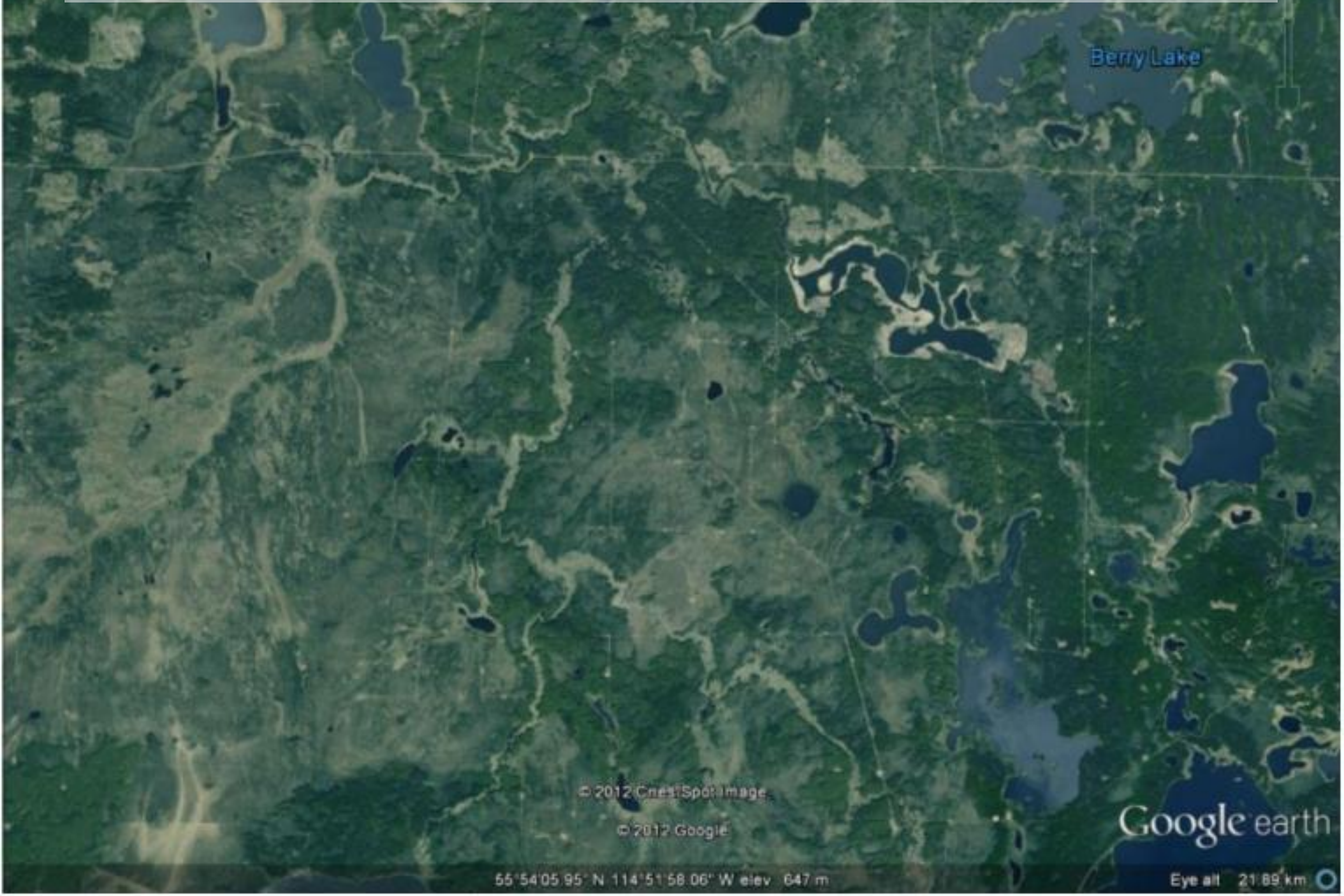
- Restoration should seek to re-establish plant cover by *Sphagnum* or brown mosses depending on the substrate minerotrophy as well as the hydrological regime typical of peatlands (Rochefort, 2000).

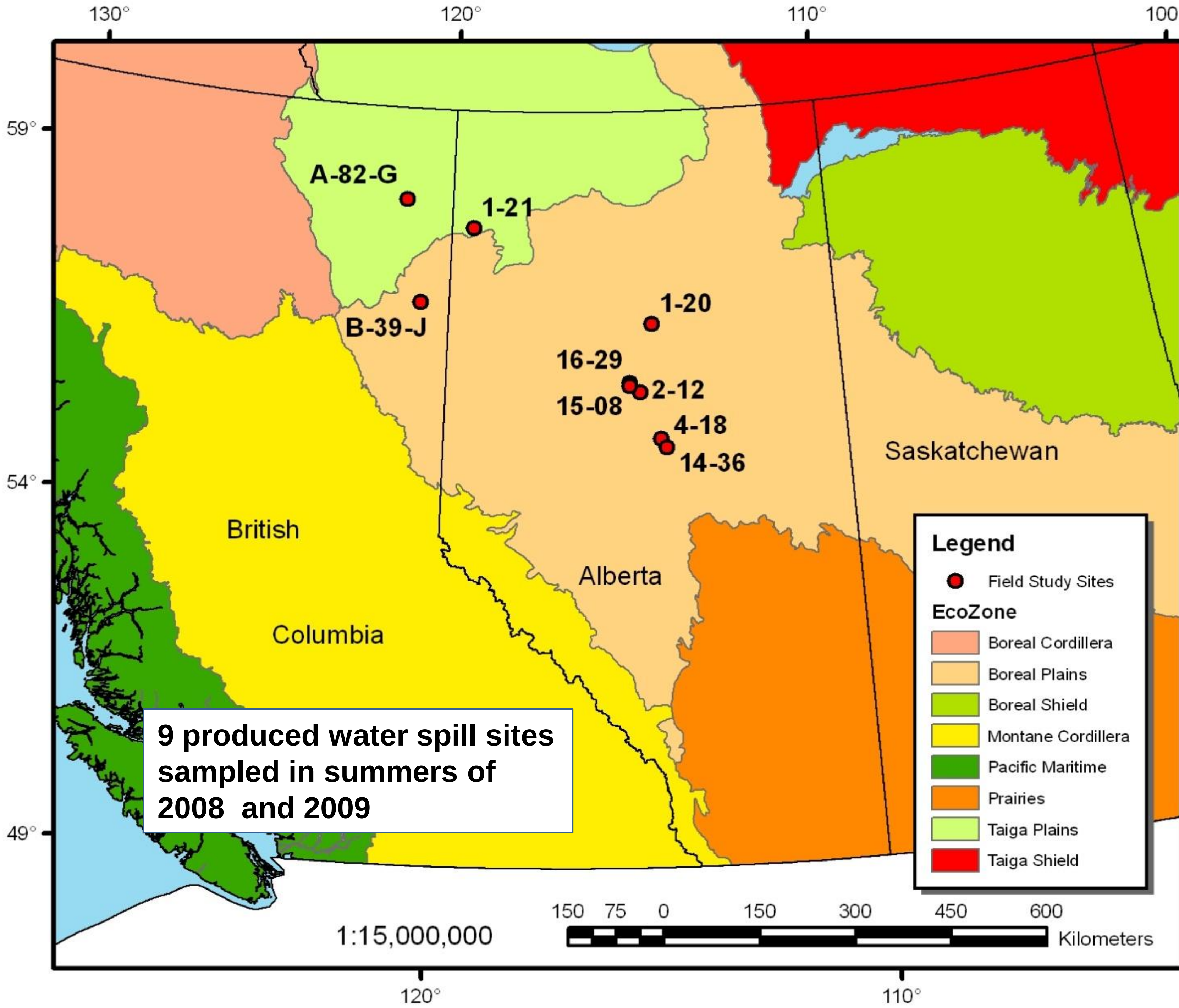
- General goal is to return the degraded peatland to wetland ecosystems such that over time and though plant succession, these wetlands should lead back to peat-accumulating ecosystems (Wieder and Vitt, 2006).

Factors affecting the success of *Sphagnum* establishment on bare peat substrates (Adapted from Rochefort, 2000).



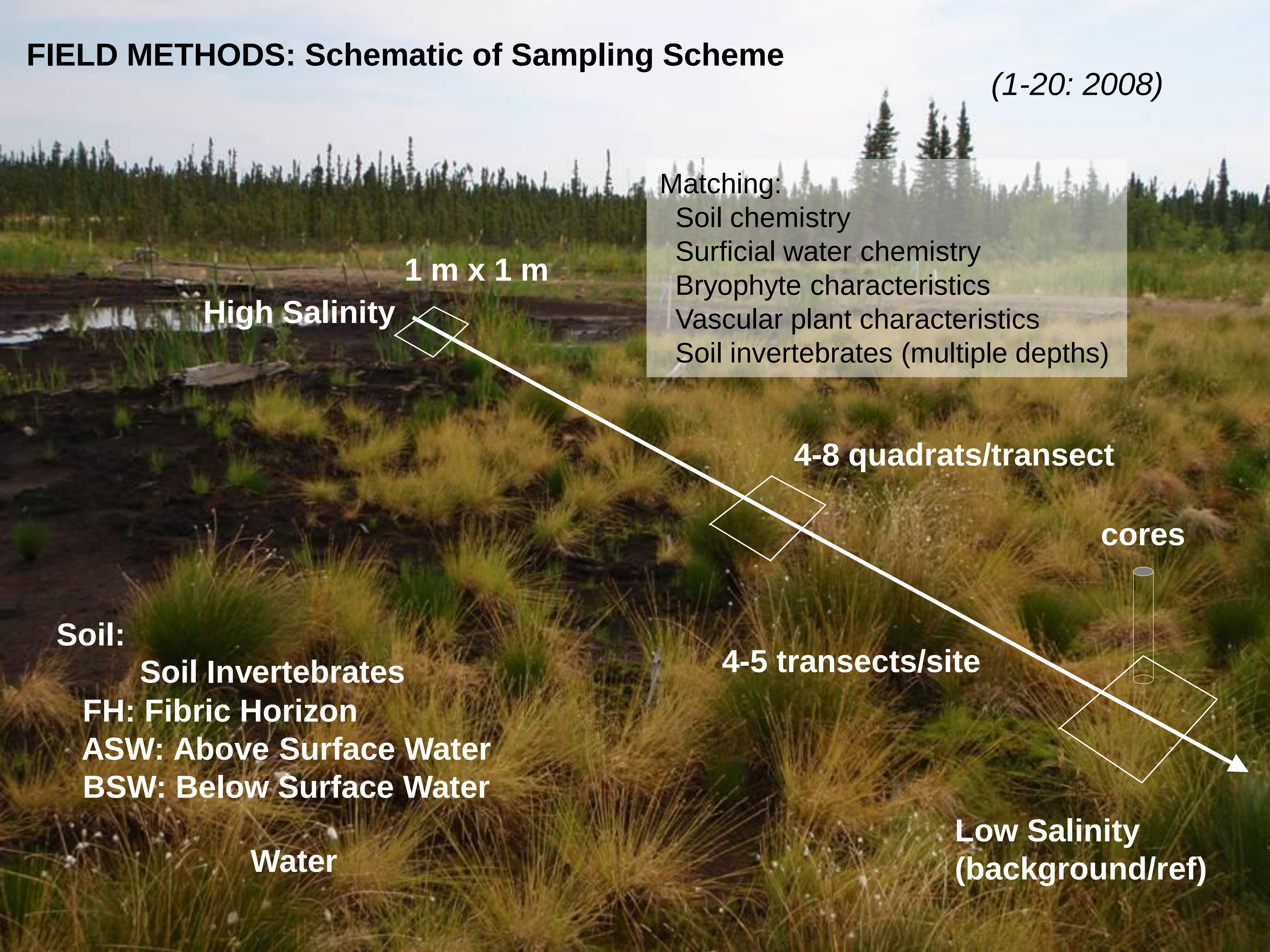
3. EXPOSURE AND EFFECTS



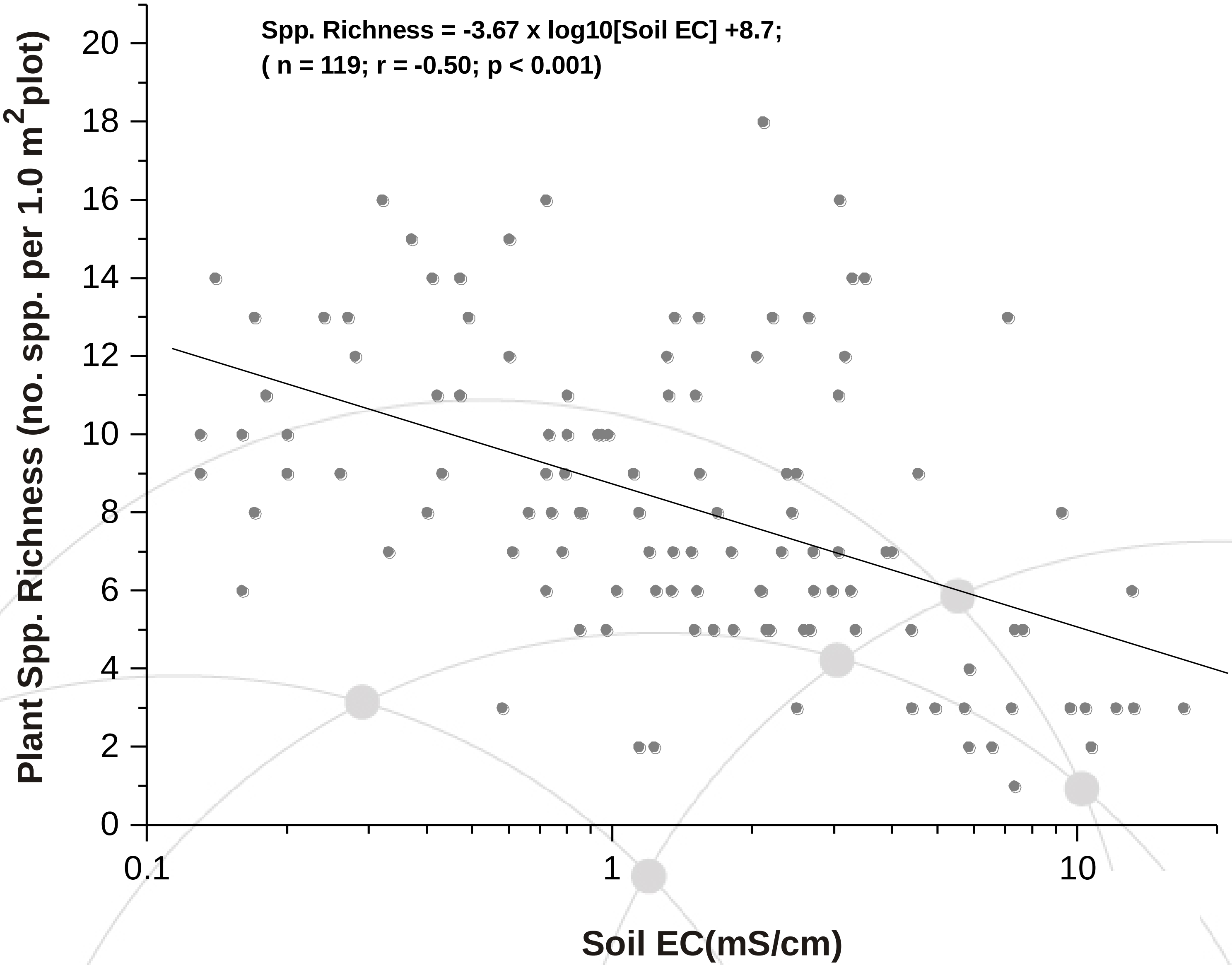

130°
120°
110°
100°
59°
54°
49°
A-82-G
1-21
B-39-J
1-20
16-29
2-12
15-08
4-18
14-36
Saskatchewan
British
Columbia
Alberta
Legend
Field Study Sites
EcoZone
Boreal Cordillera
Boreal Plains
Boreal Shield
Montane Cordillera
Pacific Maritime
Prairies
Taiga Plains
Taiga Shield
9 produced water spill sites sampled in summers of 2008 and 2009
1:15,000,000
150 75 0 150 300 450 600
Kilometers

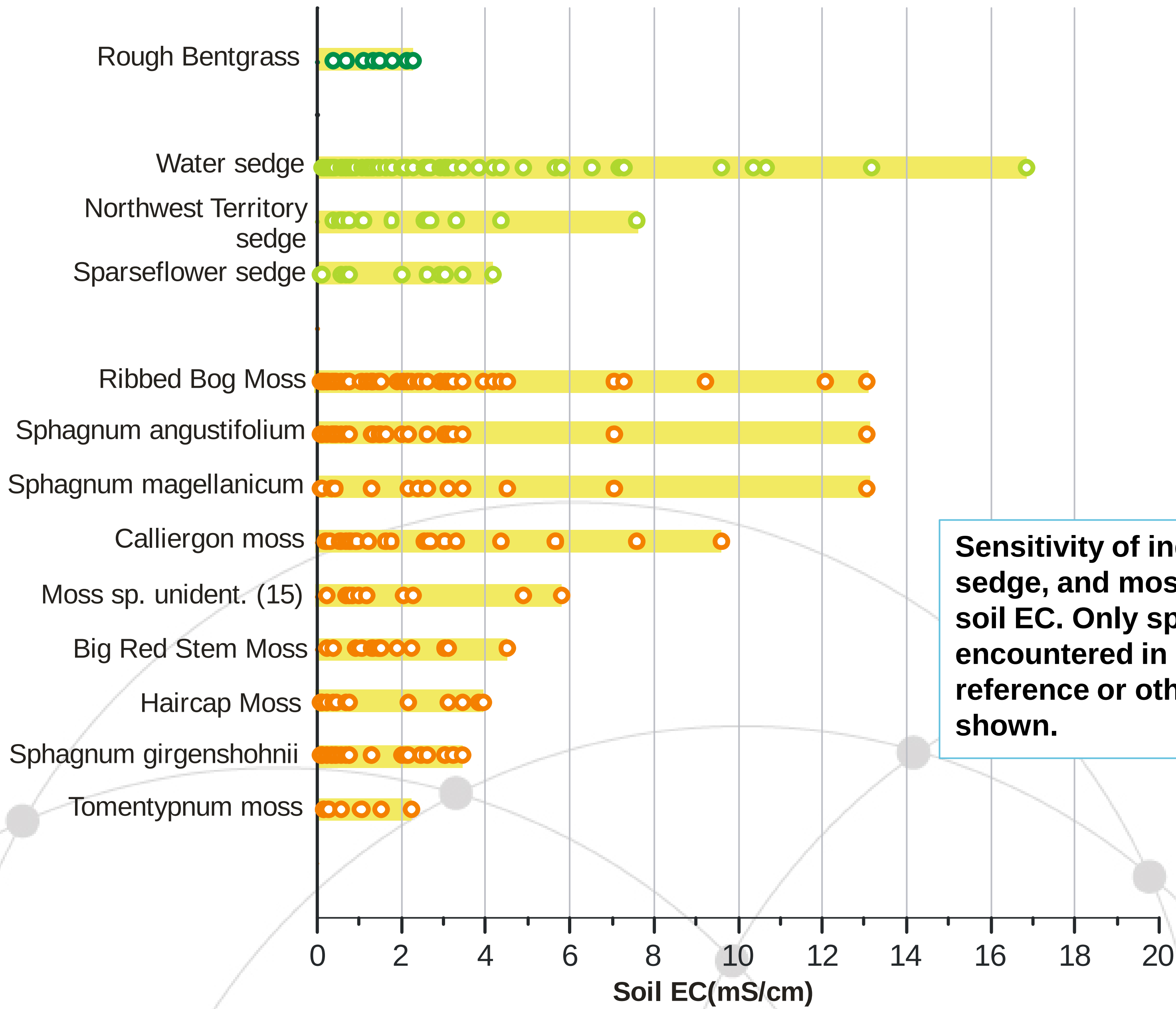
FIELD METHODS: Schematic of Sampling Scheme

(1-20: 2008)

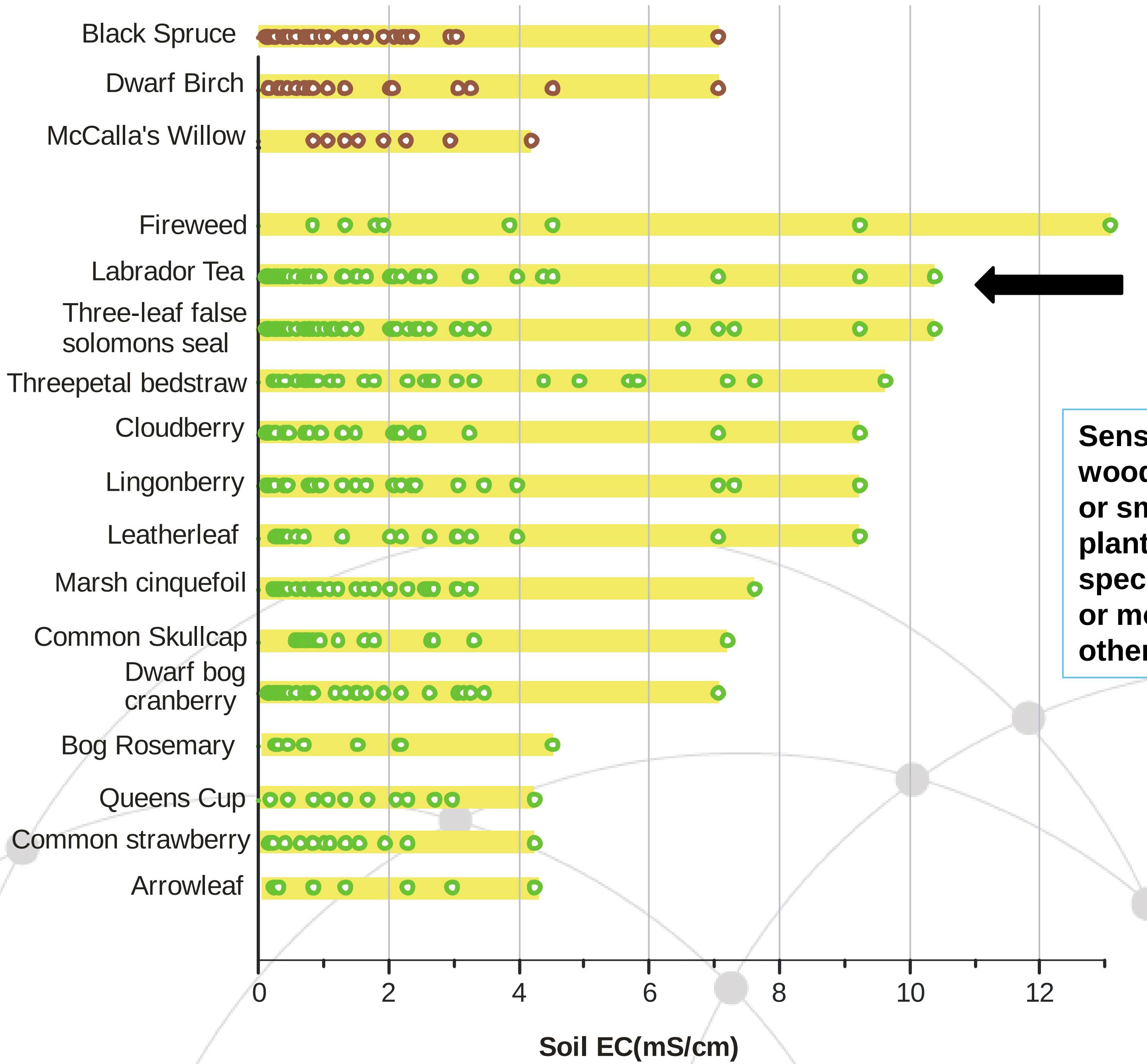


Overall relationship between soil salinity, as EC, and plant/ bryophyte species richness.

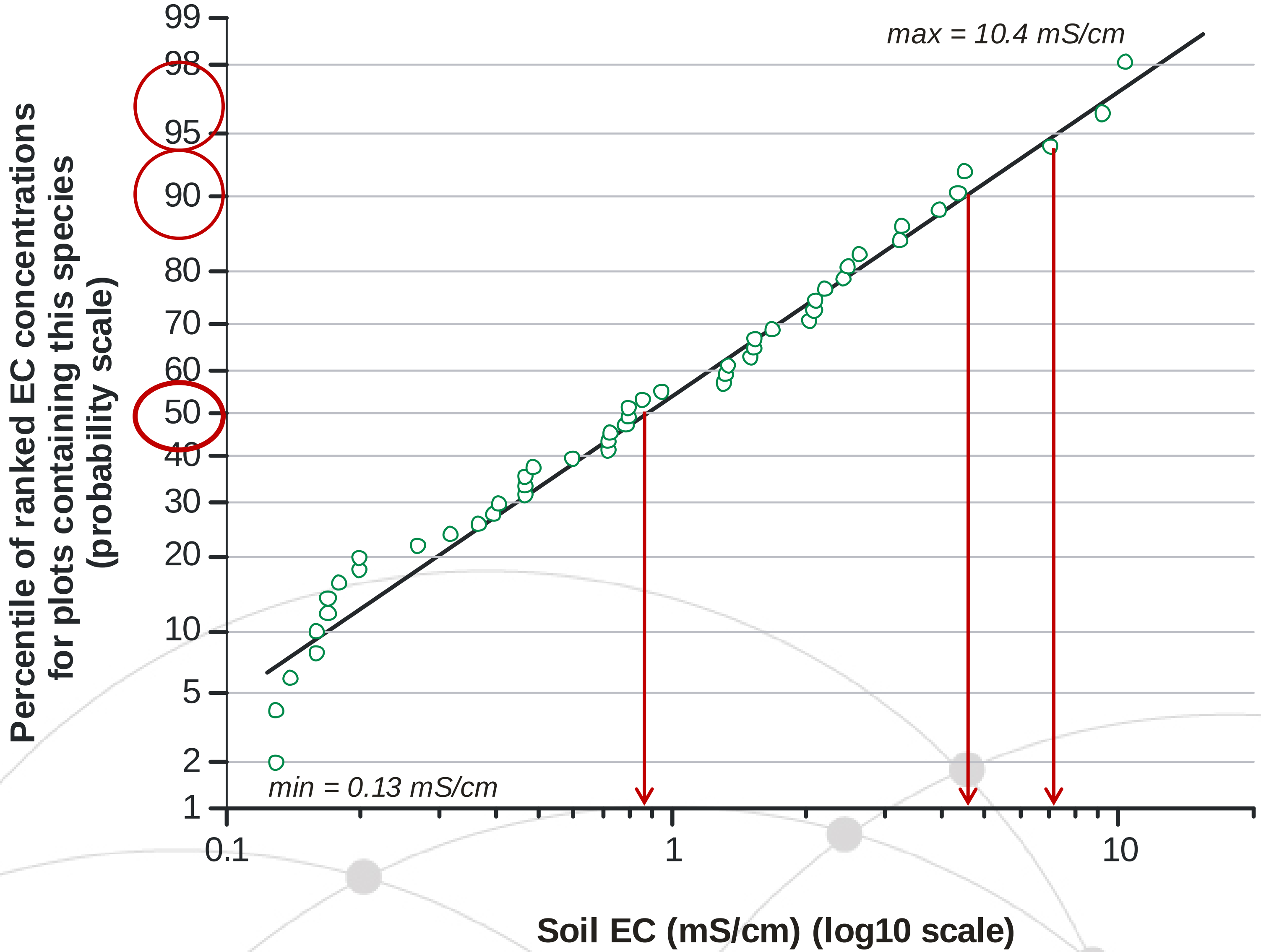




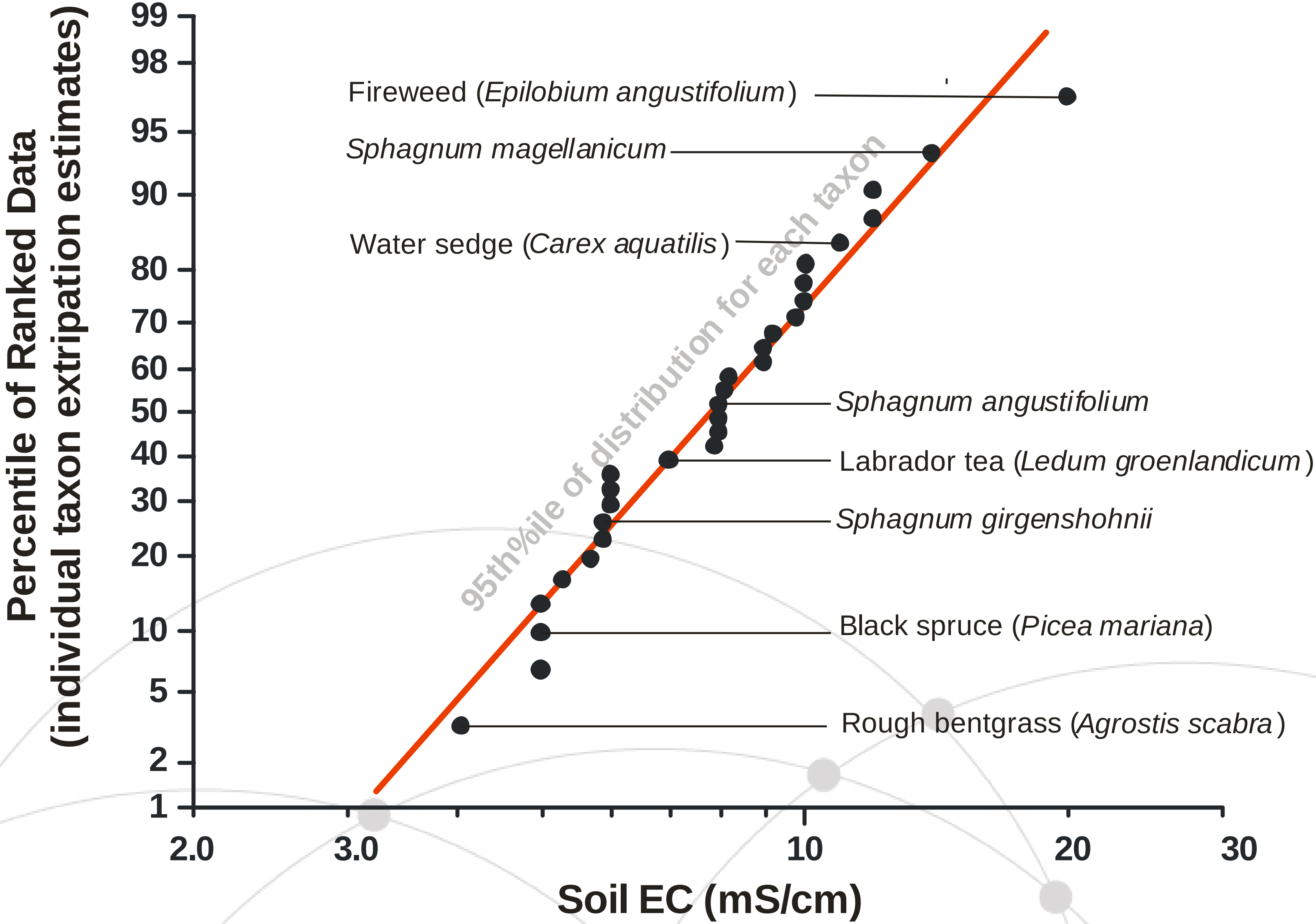
Sensitivity of individual grass, sedge, and moss species to soil EC. Only species encountered in 8 or more reference or other plots are shown.



Sensitivity of individual woody shrubs and trees or smaller vascular plants to soil EC. Only species encountered in 8 or more reference or other plots are shown.



Cumulative frequency distribution for occurrence of Labrador Tea (*Ledum groenlandicum*) relative to soil salinity



New information on relative sensitivity of different taxa is directly relevant for assessing degree of site impairment and recovery

4. RISK MANAGEMENT IMPLICATIONS

From the more theoretical to the practical

INITIAL RELEASE STAGE

Maximize recovery of contaminant mass in immediate release area (source control), while minimizing other disturbances detrimental to wetland restoration goals.

DELINEATION, ASSESSMENT, RISK ASSESSMENT

Understand what ecological receptors are at risk. Establish the short-term zone of impact (impacted baseline)

MONITORED ATTENUATION ACTIVE REMEDIATION / RISK MANAGEMENT

Understand the expected ecosystem trajectory relative to reclamation goals. Evaluate the pros and cons of more active versus more passive approaches.

RECLAMATION AND RESTORATION

Confirm that contaminant-related barriers to wetland succession and function are no longer present.

Rule 1:
Minimize landscape disturbance !!

- Physical disturbances such as stripping, excavation, trenching, or water diversions invariably create new impediments to wetland restoration while attempting to reduce contaminant-related impediments – especially for peatland systems (bogs and fens)
- Applies to all stages of response.
- Wetland structure, function, and ecological succession are strongly linked to the existing site hydrological conditions.
- Salt mass recovery achieved by pumping from one or a few bell holes is good. Massive soil disturbance is bad.
- Excessive removal of water (while recovering diminishing amounts of salt ion) is also bad.

Rule 2:
Know the spill/release site !!

Not all peatlands or wetlands are created equal:

Understanding the site hydrology & hydrogeology can tell us whether spill response needs to be more aggressive (is there a chance of contaminant transport into fish-bearing waters), and when aggressive approaches may be counter-productive.

You don't need to be a hydrologist, hydrogeologist, or wetland ecologist to understand your site adequately, nor do detailed site-specific studies:

The existing landscape is a product of the water movement regime, and understanding the wetland type and association with the larger watershed gives you the information you need to predict how a produced water release will behave over time, and to respond accordingly.

Rule 3:
Stop and ask - *What am I concerned about?*

Depending on the wetland type and position within the larger watershed, environmental protection and restoration will tend to focus on two major issues:

1. Aquatic life – i.e., in larger, standing water (shallow lentic systems) and running water (lotic systems).

2. The major landscape forming bryophyte species, as well as the dominant vascular plants that support other types of life and ecological productivity in muskegs (bogs and fens).

In rare instances, I made need to be concerned about a beneficial use aquifer and drinking water.

The remedial objectives will be different depending on which of these three issues are relevant.

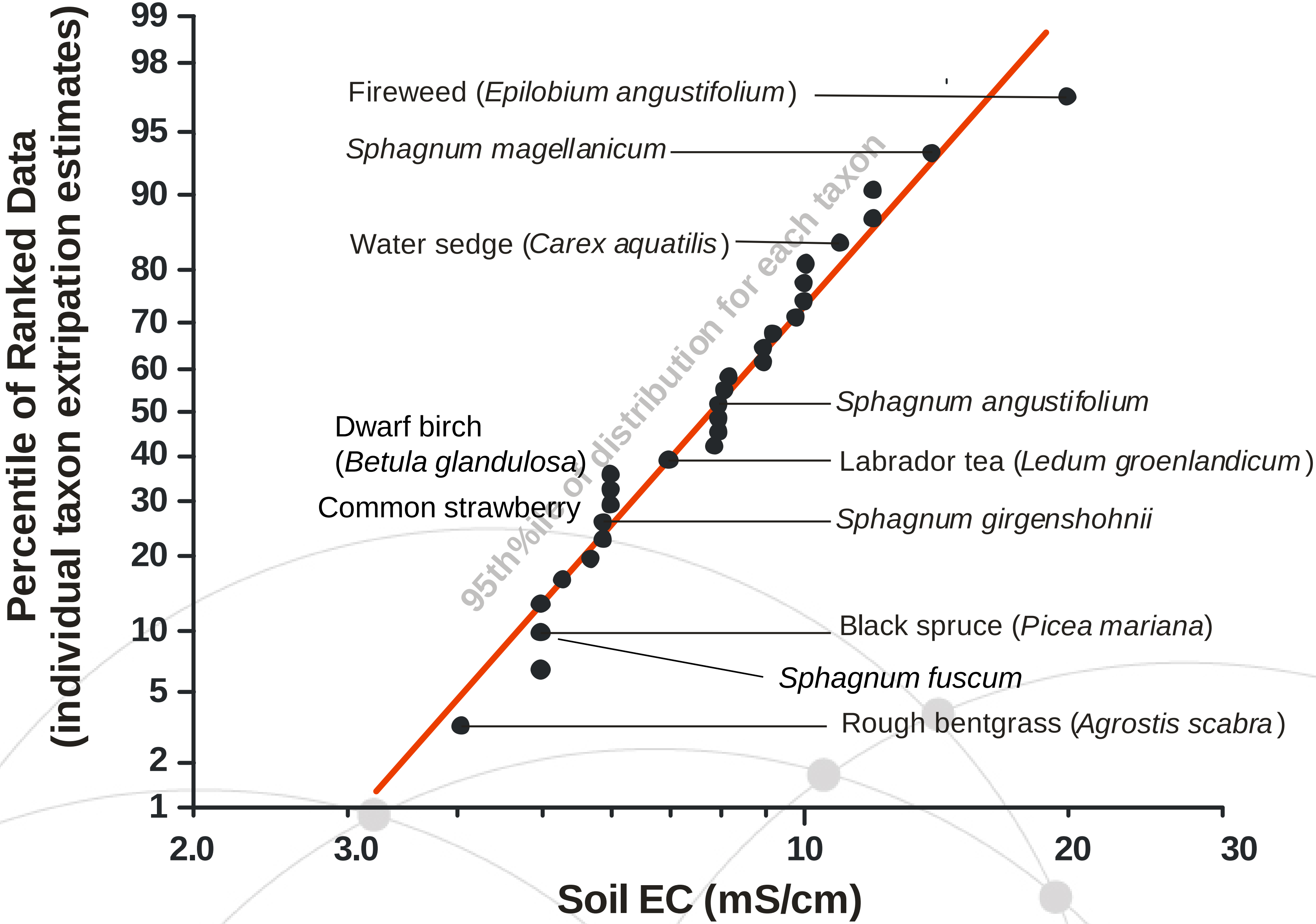
Rule 4:
Understand the relevant contaminant fate processes

Will the problem take care of itself? *If residual salt ion contamination remains, what will happen?*

- *What are the potentially viable salt attenuation mechanisms for this type of wetland, and what does this mean for my site?*
- *If I leave the site to recover through more passive (monitored) natural attenuation, do I run the risk of having the zone of ecological impact increase?*
- *How long is it likely to take for the site to recover?*

Rule 5:
The wetland vegetation response will guide us home !

- If left in an otherwise undisturbed state, the effectiveness of mass recovery (via bell hole extractions) can be discerned from the status of Sphagnidae, other bryophytes, and commonly occurring vascular plants within the fringe areas.
- We now have a good feel for the relative sensitivity of a large number of boreal wetland moss and plant species to salinization.
- It is relatively easy to support this with additional site-specific information from observations of vegetative status along salinity gradients resulting from the release.
- The presence or absence of relatively sensitive species, such as black spruce seedlings, tells us a lot about whether the current exposure concentrations would be an impediment to further succession, and to reclamation goals.



New information on relative sensitivity of different taxa is directly relevant for assessing degree of site impairment and recovery

Conclusions

- **Saline releases to wetland and especially peatland sites need to be managed (via source control, assessment, monitoring) to facilitate reclamation objectives – based on vegetation.**

- **Recent work completed to develop bryophyte/plant species sensitivity distribution for salt exposure.**

- **Use of five simple rules should further improve environmental management objectives for such sites, while reducing potential for unintended set-backs.**

Questions? Thank You!

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