

Short And Long-term Effects Of Winter Seismic Exploration On Low-Arctic Plant Communities



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Overview

- *Background*
- Project Objectives
- Methods
- Results: Recent Exploration
- Results: Older Exploration
- Conclusions
- Future Directions



Arctic Plant Communities

- Constrained by:
 - Short growing season
 - Low temperatures
 - Cold, nutrient poor soils
 - Shallow active layer
- Floristically depauperate
 - Small pool of colonizers



Arctic Plant Communities

Sensitivity to Disturbance

- Complex interactions b/w permafrost, hydrology
- Steep gradients (esp. soil moisture)
- Slow rates of change
 - periglacial processes



Seismic Impacts Research

- Vehicle disturbance-ecology research in low-arctic:
 - Has typically followed development/exploration
 - Little has occurred since the 1970s in Canada
 - Most of what we know comes from Alaska 1980s



Seismic Evolution

Techniques & Technology Change

- Vehicle types, number of vehicles
- Energy source – dynamite or vibroseis
- Bulldozing of trails
- 2D vs. 3D

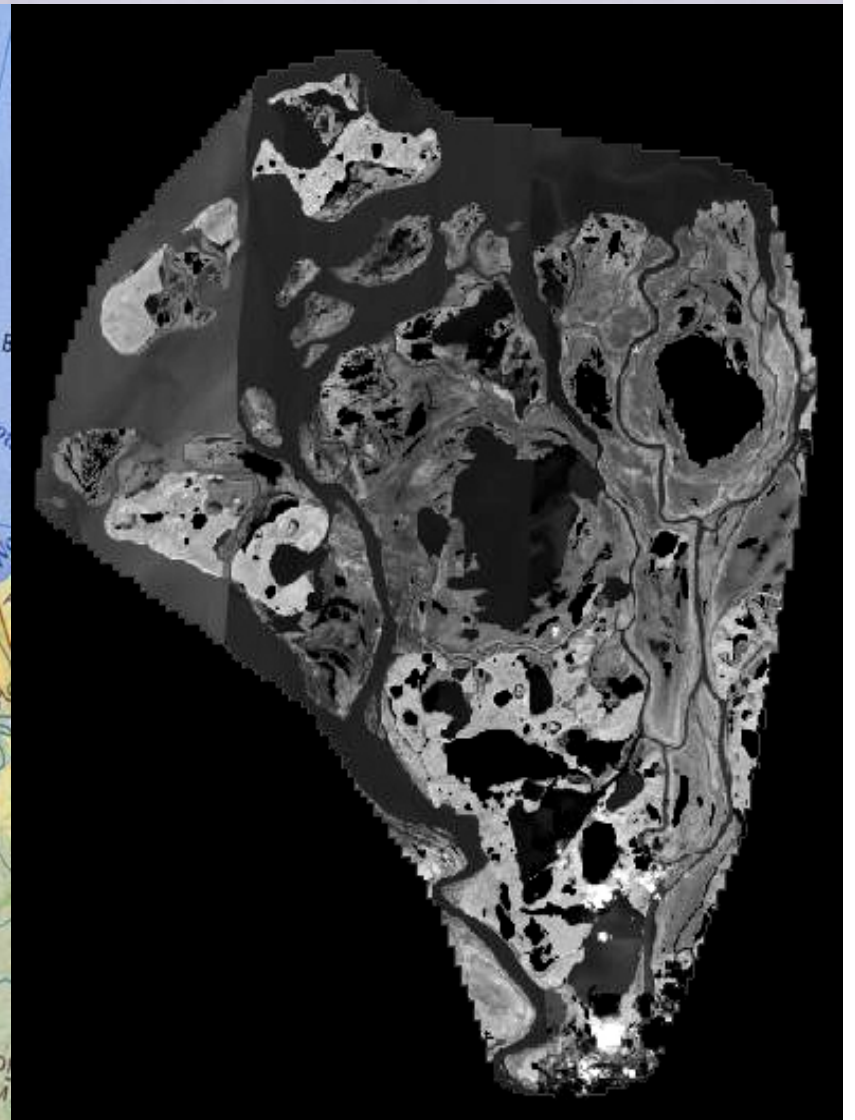


Research Objectives

1. Evaluate impacts associated with current exploration practices
2. Evaluate long-term effects of winter exploration from 1970s – 1980s
 - Not a chronosequence approach!

Study Area

Kendall Island Bird Sanctuary & Richards Island



Sampling



- 252 quadrats @ 43 sites
- Recent Exploration: lines in 2nd-3rd growing season
- Older Exploration: lines in 18th – 33rd growing season
- Paired design: seismic – control

Parameters

- Plant community composition
- Vascular plant diversity, richness
- Total cover of:
 - vascular plants by species
 - lichens, mosses
 - bare ground
- Soil and permafrost properties:
 - thaw depth
 - organic layer depth

Community Type: Medium Shrub - Heath



Community Type: Low Shrub - Heath



Community Type: Wet Graminoid Tundra



Community type: Tall Shrub - Herb



Analysis of Impacts

- Mixed linear models:
 - Change in soils, permafrost, cover

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_{k(j)} + \epsilon_{ijkl}$$

Treatment Site Treat*Site Su(site) Error

- Multivariate analyses:
 - Community composition

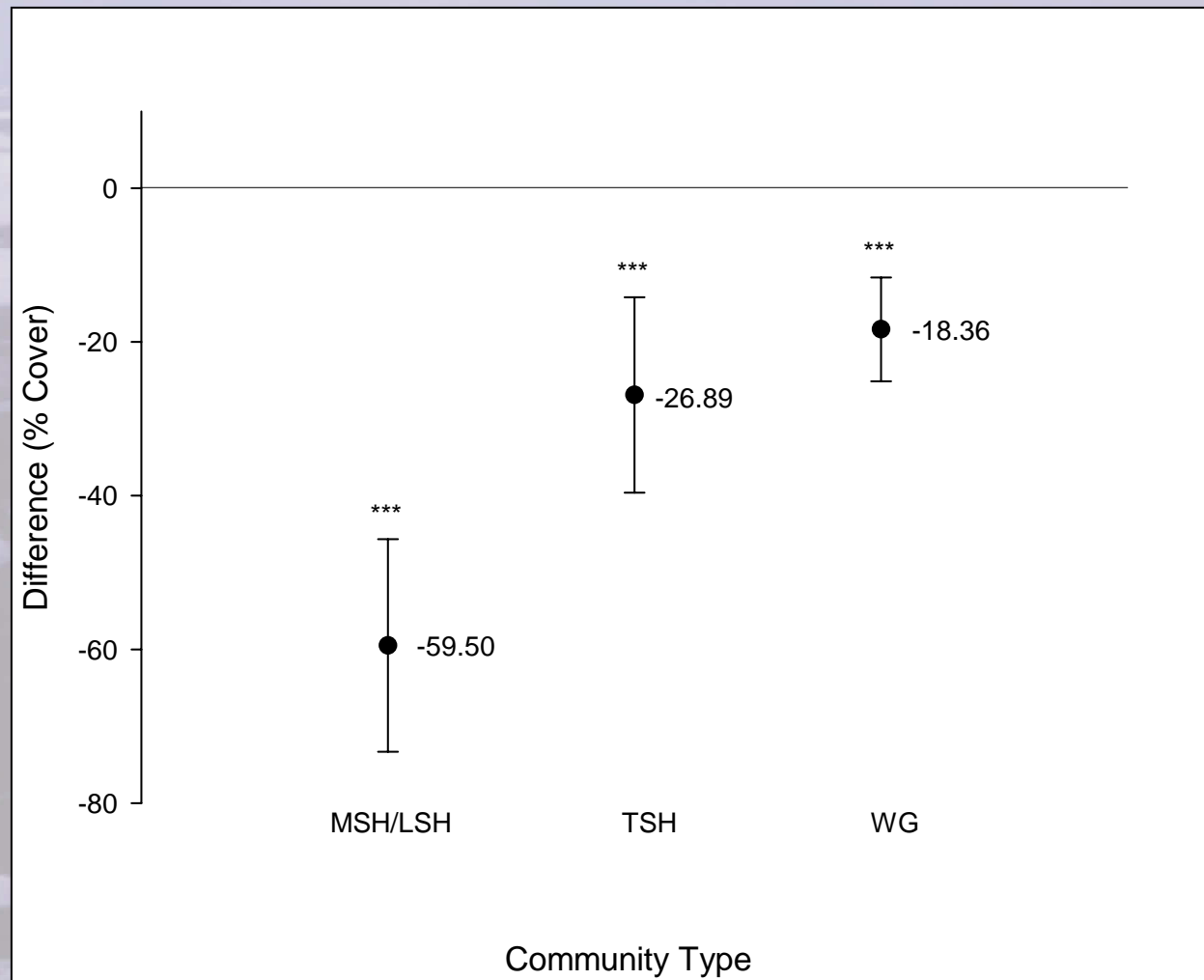
****used $\alpha = 0.1$ for all analyses**

Results – Recent Exploration

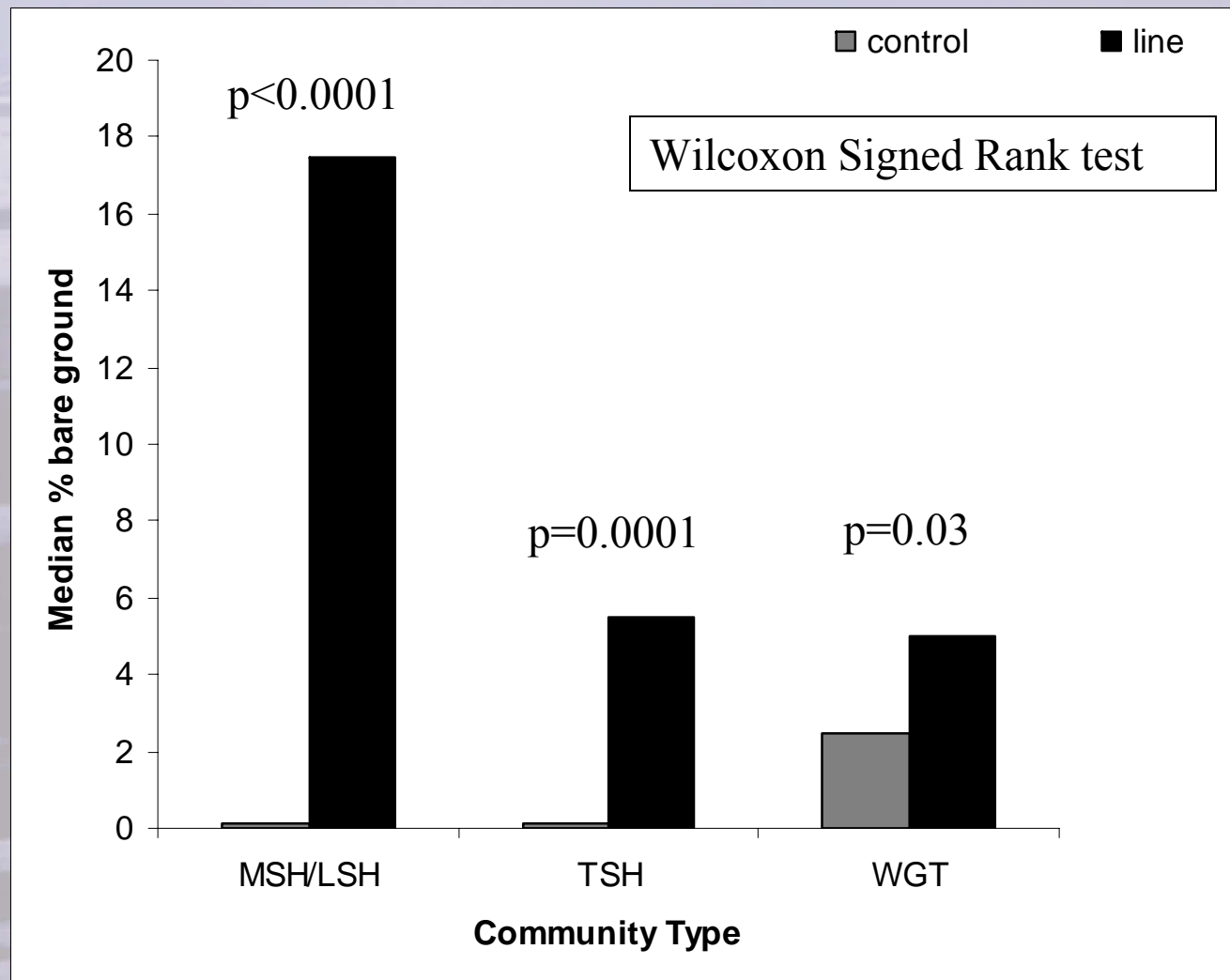
- 2 to 3 growing seasons post disturbance



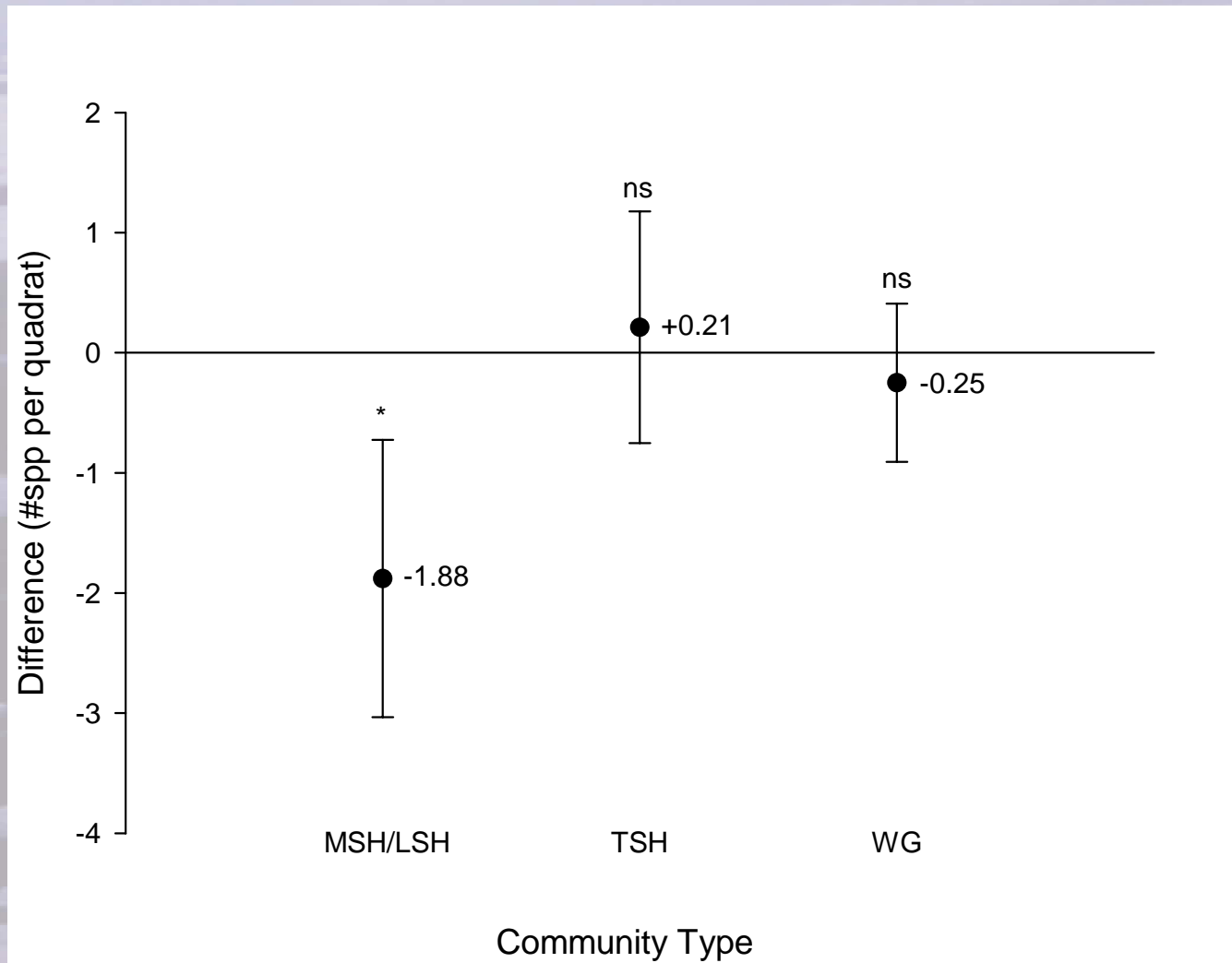
Vascular Plant Cover



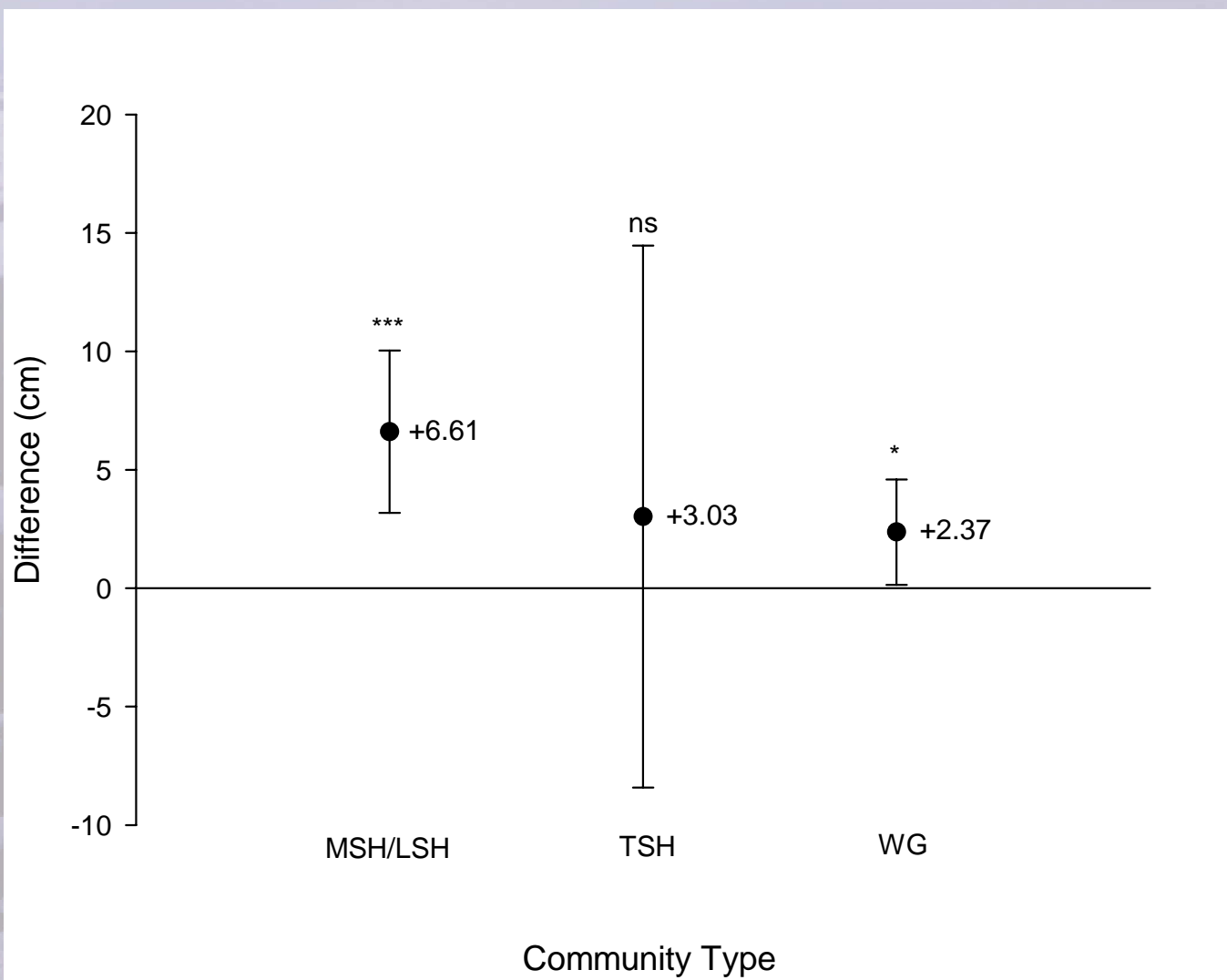
Cover of Bare Ground



Vascular Plant Richness



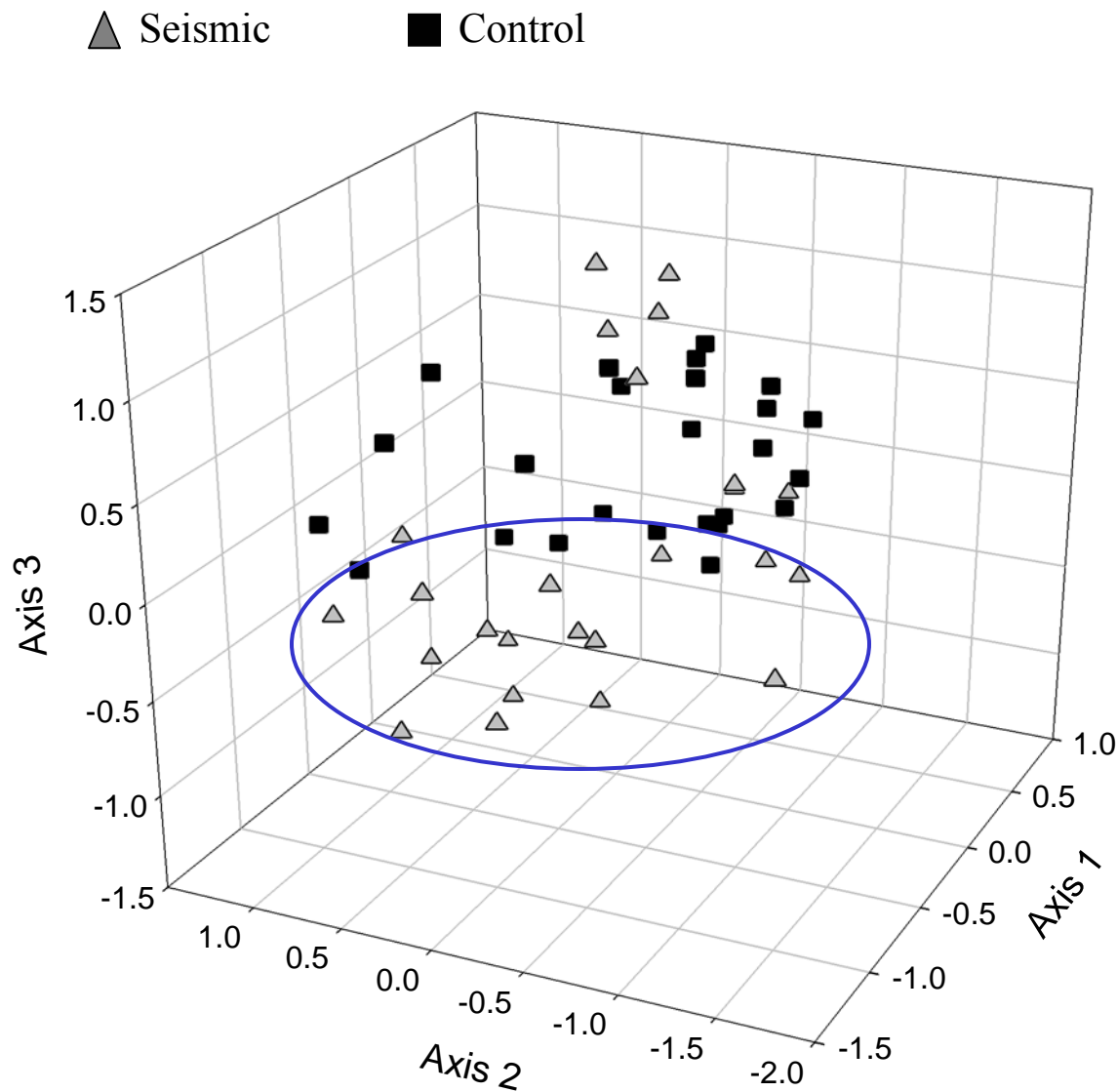
Thaw Depth



Community Composition

- Ordinations
- MRPP
- Indicator Species Analysis

Community Composition: Upland Communities (MSH & LSH)



Variance Captured:

83.4%

Final Stress:

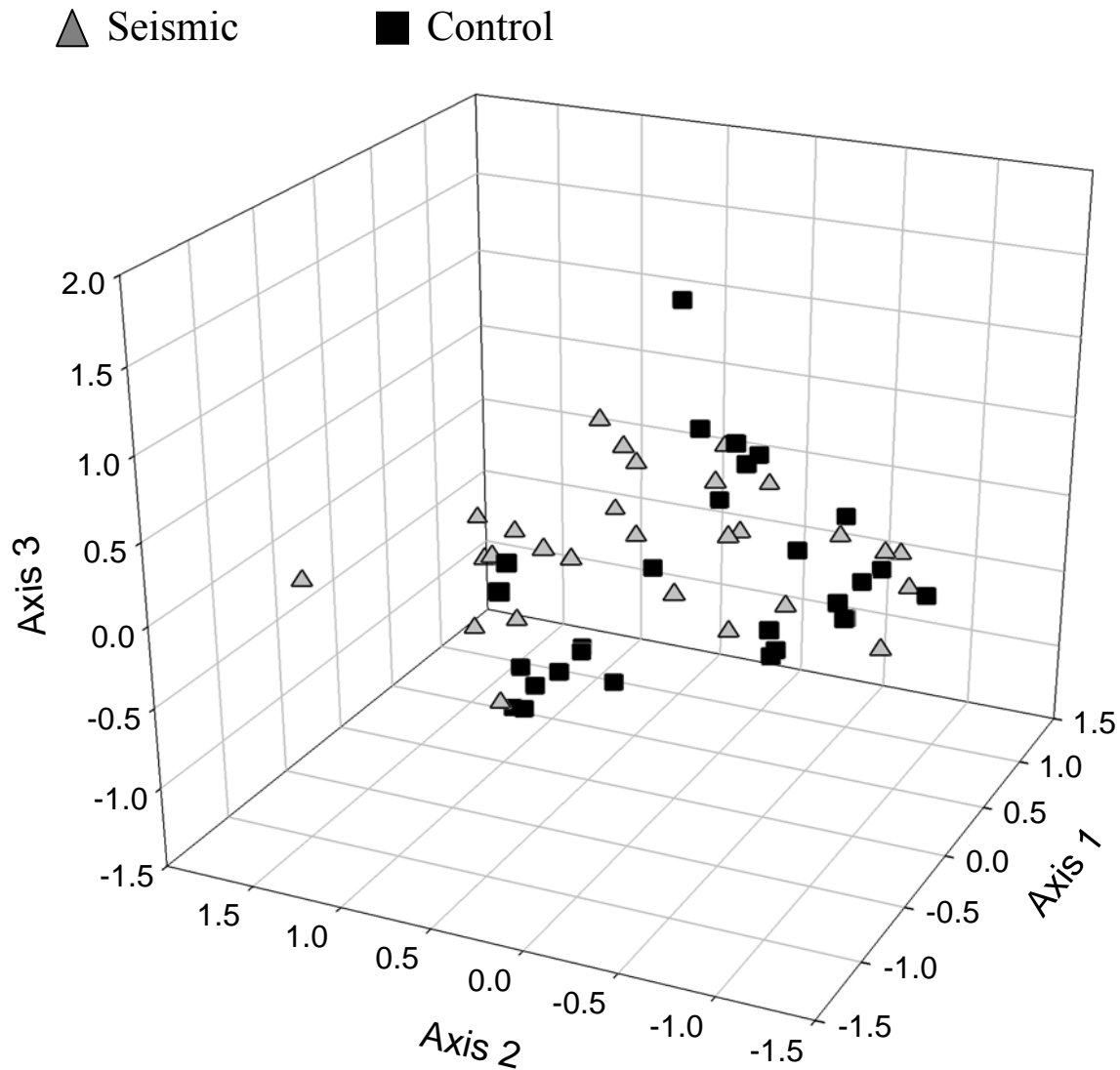
13.74

MRPP results:

$A=0.059477$

$P=0.001$

Community Composition: Tall Shrub – Herb communities



Variance Captured:

85.4%

Final Stress:

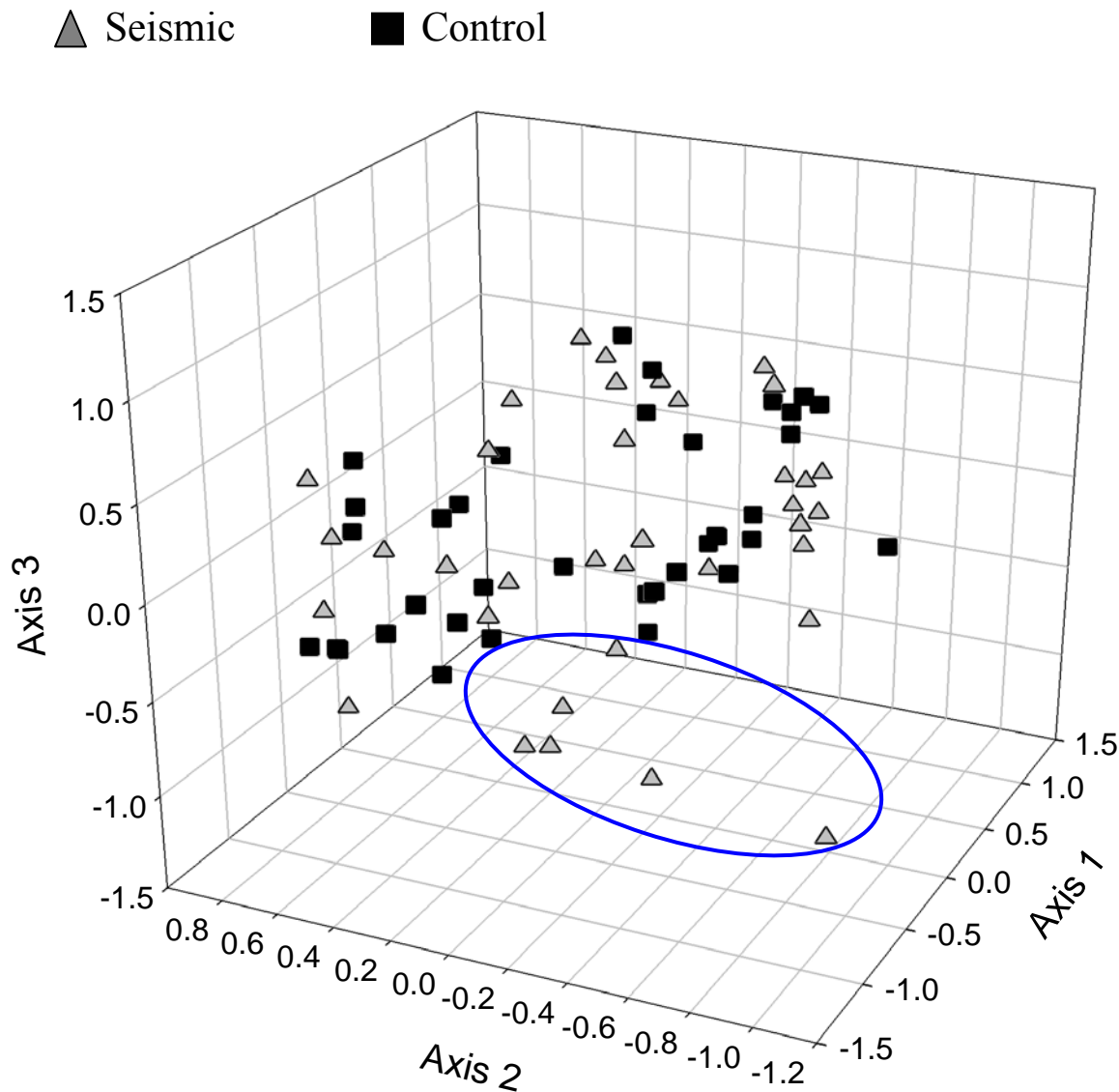
11.53

MRPP results:

$A=0.0148$

$P=0.1211$

Community composition: Wet Graminoid communities



Variance Captured:

89.6%

Final Stress:







12.22

MRPP results:

$A=0.002$

$P=0.4617$

Summary – Recent Exploration

	MSH & LSH	TSH	WG
Thaw Depth			
Organic Layer Depth			
Vascular Cover			
Moss Cover			
Lichen Cover		N/A	N/A
Diversity			
Richness			
Community Composition			

Results – Older Exploration

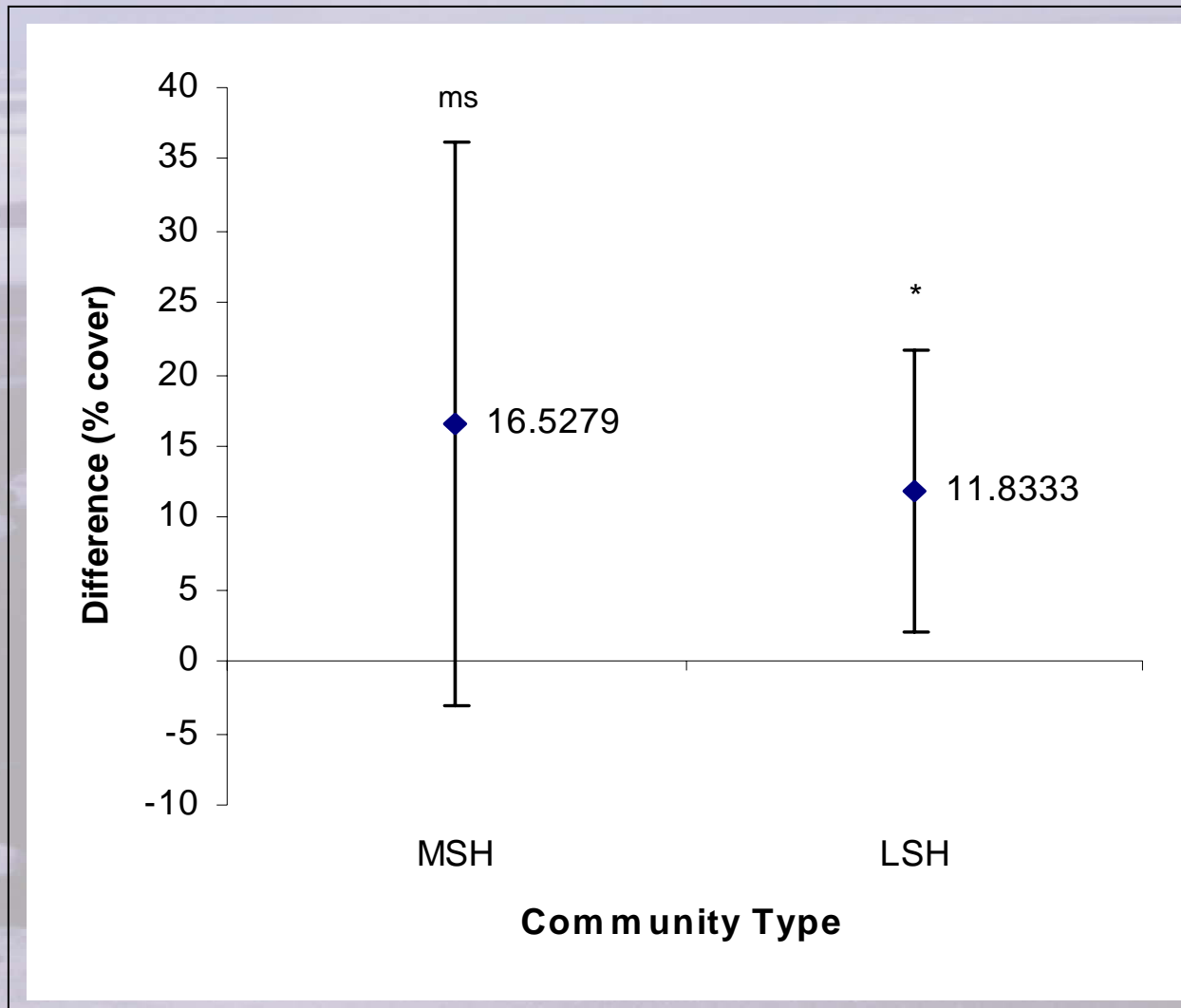
- 18 – 33 growing seasons post disturbance



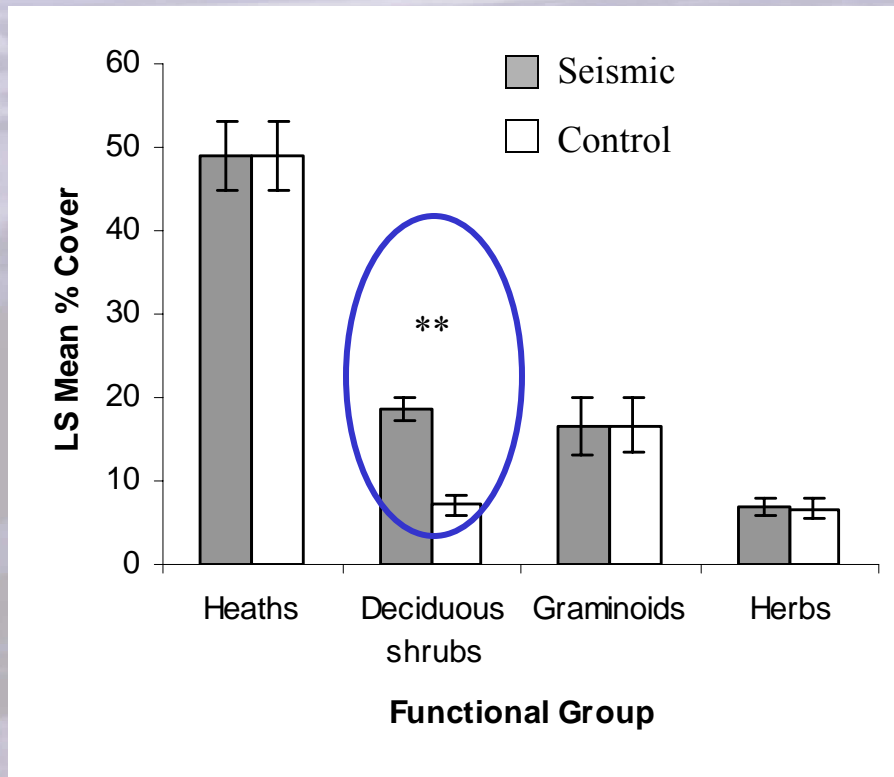
Older Seismic

- Sampled only in upland tundra communities (MSH & LSH)
 - Characterized effects for each community type separately

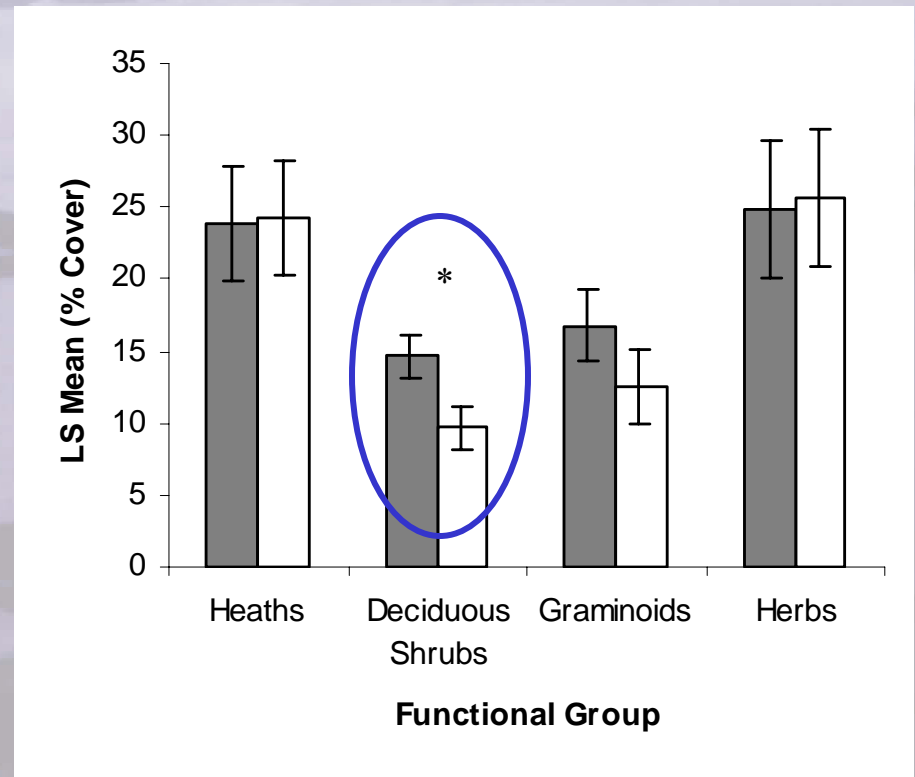
Vascular Plant Cover



Cover by Growth Form

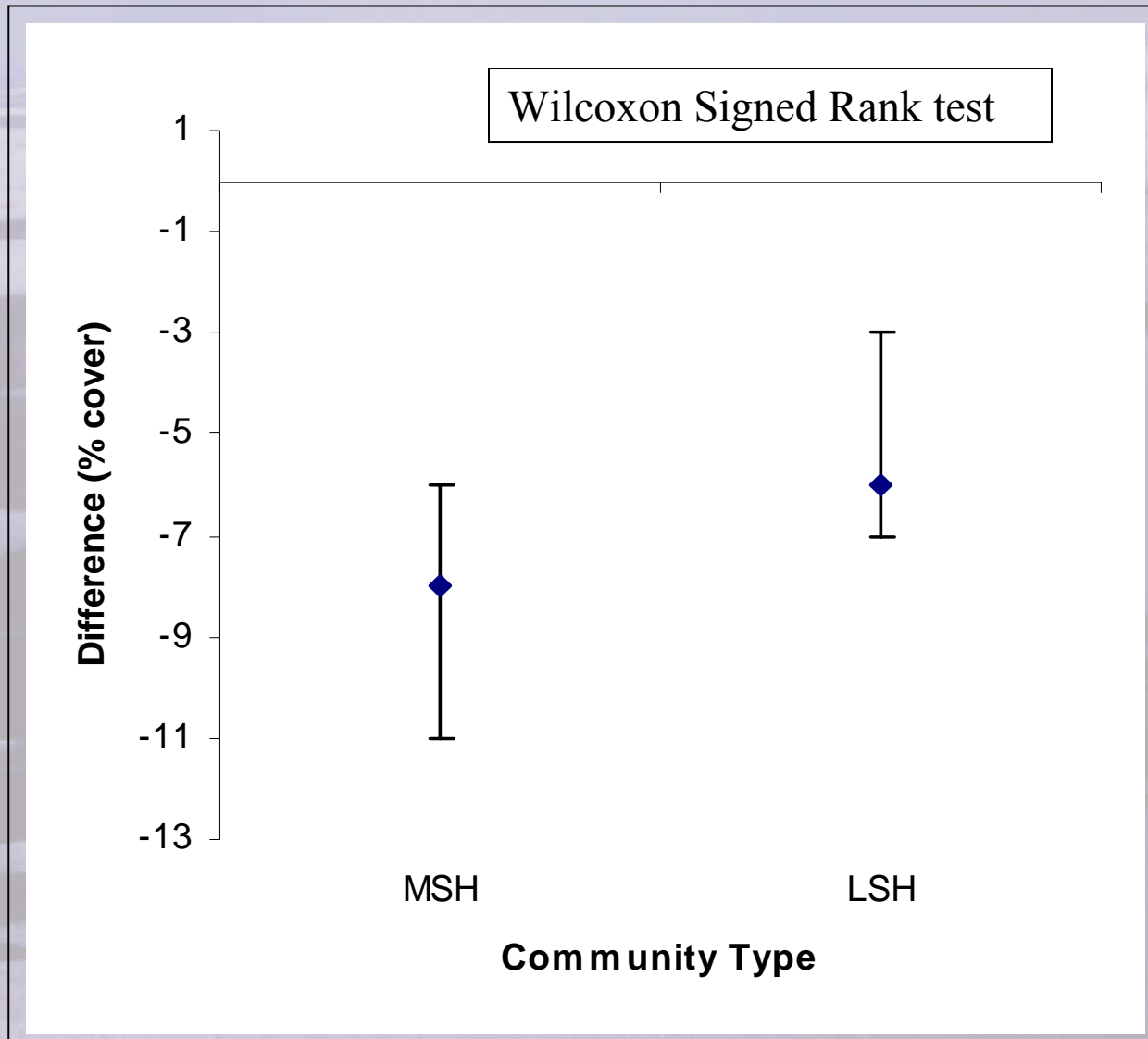


Medium Shrub - Heath

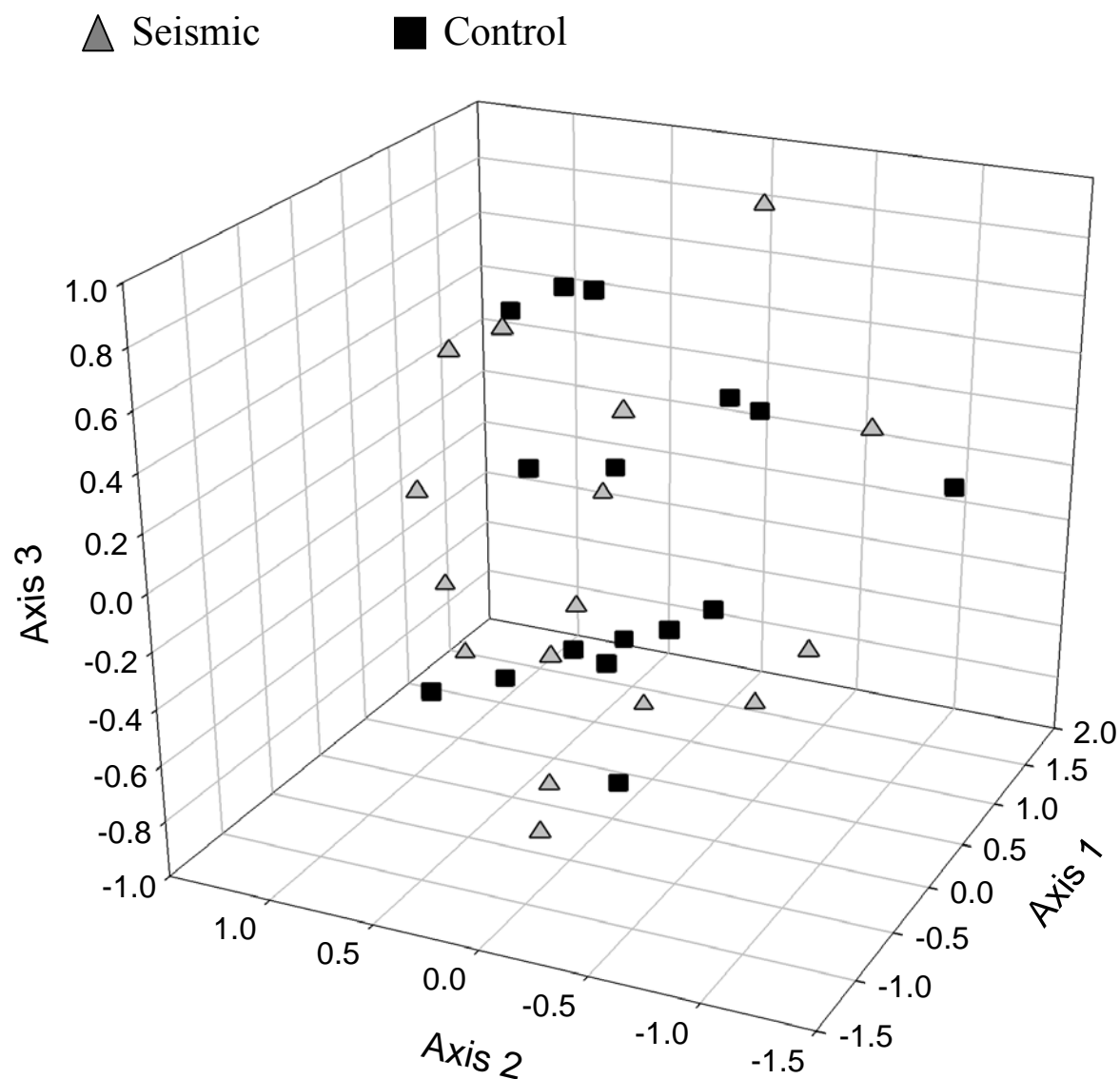


Low Shrub - Heath

Lichen Cover



Community Composition: Medium Shrub – Heath Communities



Variance Captured:
82.3%

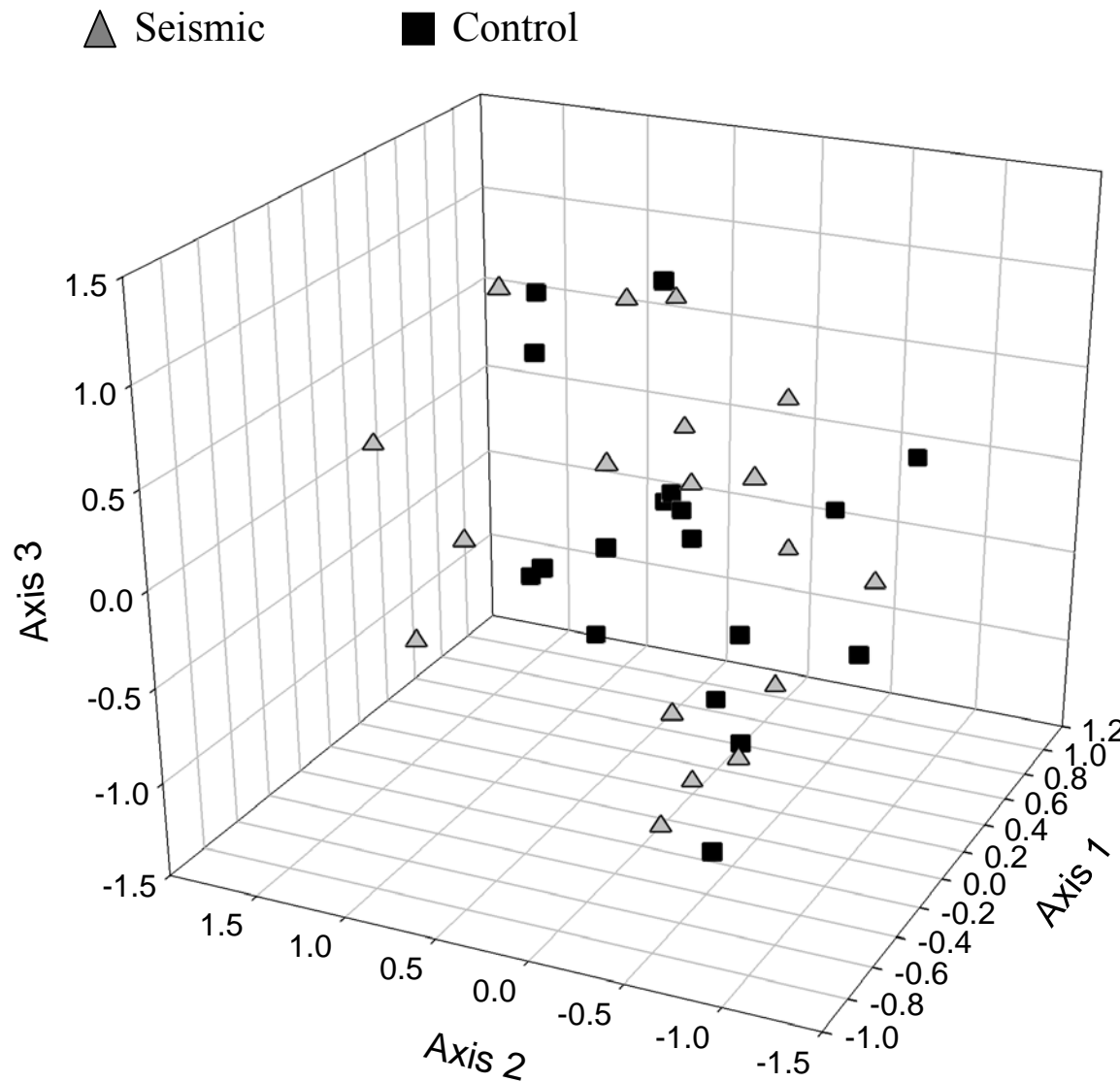
Final Stress:
13.55

MRPP results:

$A=0.01237$

$P=0.259$

Community Composition: Low Shrub – Heath Communities



Variance Captured:
85.4%

Final Stress:
12.73

MRPP results:

$A=0.00159$

$P=0.378$

Indicator Species Analysis

MSH



Betula glandulosa

p=0.008

Seismic lines

LSH



Saussurea angustifolia

p=0.013

Undisturbed
tundra

LSH



Arctagrostis latifolia

p=0.040

Seismic lines

Summary – Older Exploration

	MSH	LSH
Thaw Depth	↕	↕
Organic Layer Depth	↕	↕
Vascular Cover	↑	↑
Moss Cover	↕	↓
Lichen Cover	↓	↓
Diversity	↕	↕
Richness	↕	↕
Community Composition	?	?

Conclusions: Recent Seismic

- Significant impacts in all community types
- Upland communities most affected
 - Highest reduction in plant cover
 - Highest amount of bare ground (open sites)
 - Greatest difference in thaw depth
 - Significantly different plant communities
 - = Highest potential for long-term effects

Conclusions: Older Seismic

- Organic layer & permafrost indistinguishable from undisturbed tundra
- Similar vascular plant communities, but:
 - Higher cover of shrubs (*Betula*, *Alnus*, *Salix*)
 - Lower cover of cryptograms (shading effects?)
- Higher total plant cover
 - Higher productivity

Conclusions: Older Seismic

- What relevance to contemporary seismic?
 - Effects can persist longer than previously thought
 - Recovery of thermal equilibrium no guarantee of recovery of pre-disturbance plant community
 - Biotic interactions more important than thought?
 - Inhibition of lichens, mosses by shrubs
 - Tolerance of / inhibition by early colonizers (e.g. *Arctagrostis*)

Benefits of this Research

- Exploration will continue & intensify
- Government, Industry, EISC etc. need to know:
 - Type of effects
 - Persistence of these effects
- Prevent accumulation of impacts
 - Exceed threshold of what is acceptable



Future Research Needs

1. Modeling – cumulative effects

- Bring together other components of exploration
- Much more info needed before modeling (per se) would become appropriate tool



Future Research Needs

2. Disturbance & Climate Interactions

- Slow rates of change in absence of disturbance
 - Present communities relics of past climatic optimums?
 - Post disturbance communities similar among many studies
 - More deciduous shrubs, fewer lichens
- ? Disturbance initiated succession towards new communities, in-synch with current climate

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Thank You!

